UNITED STATES Environmental Protection Agency	**Office of Solid Waste and Emergency Response** (5201G)	July 2012 www.epa.gov/superfund

Superfund

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE

40 HOUR TRAINING

(165.5)

Presented by

HazTrain, Inc.

for the

U.S. Environmental Protection Agency

Environmental Response Team

Contract Number EP-W-09-006

THIS PAGE INTENTIONALLY BLANK

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE TRAINING (165.5)

This course is designed for personnel involved with the investigation and remediation of uncontrolled hazardous waste sites and, to a lesser extent, response to an accident involving hazardous materials. It provides basic information needed to meet the requirements of 29 CFR 1910.120 (e)(3)(i) (Hazardous Waste Operations and Emergency Response).

After completing the course, participants will be able to:

- Identify methods and procedures for recognizing, evaluating, and controlling hazardous substances.
- Identify concepts, principles, and guidelines for proper protection of site or response personnel.
- Discuss regulations and action levels to ensure health and safety of the workers.
- Discuss fundamentals needed to develop organizational structure and standard operating procedures.
- Select and use dermal and respiratory protective equipment.
- Demonstrate the use, calibration, and limitations of direct-reading air monitoring instruments, and select other test methodologies.

After completing this course, participants will be more knowledgeable in hazardous waste operations, team functions, personnel health and safety procedures, and operation of field monitoring equipment.

In some segments of the course, participants are required to wear respiratory equipment, which precludes wearing eyeglasses. Individuals who are severely restricted without their glasses should be aware that their participation might be limited unless they have contact lenses, their own spectacle kit or spectacle-equipped respirator face piece. During some exercises, participants are required to wear chemical protective clothing, which may be stressful to certain individuals.

PLEASE NOTE: A medical evaluation in accordance with the Respiratory Protection Standard, 29 CFR 1910.134 is necessary in order to participate in this course. Each student must include with their registration a letter from their supervisor or a copy of a medical certificate that clearly states that a medical evaluation is complete and that the student is medically able to wear respiratory protection equipment. Registration will not be complete nor confirmation sent until the ERTP Registrar receives such proof. If registering on-line, fax a copy of the document to the ERTP Registrar at 240-607-2198.

This course meets the U.S. Occupational Safety and Health Administration's requirement [29 CFR 1910.120(e)(3)(i)] of a minimum of 40 hours of classroom safety training for hazardous waste site workers.

Continuing Education Units: 3.8

ABIH Certification Maintenance points: 5.0

THIS PAGE INTENTIONALLY BLANK

FOREWORD

This manual is for reference use of students enrolled in scheduled training courses of the U.S. Environmental Protection Agency (EPA). While it will be useful to anyone who needs information on the subjects covered, it will have its greatest value as an adjunct to classroom presentations involving discussions among the students and the instructional staff.

This manual was developed to provide the best available current information; however, individual instructors may provide additional material to cover special aspects of their presentations.

Because of the limited availability of the manual, do not cite in bibliographies or other publications.

References to products and manufacturers are for illustration only; they do not imply endorsement by EPA.

Constructive suggestions for improvement of the content and format of the Hazardous Waste Operations and Emergency Response (165.5) manual are welcome.

THIS PAGE INTENTIONALLY BLANK

Hazardous Waste Operations and Emergency Response – 40 Hour

Formerly known as Health and Safety 40 Hour
Formerly known as HMIRO (165.5)

THIS PAGE INTENTIONALLY BLANK

INTRODUCTION TO 29 CFR 1910.120
HAZWOPER

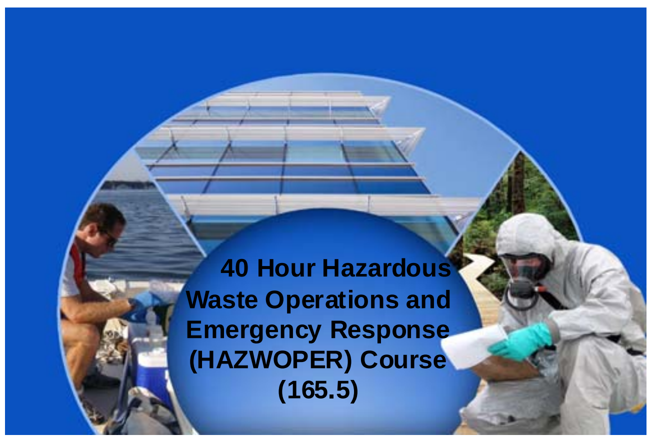
Student Performance Objectives

1. List the types of hazardous waste site operations that this regulation applies.

2. Identify which paragraphs of the regulation apply to each type of activity conducted at a hazardous waste site.

3. Identify the paragraphs of the regulation that require attendance in this course.

4. List at least 10 major topics covered by the regulations.



40 Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) Course (165.5)

presented by
HazTrain, Inc.

for the
U.S. Environmental Protection Agency
Environmental Response Team

Contract Number EP-W-09-006

THIS PAGE INTENTIONALLY BLANK

29 CFR 1910.120, HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE

This course is intended to familiarize the student with regulations governing employers and employees who have responsibility for the health and safety of personnel performing government-mandated cleanup of sites that have been contaminated by materials that are harmful to the environment. Students will perform exercises intended to demonstrate application of the regulations and the selection and use of personal protective clothing and equipment (PPE).

US EPA — Born in the wake of elevated concern about environmental pollution, EPA was established on December 2, 1970 to consolidate in one agency a variety of federal research, monitoring, standard-setting and enforcement activities to ensure environmental protection. The Administrator reports to the President.

The **Office of Solid Waste and Emergency Response** provides policy, guidance and direction for the Agency's emergency response and waste programs.

Office of Superfund Remediation and Technology Innovation administers Superfund, the federal government's program to clean up the nation's uncontrolled hazardous waste sites.

The ***Environmental Response Team (ERT)*** is a vital force in the battle to eliminate hazardous substance threats. The ERT is a group of EPA technical experts who provide around-the-clock assistance at the scene of hazardous substance releases, offering expertise in such areas as treatment, biology, chemistry, hydrology, geology, and engineering.

OSWER Training Forum

The Office of Solid Waste and Emergency Response (OSWER) Training Forum comprises training coordinators who represent the following groups: EPA Headquarters, EPA's Environmental Response Team (ERT), Superfund Regional Training Coordinators, RCRA Regional Training Coordinators, the Interstate Technology Regulatory Council (ITRC), and the Association of State and Territorial Solid Waste Management Officials (ASTSWMO). The members of the Forum coordinate their efforts to provide training to EPA, federal, state, and tribal personnel responsible for regulatory and enforcement activities. The Forum established a training exchange home page at http://www.trainex.org. This web page provides a wealth of information regarding what type of training courses are available and training modules that are already developed and ready for use on-line.

ERTP TRAINING COURSES

Course Descriptions, Class Schedules, and Registration Information are available at:

- www.trainex.org
- www.ertpvu.org

COURSE OBJECTIVES

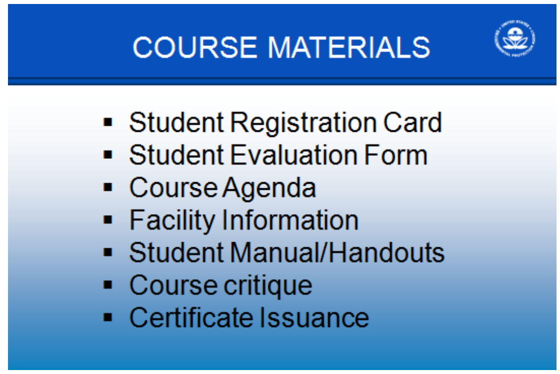
- Have the ability to locate the OSHA Regulations
- Understand basic health and safety concepts as applicable to OSHA 1910.120
- Identify the chapters of OSHA 1910.120 that apply to your worksite
- Identify regulatory exposure limits for potential contaminants
- Discuss engineering controls, work practices, and PPE to minimize risk to workers

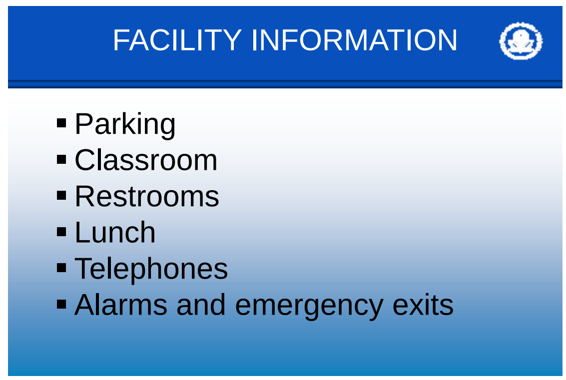
This course is designed for personnel involved with the investigation and remediation of uncontrolled hazardous waste sites and, to a lesser extent, response to an accident involving hazardous materials. The course provides basic information needed to meet the requirements of 29 CFR 1910.120 (e)(3)(i) (Hazardous Waste Operations and Emergency Response).

After completing the course, participants will be able to:

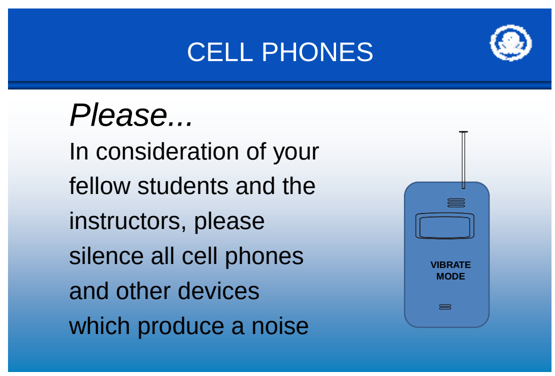
- Identify methods and procedures for recognizing, evaluating, and controlling hazardous substances.
- Identify concepts, principles, and guidelines to properly protect the site or response personnel.
- Discuss regulations and action levels to ensure health and safety of the workers.
- Discuss fundamentals needed to develop organizational structure and standard operating procedures.
- Select and use dermal and respiratory protective equipment.
- Demonstrate the use, calibration, and limitations of direct-reading air monitoring equipment.

Each student must complete a registration card. These cards are used to place the student in a training database and to produce Certificates of Training. It is important to print clearly and legibly. Facilities utilized for training vary from Agency owned, leased property, locations rented specifically for the offered training, and are configured differently. On the first day of training, instructors will point out facility information such as presented on the adjacent slide, and any additional information that is unique to a particular facility.



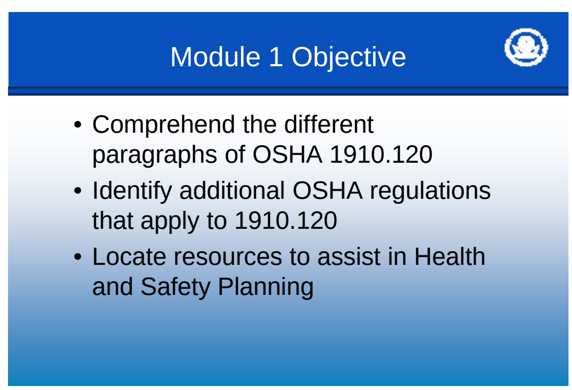


Each participant is provided a Student Manual (SM). The SM is yours and may be used for taking notes and retaining any handout materials. SMs will be available for student use during the final exam given at the completion of the lecture and practical portions of the course. A course agenda is provided so that students may follow the sequence of training. Times given are approximate and will vary with each class depending on size and experience-level of the students. In addition to the SM, students may be provided with handout material to enhance or emphasize several of the training areas. Students are required to complete a Course Critique prior to receiving their Certificate of Training.



Before proceeding further, it is important all devices that may make a sound be placed in the silent or vibrate only mode. Instructors recognize the need for some students to be reachable at any time. However, if it becomes necessary to answer a cellular phone call, please press answer and wait until you have left the classroom to answer the call.

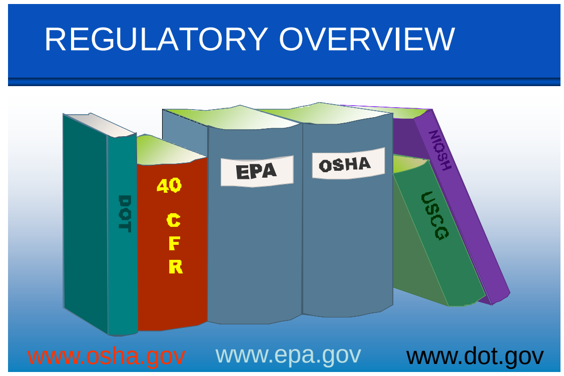
Module 1 Objectives



Regulations explain the technical, operational, and legal details necessary to implement laws. In this Module, students will become familiar with OSHA regulation 29 CFR 1910.120 through review of each paragraph of the regulation. As the student progresses through the course, details of the requirements will be explained and the student will experience through classroom and practical exercises how to read, understand and apply regulatory requirements to situations on sites where HAZWOPER applies. Students will be shown where to locate and how to use information resources to assist in Health and Safety planning.

Regulatory Overview

OSHA 29 CFR 1910.120 covers operations where employee exposure or the reasonable possibility for employee exposure to safety or health hazards may exist.



40 CFR 311 -- The substantive provisions found at 29 CFR 1910.120 on and after March 6, 1990, and before March 6, 1990, found in the *Federal Register* (FR) at 54 FR 9317 (March 6, 1989), apply to State and local government employees engaged in hazardous waste operations, as defined in 29 CFR 1910.120(a), in States that do not have a State plan approved under section 18 of the Occupational Safety and Health Act of 1970.

REGULATORY OVERVIEW

Regulatory guidance:

OSHA 29 CFR \ 1910.120

- CERCLA – Comprehensive Environmental Response Compensation Liability Act
- SARA Section 126 – Superfund Amendment Reauthorization Act
- EPA 40 CFR \ 311

Resource Conservation and Recovery Act (RCRA)

What is RCRA?

Enacted by Congress in 1976 due to the growing problem of pollution of the land by ordinary household waste, as well as hazardous commercial and industrial wastes

Goals:

– Protect human health and the environment
– Conservation of energy and natural resources
– Reduction in wastes generated
– Environmentally sound waste management practices

Industrial waste dumped at a community land fill

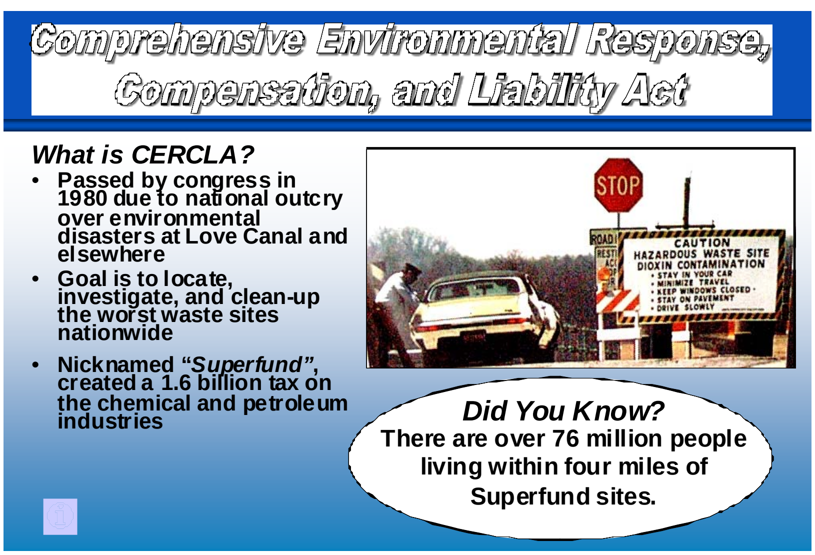
What is RCRA?

The Resource Conservation and Recovery Act (P.L. 94-580) enacted October 21, 1976, addresses the handling and disposal of hazardous wastes, which are generated mainly by industry. The law also required that open dumping of all solid wastes be brought to an end throughout the country by 1983. In addition, the law also calls for research, demonstrations, studies, training, information dissemination, and public participation activities to enlarge the base of knowledge and public involvement necessary for developing strong State and local programs.

What is Regulated Under RCRA?

The Resource Conservation and Recovery Act (RCRA) gives EPA the authority to control hazardous waste from "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of non-hazardous solid wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. **HSWA** - the Federal Hazardous and Solid Waste Amendments - are the 1984 amendments to RCRA that focused on waste minimization and phasing out land disposal of hazardous waste as well as corrective action for releases. Some of the other mandates of this law include increased enforcement authority for EPA, more stringent hazardous waste management standards, and a comprehensive underground storage tank program.

Comprehensive Response, Compensation and Liability Act

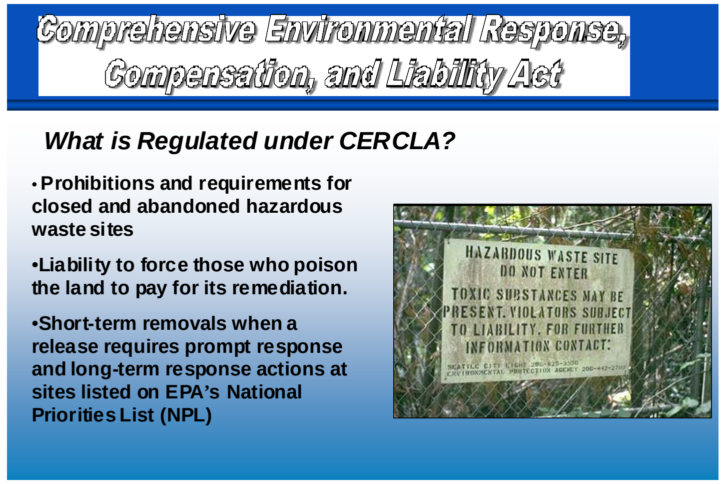


The Comprehensive Environmental Response, Compensation, and Liability Act -- otherwise known as CERCLA or Superfund -- provides a Federal "Superfund" to clean up uncontrolled or abandoned hazardous-waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment.

What is Regulated Under CERCLA?

CERCLA established prohibitions and requirements for closed and abandoned hazardous waste sites, and provided for liability to force those who poison the land to pay for its remediation.

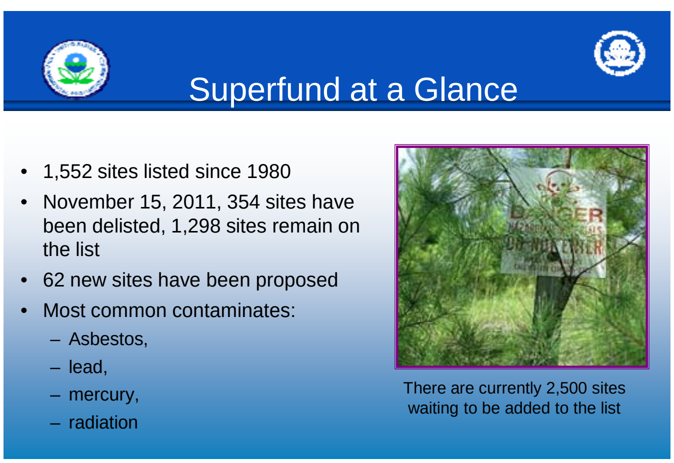
The law addresses short-term removals when a release requires prompt response and long-term response actions at sites listed on EPA's *National Priorities List* (NPL).

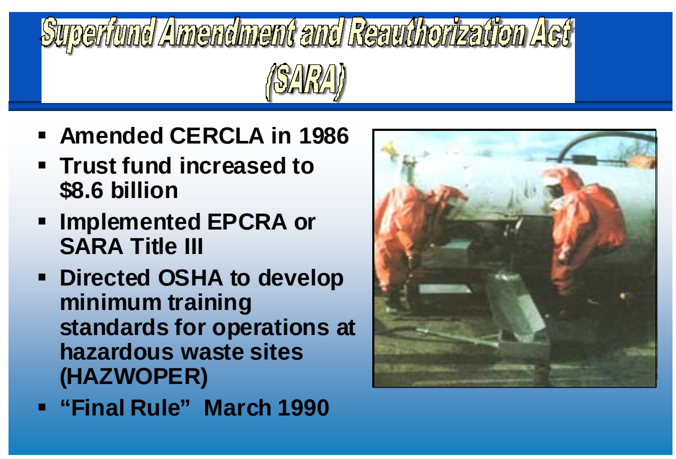


There is no statute of limitations on a generator's responsibility under CERCLA.

Superfund Amendments and Reauthorization Act

The Superfund Amendments and Reauthorization Act (SARA) of 1986 reauthorized CERCLA to continue cleanup activities around the country. Several site-specific amendments, definitions clarifications, and technical requirements were added to the legislation, including additional enforcement authorities. In addition, Title III of SARA authorized the Emergency Planning and Community Right-to-Know Act (EPCRA)





Introduction to 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response (HAZWOPER) Regulation

Upon completion of this module, the student will be able to:

List the types of hazardous waste site operations to which this regulation applies.

Identify which paragraphs of the regulation apply to each type of activity conducted at a hazardous waste site.

Identify the paragraphs of the regulation that require attendance in this course.

List at least 10 major topics covered by the regulation.

The entire curriculum of this course is based on the information that site workers are required to know and be able to carry out as part of their routine site activities. Those requirements are contained within this regulation. The regulation will be covered paragraph by paragraph, beginning with paragraph a.

The "HAZWOPER" Standard

INTRODUCTION TO
29 CFR 1910.120

Hazardous Waste Operations and Emergency Response

REGULATORY OVERVIEW

Groups of workers:

- Mandatory cleanups at uncontrolled hazardous waste sites
- Voluntary cleanups at uncontrolled hazardous waste sites
- Corrective actions at Resource Conservation Recovery Act (RCRA) Treatment, Storage, and Disposal (TSD) facilities

REGULATORY OVERVIEW

Groups of workers:

- Routine hazardous waste operations at RCRA TSD facilities
- Emergency response without regard to location

REGULATORY OVERVIEW

OSHA 1910.120 Regulation

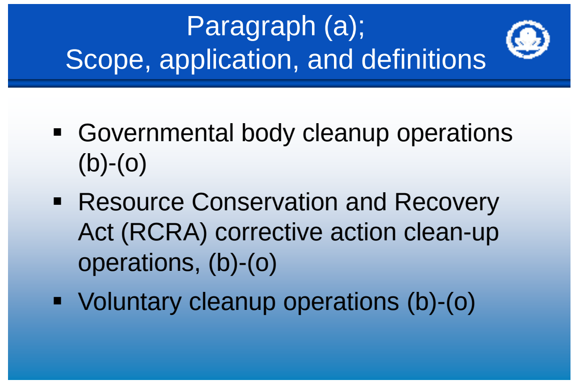
Paragraphs(a – f):

a. Scope, application, and definitions
b. Safety and health program
c. Site characterization and analysis
d. Site control
e. Training
f. Medical surveillance

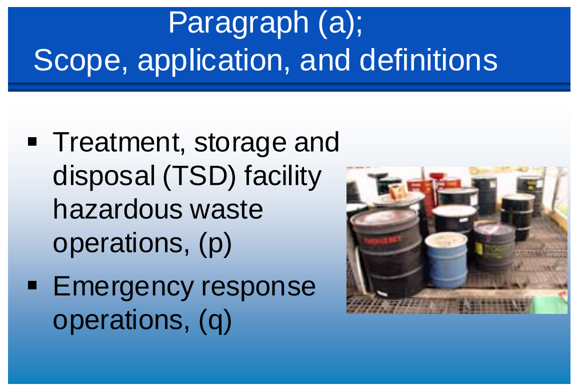
Paragraph a -- Scope, Application and Definitions

Paragraphs b-o of 29 CFR 1910.120 were written for site work in the field. These apply to the following organizations and sites:

- Governmental body cleanup operations required by federal, state or local agencies
- Superfund sites and state cleanups
- Corrective actions involved with Resource Conservation and Recovery Act (RCRA) cleanup operations
- Closures, landfill linings and facility upgrades
- Voluntary cleanup operations conducted at sites recognized by federal, state or local governmental bodies



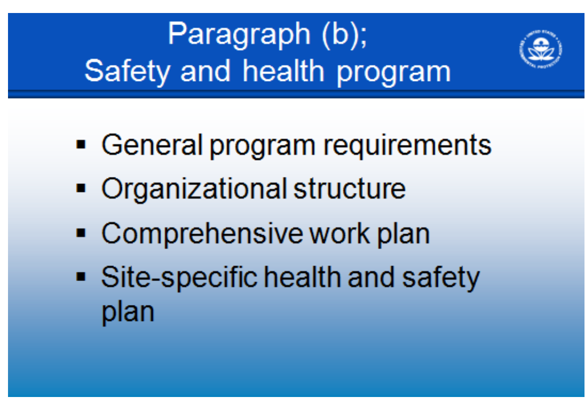
Paragraph p of 29 CFR 1910.120 was written for fixed facilities and applies to Operation of Treatment, Storage and Disposal (TSD) facilities. These facilities are regulated by 40 CFR Part 264 and 265 except for small quantity generators with less than 90 days accumulation of hazardous wastes. This includes workers in routine operations of these facilities and state Superfund site workers, general laborers, equipment operators and their supervisors.



Paragraph q of 29 CFR 1910.120 was written for the response to emergencies involving hazardous materials regardless of response location and applies to those hazardous materials response personnel that respond to sites other than their own.

Paragraph b is for Safety and Health Programs.

General program requirements: written program to identify, evaluate and control the hazards to which employees may be exposed; and organizational structure established to ensure program requirements are met. Two positions specifically addressed: General Supervisor and Site Safety and Health Supervisor.



Comprehensive site work plans to identify safety hazards to be addressed. Components of a work plan shall:

- Address anticipated cleanup activities.
- Define work tasks and objectives and identify methods for accomplishing those.
- Establish personnel requirements for implementing the plan.
- Provide for the implementation of the training.
- Provide for the implementation of the required informational programs.
- Provide for implementation of medical surveillance program.
- Site-specific health and safety plan to address the hazards identified in the comprehensive work plan states minimum elements of site safety and health plan. The elements of this section will be discussed in the Site Entry and Reconnaissance, Response Organization and Incident Command modules.

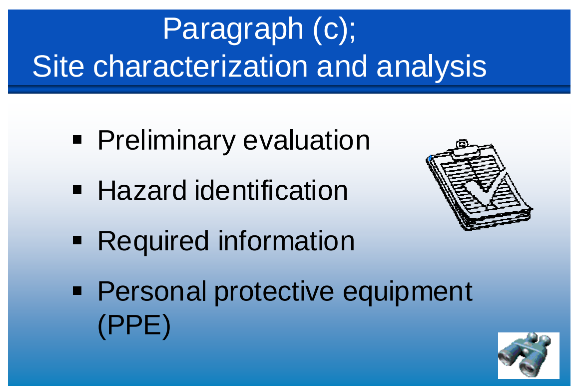
Photograph of morning safety meeting.

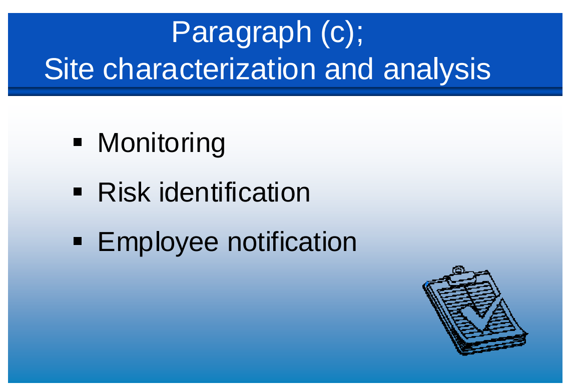
Coordination and planning of multi-agency job sites needs to be addressed in the work plans, organizational structure, and the site-specific health and safety plans. This ensures proper communication, and enables the completion of work in an orderly manner following one set of health and safety guidelines.

Paragraph c is for site characterization and analysis. Identifies information needed for characterizing a site.

Preliminary evaluation is the offsite portion that involves document collection and review to identify potential hazards. Hazard identification occurs on initial site entry and continually evaluated during subsequent entries. Examples of site hazards include confined spaces, biological indicators, vapor plumes, explosive conditions, leaks and spills.

Hazard Identification and Risk Assessment must take place.



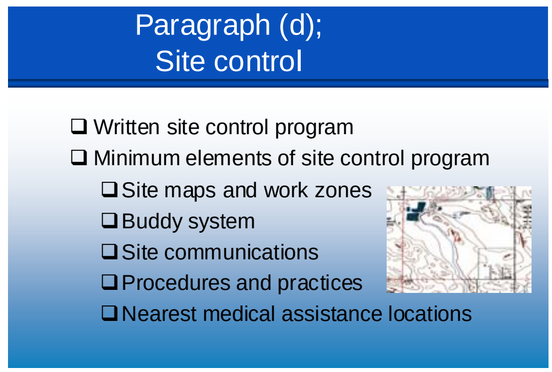


Required information must be known before employees enter a site. Information consists of eight major points ranging from location and size of site, to hazardous substances and associated health hazards.

Personal protective equipment for initial site entry is discussed.

Monitoring of atmospheric hazards posed to workers by ionizing radiation, toxic gasses or vapors, corrosives, explosion potential and the presence of normal levels of oxygen are addressed.

Employee notification of hazards and risks, similar to the Right-to-Know requirements of the Hazard Communication standard 29 CFR 1910.1200, must occur.



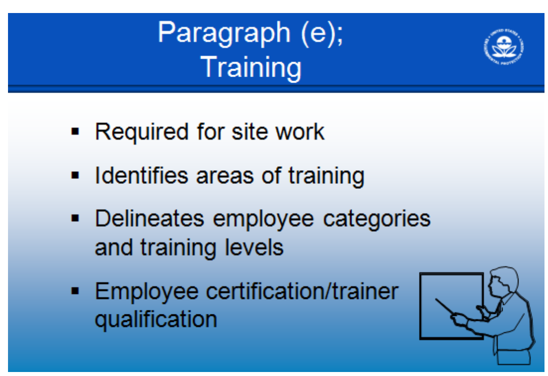
Paragraph d is for site control.

Written site control program must be developed. The minimum elements include:

- Site map
- Site work zones
- Use of “buddy system”
- Site communications
- Operating procedures and work practices
- Nearest medical assistance

The contents of this paragraph are covered in the Site Entry and Reconnaissance module.

Most of the elements are addressed in the site-specific health and safety plan.

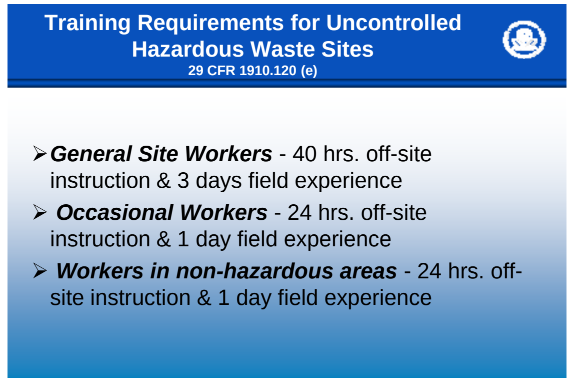


Paragraph e is for training. This is the reason why you are here today.

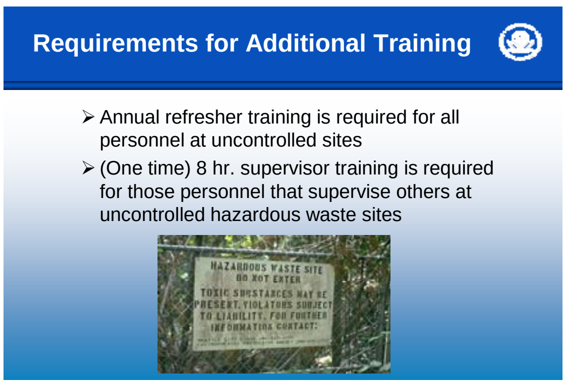
No employee is allowed to work onsite until after receiving all of the required training. Initial training for general site workers must include the required three days of onsite-supervised training.

Areas of training to be covered are identified.

Workers and supervisors are divided into employee categories with different levels of training based on their potential exposures and supervisory responsibilities.



Trainers must be certified by employer to perform training. Employees must be certified by employer to perform site work. Off-site training allows the participant to experience the process of selection, donning and doffing, and working in and with equipment and processes simulating working conditions and cleanup/response objectives, but without the hazards. Making a mistake in training is a learning experience, making the same mistake in a hazardous environment may have a more adverse outcome.



Refresher Training

Employees specified in paragraph (e)(1) of this section, and managers and supervisors specified in paragraph (e)(4) of this section, shall receive eight hours of refresher training annually on the items specified in paragraph (e)(2) and/or (e)(4) of this section. In addition, discuss any critique of incidents that have occurred in the past year that can serve as training examples of related work, and other relevant topics.

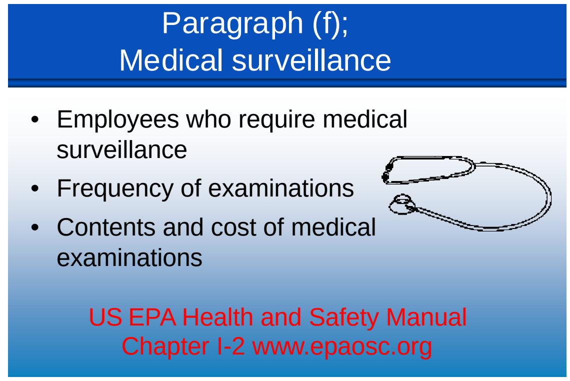
Management and Supervisor Training

On-site managers and supervisors directly responsible for, or who supervise employees engaged in, hazardous waste operations shall receive 40 hours initial training, and three days of supervised field experience (the training may be reduced to 24 hours and one day if the only area of their responsibility is employees covered by paragraphs (e)(3)(ii) and (e)(3)(iii)). At least eight additional hours of specialized training at the time of job assignment on such topics as, but not limited to, the employer's safety and health program and the associated employee training program, personal protective equipment program, spill containment program, and health hazard monitoring procedure and techniques.

Training Certification

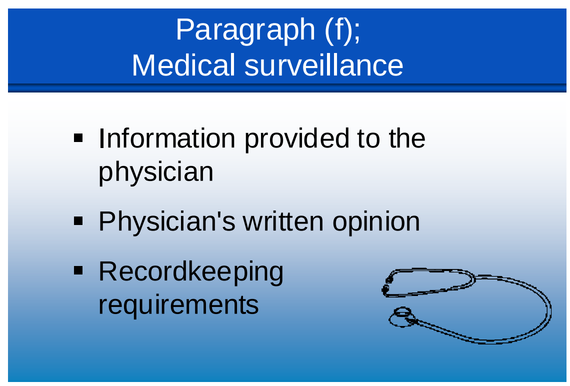
Employees and supervisors that have received and successfully completed the training and field experience specified in paragraphs (e)(1) through (e)(4) of this section shall be certified by their instructor or the head instructor and trained supervisor as having completed the necessary training. A written certificate shall be given to each person so certified.

Paragraph f - Medical Surveillance



Employers must bear cost of medical exam. Types of employees medically monitored include employees exposed at or above OSHA Permissible exposure limits (PEL) for thirty days or more a year. In addition, employees who wear a respirator for thirty days or more a year, employee has developed signs or symptoms indicating possible overexposure, employees who suffer injury due to overexposure from an emergency incident, and members of HAZMAT (response) teams.

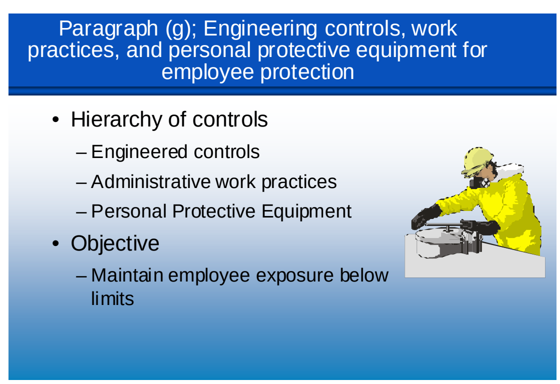
Frequency of Medical Monitoring



Initial baseline performed, then annually, or up to 24 months if approved by a physician, at the time of termination of employment, if the employee shows signs or symptoms of exposures to hazardous materials or if requested by the occupational physician.

The content of medical examinations or consultations made available to employees pursuant to paragraph (f) shall be determined by the attending physician.

Information needed to make assessment must be provided by the employer to the physician and the physician must provide written statement of employee's ability to perform job duties. Record keeping requirements contained in 29 CFR 1910.1020; records must be maintained for 30 years after last date of employment.



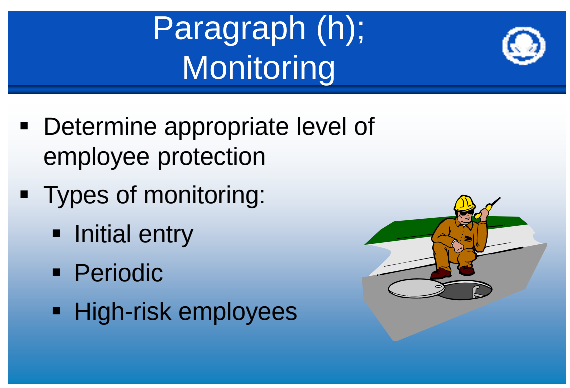
Engineering controls, work practices, and PPE for substances not regulated in Subparts G and Z. An appropriate combination of engineering controls, work practices, and personal protective equipment shall be used to reduce and maintain employee exposure to or below published exposure, levels for hazardous substances and health hazards not regulated by 29 CFR Part 1910, Subparts G and Z.

Monitoring shall be performed in accordance with this paragraph where there may be a question of employee exposure to hazardous concentrations of hazardous substances in order to assure proper selection of engineering controls, work practices and personal protective equipment. Air monitoring shall be used to identify and quantify airborne levels of hazardous substances and safety and health hazards in order to determine the appropriate level of employee protection needed on site.

Initial Entry

Upon initial entry, conduct representative air monitoring to identify any immediately dangerous to life or health (IDLH) condition, exposure over permissible exposure limits or published exposure levels, exposure over a radioactive material's dose limits or other dangerous condition such as the presence of flammable atmospheres, oxygen-deficient environments.

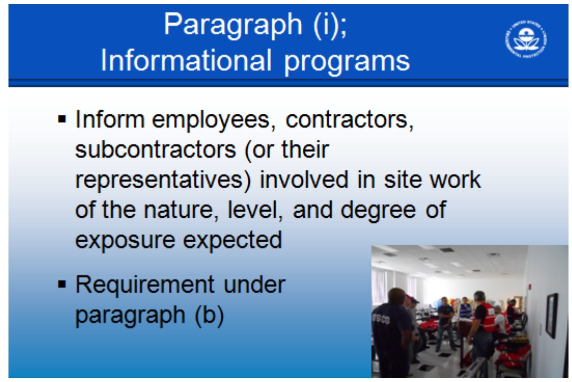
Periodic Monitoring



Periodic monitoring shall be conducted when the possibility of an IDLH condition or flammable atmosphere has developed or when there is indication that exposures may have risen over permissible exposure limits or published exposure levels since prior monitoring. Situations where it shall be considered whether the possibility that exposures have risen are as follows: When work begins on a different portion of the site, when contaminants other than those previously identified are being handled, when a different type of operation is initiated (e.g., drum opening as opposed to exploratory well drilling), and when employees are handling leaking drums or containers or working in areas with obvious liquid contamination (e.g., a spill or lagoon).

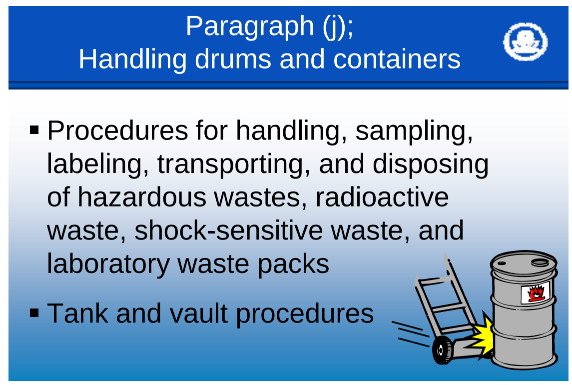
Paragraph i - Informational Programs

Employers shall develop and implement a program which is part of the employer's safety and health program required in paragraph (b) of this section to inform employees, contractors, and subcontractors (or their representative) actually engaged in hazardous waste operations of the nature, level and degree of exposure likely as a result of participation in such hazardous waste operations.



Paragraph j - Container Handling

Written procedures that meet appropriate DOT, OSHA and EPA regulations to address: handling, sampling, labeling, transporting and disposing of hazardous wastes, radioactive and shock-sensitive wastes and laboratory-chemical packs.

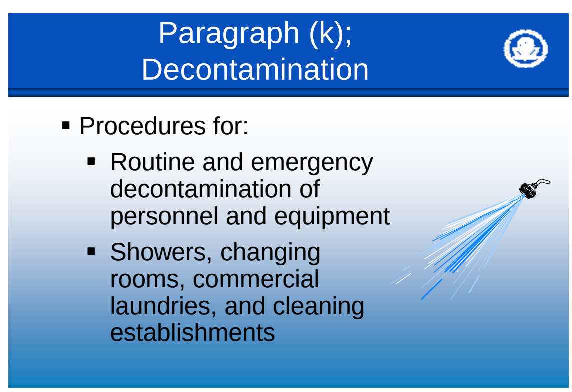


Containerized materials present a variety of hazards; extreme caution should be used in addition to adhering to procedures addressed in this paragraph. Site operations shall be organized to minimize the amount of drum or container movement.

Prior to movement of drums or containers, all employees exposed to the transfer operation shall be warned of the potential hazards associated with the contents of the drums or containers.

Paragraph k - Decontamination

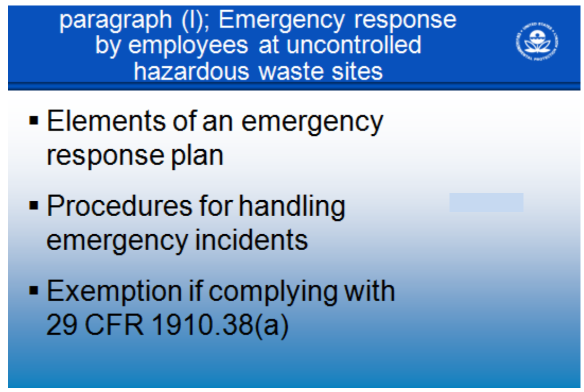
A decontamination procedure shall be developed, communicated to employees and implemented before any employees or equipment may enter any area on site where potential for exposure to hazardous substances exists. Standard operating procedures shall be developed to minimize employee contact with hazardous substances or with equipment, which has contacted hazardous substances.



Procedures for routine and emergency decontamination shall be developed.

Decontamination shall be performed in geographical areas that will minimize the exposure of uncontaminated employees or equipment to contaminated employees or equipment. All equipment and solvents used for decontamination shall be decontaminated or disposed of properly. Where the decontamination procedure indicates a need for regular showers and change rooms outside of a contaminated area, they shall be provided and meet the requirements of 29 CFR 1910.141.

Paragraph l - Emergency Response Plan

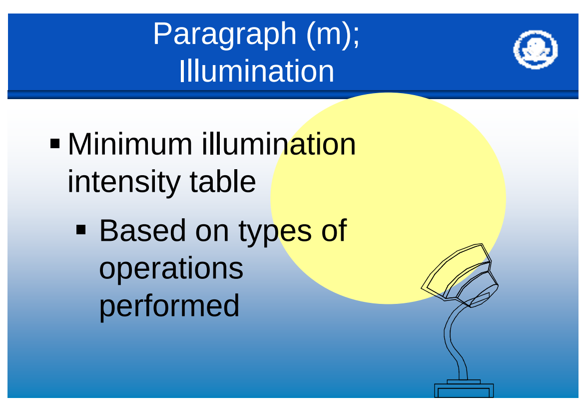


An emergency response plan shall be developed and implemented by all employers within the scope of paragraphs (a)(1)(i) through (ii) of this section to handle anticipated emergencies prior to the commencement of hazardous waste operations. The plan shall be in writing and available for inspection and copying by employees, their representatives, OSHA personnel and other governmental agencies.

There are 11 elements required in the plan:

- Pre-emergency planning.
- Personnel roles, lines of authority, training, and communication.
- Emergency recognition and prevention.
- Safe distances and places of refuge.
- Site security and control.
- Evacuation routes and procedures.
- Decontamination procedures that are not covered by the site safety and health plan. Emergency medical treatment and first aid.
- Emergency alerting and response procedures.
- Critique of response and follow-up.
- PPE and emergency equipment.

Paragraph m - Illumination



Areas accessible to employees shall be lighted to not less than the minimum illumination intensities listed in Table H-120.1 contained in this paragraph while any work is in progress.

Paragraph n - Necessary Facilities for Sanitation Services

An adequate supply of potable water shall be provided on the site. Any container used to distribute drinking water shall be clearly marked.

Outlets for non-potable water shall be identified to indicate clearly that the water is unsafe and is not to be used for drinking, washing, or cooking purposes.

Wash and shower facilities are required for sites expected to operate six months or longer. Change rooms must meet 29 CFR 1910.141, Sanitation, and have two separate areas for exit from work site into support zone.

Paragraph (n); Sanitation at temporary workplaces

- Potable and nonpotable water separate
- Toilet facilities, given number of employees
- Wash facilities near workplace
- Showers for operations >6 months
- Change rooms must meet 29 CFR 1910.141(e)

Paragraph o - New Technology Programs

The employer shall develop and implement procedures for the introduction of effective new technologies and equipment developed for the improved protection of employees working with hazardous waste clean-up operations, and the same shall be implemented as part of the site safety and health program to assure that employee protection is being maintained.

Paragraph (o); New technology programs

- Develop and implement procedures to improve protection
- Provide to OSHA upon request for evaluation and sharing

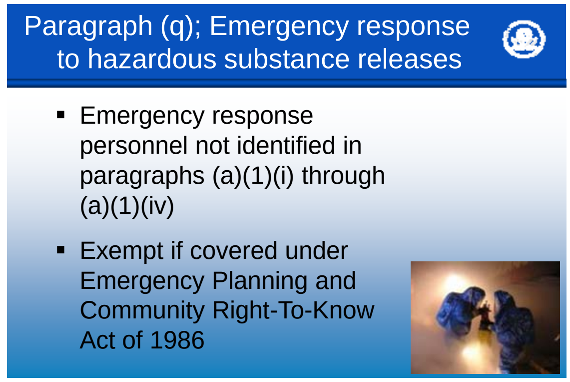
Paragraph p - Certain Operations Conducted Under the Resource Conservation and Recovery Act of 1976 (RCRA)

Employers conducting operations at treatment, storage and disposal (TSD) facilities specified in paragraph (a)(1)(iv) of this section shall provide and implement the programs specified in this paragraph.

Paragraph (p); Certain operations conducted under the Resource Conservation and Recovery Act of 1976 (RCRA)

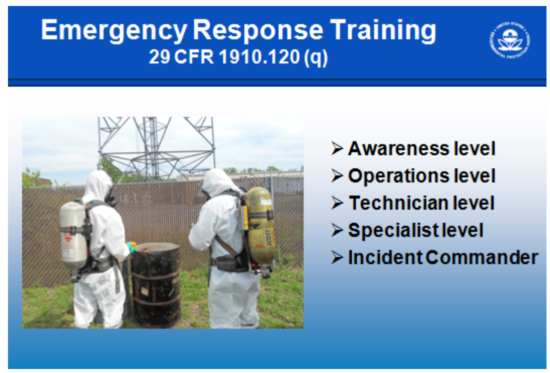
- Applies to Treatment, Storage, an d Disposal (TSD) facilities regulated under 40 CFR Parts 264 and 265
- Many sections refer to paragraphs (b) through (o)

Paragraph q - Emergency Response Plan



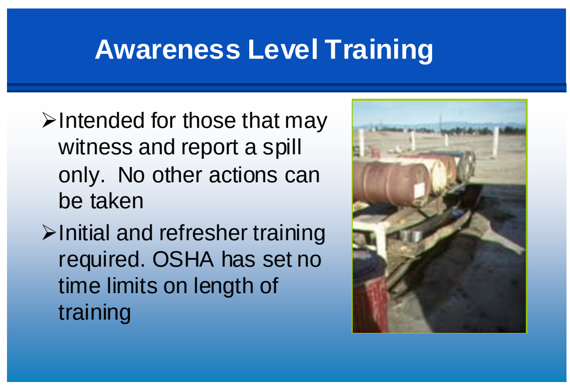
An emergency response plan shall be developed and implemented by all employers. The emergency response plan shall be a written portion of the employer's safety and health program required in paragraph (p)(1) of this section. Employers who will evacuate their employees from the worksite location are exempt from the requirements of paragraph (p)(8) if they provide an emergency action plan complying with 29 CFR 1910.38.

Paragraph (q)(8) Series - Emergency Response Training

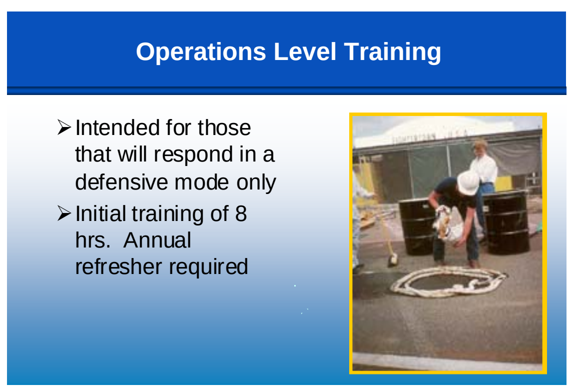


Training for emergency response employees shall be completed before they are called upon to perform in real emergencies. Such training shall include the elements of the emergency response plan, standard operating procedures the employer has established for the job, the personal protective clothing and equipment (PPE) to be worn and procedures for handling emergency incidents. There are exceptions to training requirements.

Employee members of TSD facility emergency response organizations shall be trained to a level of competence in the recognition of health and safety hazards to protect themselves and other employees.



First responders at the awareness level are individuals who are likely to witness or discover a hazardous substance release and who have been trained to initiate an emergency response sequence by notifying the proper authorities of the release. They would take no further action beyond notifying the authorities of the release.

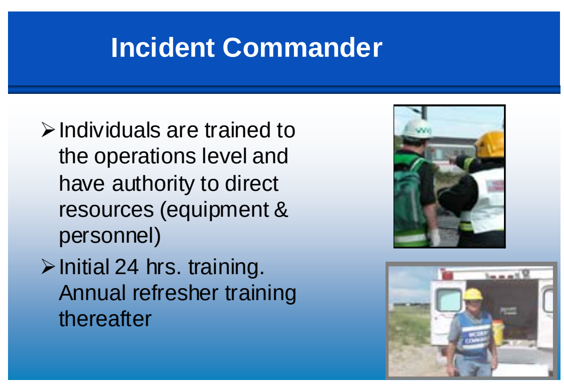


First Responders at the Operations Level are individuals who respond to releases or potential releases of hazardous substances as part of the initial response to the site for the purpose of protecting nearby persons, property, or the environment from the effects of the release. They are trained to respond in a defensive fashion without actually trying to stop the release. Their function is to contain the release from a safe distance, keep it from spreading, and prevent exposures. First responders at the operational level shall have received at least eight hours of training.

Hazardous Materials Technicians are individuals who respond to releases or potential releases for stopping the release. They assume a more aggressive role than a first responder at the operations level does in that they will approach the point of release in order to plug, patch or otherwise stop the release of a hazardous substance. Hazardous materials technicians shall have received at least 24 hours of training equal to the first responder operations level and have additional training in several key areas.

Hazardous Materials Specialists are individuals who respond with and provide support to hazardous materials technicians. Their duties parallel those of the hazardous materials technician, however, those duties require a more directed or specific knowledge of the various substances they may be required to contain. The hazardous materials specialist would also act as the site liaison with Federal, state, local and other government authorities in regards to site activities. Hazardous materials specialists shall have received at least 24 hours of training equal to the technician level and in addition have other competency in several areas.

On-Scene Incident Commanders, who will assume control of the incident beyond the first responder awareness level, shall have received at least 24 hours of training equal to the first responder operations level. In addition, have competency in the following areas: know and be able to implement the employer's incident command system, know how to implement the employer's emergency response plan, know and understand the hazards and risks associated with employees working in chemical protective clothing, know how to implement the local emergency response plan. Know the state emergency response plan and of the Federal Regional Response Team, and know and understand the importance of decontamination procedures.



Appendices to 29 CFR 1910.120 provide additional regulatory guidance.

Appendix A, *Personal protective equipment test methods*

Appendix B, General description and discussion of the levels of protection and protective gear, sets forth information about personal protective equipment (PPE) protection levels which may be used to assist employers in complying with the PPE requirements of this section.

Appendix C, Compliance guidelines, helps employer's develop a site-specific occupational safety and health program.

Appendix D provides a list of references that may be consulted for further information on the subject of this standard, and

Appendix E is a non-mandatory Training Curriculum Guideline.

Other regulations that directly or indirectly influence hazardous waste operations and emergency response are those governing the manufacture and certifications of personal protective equipment and chemical protective clothing.
To Quote the Regulation: " All requirements of Part 1910 and Part 1926 of Title 29 of the Code of Federal Regulations apply pursuant to their terms to hazardous waste and emergency response operations whether covered by this section or not. If there is a conflict or overlap, the provision more protective of employee safety and health shall apply without regard to 29 CFR 1910.5(c)(1)."

This introduction to the regulation is a starting point. Continuing training and on the job experience will further your knowledge and ability to perform safely during hazardous waste operations and emergency response to incidents hazardous substances.

29 CFR 1910.120 Appendices

(Appendix A – E):

- Appendix A PPE Test Methods
- Appendix B Levels of Protection
- Appendix C Compliance Guidelines
- Appendix D References
- Appendix E Training Curriculum Guidelines

Potentially applicable OSHA regulations (not inclusive):

- 29 CFR \ 1910.38 Emergency Action Plans
- 29 CFR \ 1910.95 Occupational Noise Exposure
- 29 CFR \ 1910.1096 Ionizing Radiation
- 29 CFR \ 1910.134 Respiratory Protection
- 29 CFR \ 1910.146 Confined Space Entry
- 29 CFR \ 1910.147 Lockout/Tagout

Summary

- Ability to locate the OSHA Regulations
- Understand basic health and safety concepts as applicable to OSHA 1910.120
- Identify the chapters of OSHA 1910.120 that apply to your worksite
- Identify regulatory exposure limits for potential contaminants
- Discuss engineering controls, work practices, and PPE to minimize risk to workers

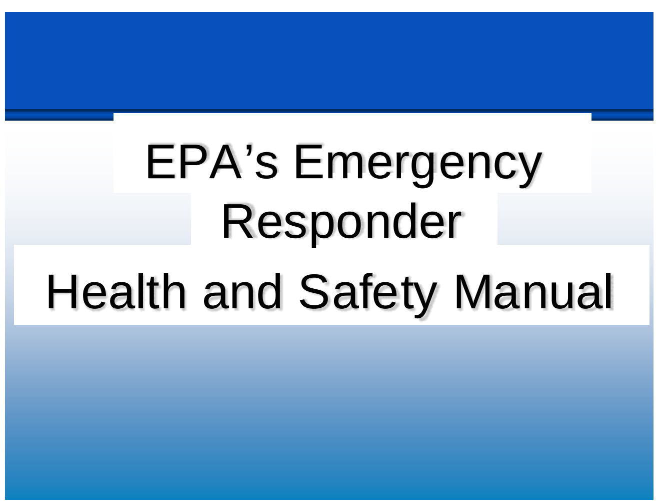
THIS PAGE INTENTIONALLY BLANK

EPA HEALTH AND SAFETY MANUAL OVERVIEW

Student Performance Objectives

1. List major components of EPA's Emergency Responder Health and Safety Plan

2. Identify Location where most current version of manual can be found



THIS PAGE INTENTIONALLY BLANK

EPA's Emergency Responder
Health and Safety Manual

Presentation Overview

- Background Information
  - What is the manual?
  - The manual's main objectives
  - The manual's Table of Contents
  - Who must implement the manual?
  - What does implementation involve?
  - Where is the manual located?
- Support Network
- Closing Remarks

Chapters
+ Field Guide
The Manual

What Is the Manual?

- **Consists of a series of chapters that:**
  - Explain what EPA must do to protect the health and safety of the Agency's emergency responders
  - Promote consistency in the way that OSHA standards, EPA policies, and other guidelines are applied across the Agency
  - Assign responsibility for health and safety-related tasks
- **Includes a Field Guide that:**
  - Summarizes the manual's main points in a succinct and user-friendly format
  - Covers each chapter in four pages or less
  - Captures information that emergency responders must have at their fingertips when working in the field

The Manual's Main Objectives

- Protect EPA's emergency responders
- Meet regulatory requirements
- Promote a consistent approach to health and safety across EPA
- Serve as a "living" document that allows flexibility to incorporate evolving best management practices and user feedback
- Provide the foundation for site-specific health and safety plans (HASPs)

Table of Contents*

** Chapters are in varying states of completion.*

Who Developed the Manual?

Chapter development teams consist of:

- OSCs
- Health and Safety Program Contacts (HSPCs)
- Safety, Health and Environmental Management Program (SHEMP) Managers
- Removal Managers
- Representatives from:
  - The Safety, Health and Environmental Management Division (SHEMD)
  - The Office of Emergency Management (OEM)
- Certified industrial hygienists

The Manual is a "Living" Document

- Chapters and Field Guide reviewed annually, modified if necessary
- SHEMD/OEM obtains feedback from:
  - The T1 Group (SHEMP Managers and HSPCs)
  - Core ER audit results
  - Comments submitted via the manual's Web site

The Manual is a "Living" Document

- Contractor compiles comments, verifies whether new or updated regulations, consensus standards, or guidance have been issued since the last chapter update
- T2 Group resolves comments, chapters modified and re-released
- EPA organizations will be alerted of modifications
  - E-mail notifications
  - Major changes will be posted on the "History of Revisions" section of the manual's Web site

Who Must Implement the Manual?

The manual has been written for EPA's emergency responders

Current Requirements → The following organizations must implement the manual:
-10 regions
-The Environmental Response Team (ERT)
-The National Decontamination Team (NDT)
-Headquarters (HQ)

Future Plans → SHEMD's eventual goal is to apply the manual to additional groups and to formalize the manual in an EPA Order

What Does Implementation Involve?

Each EPA organization must:

- Adopt the requirements and best management practices outlined in the manual
- Customize the manual's chapters with organization-specific information
- Develop a customized Field Guide
- Review/update their customized chapters and Field Guide annually

Removal Managers, SHEMP Managers, and Health and Safety Program Contacts should work together to customize the chapters and Field Guide.

The Manual's Web Site
http://www.epaosc.org/_HealthSafetyManual/

Appendices for Documenting Additional Policies and Procedures

- The chapters present the **minimum requirements** that each EPA organization must meet
- Most of the chapters include an appendix that provides space for users to indicate whether their organization has instituted additional policies or procedures to protect employees

Quick Reference Guides (QRGs)

- Each chapter includes a QRG as an appendix
- QRGs summarize key information that emergency responders need to know:
  - Before they go into the field
  - When they are in the field
- QRGs are typically 2 to 4 pages long
- The QRGs must be customized with organization-specific information
- The QRGs provide the building blocks for the Field Guide

The Field Guide

- **What is the Field Guide?**
- A **short** document that summarizes the manual's main points in a succinct and user-friendly format
- Captures information that emergency responders must have at their fingertips

Example #1: Who should you contact if you think your exposure to radiation might exceed the Agency's administrative control level?
Example #2: What are the warning signs of heat stroke?

"The Field Guide is the single most important tool associated with the manual"
-- Tier 1 Group

Status:
• A Field Guide template has been posted to the manual's Web site
• EPA organizations must distribute customized Field Guides to emergency responders

Closing Remarks

- **The manual has been created to:**
  - Protect EPA's emergency responders
  - Assist EPA in complying with the letter of the law
  - Ensure that EPA implements a consistent health and safety program across the Agency
- **The 10 regions, ERT, NDT, and HQ must:**
  - Customize the manual's chapters and create a customized Field Guide
  - Post customized documents to the manual's Web site and ensure that they remain up-to-date
  - Implement the procedures advocated in the manual
- **The manual is a living document**
  - New chapters will be released as they are completed
  - Existing chapters will be modified to keep pace with evolving best management practices and to address user feedback

Questions ?

APPENDIX D

Quick Reference Guide for EPA Emergency Responders: Medical Surveillance

Background Information/Instructions

This appendix provides tools to assist emergency responders, including:

- A checklist of medical monitoring-related issues that employees must address before going into the field, and

- Information on what employees must do if they know (or suspect) that they have been exposed to hazardous substances.

This appendix has some blank lines (highlighted in yellow) that must be customized with organization-specific information. This same organization-specific information must be incorporated into the organization's Field Guide and distributed to emergency responders, who will be instructed to bring the guide into the field (see Section 4.4 of the Introduction for further instructions and the manual's Web site).

Medical Surveillance Program
Quick Reference Guide for Emergency Responders in Organization Name

Part I: What You Need to Do Before Going Into the Field

1. Have you attended a medical surveillance awareness training session? G
   If so, do you have documentation confirming that you completed this training? G
2. Are you up-to-date on your medical examinations? G
   (Note: Exams should be performed on an annual basis.)
3. When you visit the physician, do you share information about your medical history, occupational history, and exposure history? G
4. Do you retain records of all of the *Medical Clearance Statements* that are issued on your behalf? G
5. Have you shared information about your immunization status with your physician, either by providing documentation of past vaccinations or by allowing the physician to perform a simple blood test to determine whether you are immunized against specific diseases? G
6. Have you received all of the vaccinations that the Agency recommends? (See Table 4 of the Medical Surveillance Program chapter for a list.) G
   If you lack any of these vaccines:
   - Have you been informed of the fact that EPA is willing to provide these vaccines to you if you desire them? G
   - Have you consulted your physician about whether you should be vaccinated? G
   - Have you signed a *Vaccine Declination Statement*? G
7. Do you have the most up-to-date documentation of your vaccination status, and do you maintain it in an accessible location so that you could carry it with you when you are sent into the field? G
8. Does your SHEMP Manager (or another designated person) have a signed prescription for antibiotics from your physician on file? G
9. Has your HSPC or SHEMP Manager (or another designated person) provided you with a nerve agent antidote kit, if needed? G
10. Have you attended training on how to use nerve agent antidote kits? G
    If so, do you have documentation confirming that you completed this training? G
11. Are you up to date with all of your *Exposure, Injury, and Dosimetry Tracking Forms*? G
    (Note: These forms must be completed monthly and submitted to the SHEMP Manager [or another designated person] on a quarterly basis.)

Medical Surveillance Program
Quick Reference Guide for Emergency Responders in Organization Name

Part II: What to Do If You Know (or Suspect) That You Have Been Exposed to Hazardous Substances

Step #1: If you know or suspect you have been exposed to a hazardous substance, obtain medical attention immediately, if appropriate.

Step #2: Follow the emergency procedures that your organization has identified for non-life threatening exposure events as shown here:

Emergency Procedures for Non-Life-Threatening Exposures
Organization Name
Medical Surveillance Program

If you have had a significant exposure to a hazardous chemical or toxic substance, please follow these instructions.

1. Seek medical care at the nearest medical facility and identify yourself as a participant in the EPA Medical Surveillance Program. Report exposures. Have the name of the substance(s) to which you have been exposed, if known. Describe the symptoms you are experiencing.
2. To report exposure and receive advice and directions, have the medical facility doctor or nurse contact:

During duty hours (_____ a.m. - _____p.m.)	**After duty hours**
Name: ______________________________	Name:______________________________
Contact Info:__________________________	Contact Info:_________________________
____________________________________	____________________________________

3. If treatment is necessary, inform the medical facility that a standard authorization form for examination and/or treatment under the Office of Workers' Compensation (OWCP) will be forwarded to them by your supervisor.
4. Immediately inform your supervisor of the exposure incident. (Supervisor approval is not needed before contacting ____________________________.)

Step #3: Submit the following form to your supervisor: EPA Form 1340.1, *OSHA & EPA 301—Injury, Illness & Near Miss Report*.

Step #4: If illness or injury results, consult the SHEMP Manager (or another designated person) for advice and inform your supervisor if you think you need follow-up medical evaluation or treatment.

Step #5: Refer to the Injury, Illness, and Exposure Reporting chapter for additional information on follow-up reporting activities.

APPENDIX D

Quick Reference Guide for EPA Emergency Responders: Respiratory Protection Program

Background Information/Instructions

This appendix summarizes information that emergency responders must know about the respiratory protection program, including:

- A checklist of items that emergency responders must address before going into the field,
- A checklist of items that emergency responders must address while working in the field, and
- Information that emergency responders need to know in the field.

The Quick Reference Guide must be incorporated into the organization's Field Guide and distributed to emergency responders, who will be instructed to bring the guide with them into the field (see Section 4.4 of the Introduction for further instructions and the Manual's Web site).

Respiratory Protection Program
Quick Reference Guide for Emergency Responders in Organization Name

Part I: What You Need to Do Before Going Into the Field

If you are going to a site where respirators are required, you must have done the following within the past year:

1. Received medical clearance to wear each type of respirator that you might use in the field. ☐
2. Completed initial (or refresher) respiratory protection training and engaged in a hands-on exercise. ☐
3. Demonstrated that you can breathe down a tank of air for a minimum of 20 minutes. (*Note: This is relevant for SCBA users only.*) ☐
4. Pass a quantitative fit test (QNFT) for *each* type of respirator that you might use. ☐

When preparing to take respirators to a site, you must:

5. Conduct a hazard evaluation of the site. ☐
6. Produce a site-specific written respiratory protection program (RPP), including respirator use, selection, and care information as part of the HASP. ☐
7. Ensure that the site-specific HASP indicates which specific respirator type and filter/cartridge is needed. ☐
8. Examine the respiratory protection equipment to be taken to the site to ensure that it is appropriate, complete, and in service (no red tags, no expired cartridges/cylinders), and that spare parts and an adequate number of filters/cartridges are included for each brand of respirator to be used at the site. ☐
9. Know respirator care procedures, including the contact time required for respirator disinfection solutions to be used and which sanitation compounds are incompatible with respirators at the site. ☐
10. If you wear corrective lenses, obtain a spectacle kit for your make/model of respirator or confirm that alternate lenses do not interfere with the respirator face-to-facepiece seal. ☐

Part II: Things You Must Do In the Field

1. Implement engineering, work practice, and/or administrative controls whenever feasible to minimize hazardous air contaminants. ☐
2. Before entering a site, confirm that you agree with the respirator selection that has been chosen for each task that you will be expected to perform. ☐
3. Conduct air monitoring to confirm that the selection is appropriate. ☐
4. Maintain proper facial conditions for respirator(s) to seal to your face (e.g., shave, wash). ☐
5. Inspect respirators, with special attention to inhalation and exhalation valves, and conduct a user seal check (fit check) each time you don a respirator.
6. Track chemical cartridge service life and change cartridges and filters according to HASP requirements (at the end of each shift or more frequently as conditions require). ☐
7. Exit hazardous atmospheres immediately when detected and report problems if respirators do not perform as expected (breakthrough odor, breathing resistance, or malfunctions) or if site conditions change significantly (new contaminants emerge or concentrations change). ☐
8. Clean respirators during the shift when visible accumulation is present. ☐
9. Clean, disinfect, and properly store respirators at the end of every shift. ☐
10. Ensure that breathing air obtained from an outside source is Grade D breathing air and provide documentation of this to the Health and Safety Program Contact. ☐
11. Maintain and use any breathing air compressor under your control according to manufacturer's recommended procedures and document all compressor care/use. ☐

Respiratory Protection Program
Quick Reference Guide for Emergency Responders in Organization Name

Part III: Things You Need to Know in the Field

RESPIRATOR SELECTION

- Use EPA standard issue respirators unless the SHEMP Manager (or another designated person) has authorized a different respirator or if the conditions for voluntary respirator use are in effect.

- **Standard Issue Respirators – Specified Facepieces and Conditions of Use**:
  - ***Air-Purifying Respirators (APRs)***
    Negative-pressure: Full-facepiece; P-100 filter and/or suitable chemical cartridge.
    PAPR: Tight-fitting full-facepiece; continuous flow mode; P-100/HEPA filter and/or suitable chemical cartridge.
  - ***Atmosphere-Supplying Respirators (ASRs)***
    SCBA: Tight-fitting full-facepiece; positive-pressure open-circuit mode.
    Airline: Tight-fitting full-facepiece; connected to an appropriate cascade system.

- **Conditions Requiring SCBA**:
  - O_2 is less than 19.5%.
  - Possibility of an IDLH atmosphere.
  - Contaminants of unknown identity or concentration might be present.
  - Other ASR might be permitted under certain circumstances with approval of the SHEMP Manager (or another designated person).

- **Situations When an APR is Acceptable**:
  - O_2 in ambient air is equal to or greater than 19.5%.
  - A filter or cartridge that can remove the contaminant is available.
  - Airborne concentration of the contaminant does not exceed the maximum use concentration (MUC).

- **Calculating the MUC**:
  - MUC = APF x 0.5 PEL. *[Note: 0.5 PEL represents a conservative MUC for EPA employees.]*
  - APF is the assigned protection factor for the respirator published by NIOSH or OSHA (not the fit factor from QNFT).
  - PEL is the permissible exposure limit (e.g., from OSHA 29CFR 1910.1000). In the MUC equation, it is also acceptable to use exposure limits published by other organizations (e.g., ACGIH, NIOSH).

- **OSHA APFs to Use in MUC Calculations:**
  - ***With QNFT fit testing:***
    - Half-facepiece APR: APF = 10 (half-mask use must be approved by SHEMP Manager).
    - Full-facepiece APR: APF = 50.
    - Full-facepiece (tight-fitting) PAPR: APF = 1,000 (1,000 with SHEMP Manager approval).
    - Full-facepiece SCBA (standard issue configuration): APF = 10,000.
  - ***With emergency field QLFT fit test:***
    - Full-facepiece APR: APF = 10.
    - Full-facepiece SCBA (standard issue configuration): APF = 10,000.

ESCAPE RESPIRATORS

- Choose based on:
  - Time needed to escape.
  - Likelihood of IDLH or oxygen deficiency conditions, which require an ASR-style escape respirator.

VOLUNTARY RESPIRATOR USE

- For nuisance dust and odors.
- If a hazard evaluation indicates that a respirator is not required for the task or area and that wearing a respirator voluntarily will not in itself create a hazard.
- If you have received EPA emergency responder respiratory protection training, OR if you (1) have received OSHA's information for voluntary users (29 CFR 1910.134 Appendix D), (2) have received training on wearing respirators, and (3) are medically qualified to wear a respirator. (Exception: medical evaluation and training are not required for voluntary use of filtering facepieces ["dust masks"].)

OSHA SUBSTANCE-SPECIFIC STANDARDS THAT CONTAIN RESPIRATORY PROTECTION REQUIREMENTS

See Appendix G for links to these standards: asbestos,[1] 13 carcinogens,[2] vinyl chloride, arsenic (inorganic), lead, cadmium, benzene, coke oven emissions, cotton dust, 1,2-dibromo-3-chloropropane, acrylonitrile,[1] ethylene oxide, formaldehyde,[1] methylenedianiline, 1,3-butadiene,[1] and methylene chloride.

FILTERS AND CHEMICAL CARTRIDGES

- **Selecting Filters and Cartridges:**
  - Use only NIOSH-approved filters, cartridges, and parts intended for the specific make and model of respirator.
  - The P-100 is the designated filter for standard issue respirator configurations. If the SHEMP Manager (or another designated person) authorizes other respirators/configurations for a specific worksite, select filter styles based on potential presence of oil particles and type of dust:
    - N for Not resistant to oil,
    - R for Resistant to oil
    - P for oil Proof
  - Select filter efficiency (i.e., 95%, 99%, or 99.97% [nominally 100]) depending on how much filter leakage can be accepted. Higher filter efficiency means lower filter leakage.
  - Consult manufacturer's product information to select suitable chemical cartridges.
- **Change Schedules for Filters and Cartridges:**
  - ***Filters*** (whichever of the following occurs sooner):
    - At the end of each shift.
    - Breathing resistance increases significantly.
  - ***Chemical Cartridges*** (whichever of the following calls for the earliest exchange):
    - At the end of each shift.
    - Based on airborne contaminant concentration(s), cartridge capacity, work rate, and atmospheric conditions.
    - As specified by local/regional policy.
    - Based on indication from end-of-service-life-indicator (ESLI).

EMERGENCY FIT TESTING IN THE FIELD

- A qualitative fit test (QLFT) may be used as a temporary measure under emergency conditions.
- Use irritant smoke (stannic chloride).
- QLFT is NOT a substitute for quantitative fit testing! Obtain a QNFT as soon as feasible.
- Prior to a QLFT, you must be trained and medically qualified to wear a respirator.

ENTRY PROCEDURES FOR AN IDLH ATMOSPHERE

- Wear SCBA with a minimum of 30 minutes of service life or an airline respirator (pressure-demand mode) with auxiliary self-contained air supply.
- Use the "Buddy System."
- A standby employee must maintain communication with employee(s) in an IDLH atmosphere.
- The standby employee must have rescue equipment and a respirator suitable for an IDLH atmosphere.
- The standby employee must notify designated personnel before entering an IDLH environment to provide emergency rescue.

BREATHING AIR QUALITY (USED WITH ASRs)

- Must meet the criteria for Grade D breathing air:

- < O_2 is between 19.5% and 23.5%.
- < Hydrocarbons (condensed) are 5 mg/m^3 or less.
- < Carbon monoxide (CO) is 10 ppm or less.
- < Carbon dioxide (CO_2) is 1,000 ppm or less.
- < No noticeable odor.
- Always obtain supplier certification that air is of at least Grade D quality.
- Grade E breathing air is also acceptable.
- Oxygen-enriched air (above 23.5% O_2 – of medical/breathing purity) is:
  - < Unacceptable unless a dedicated facemask for O_2 enriched air is used.
  - < Required at altitude above 14,000 feet.

RESOURCES FOR RESPIRATORY PROTECTION

- Scott Health & Safety Technical Support (for standard issue respirators)
  - < Tel: 1-800-247-7257
  - < techsupport.scotths.us@tycoint.com
  - < http://www.scotthealthsafety.com/Americas/en/Support/Support.aspx

- NIOSH
  - < Respirator Selection Logic (2004)
    - - General
    - - Escape Respirators (Chapter IV)
  - < Pocket Guide – IDLH levels

- OSHA PELs
  - < Table Z-1 (air contaminants)
  - < Table Z-2
  - < Table Z-3 (mineral dusts)
  - < Calculate the PEL for a chemical mixture (for use in MUC equation)

[1]Contains information specific to respirator filter/cartridge selection or change schedules.

[2]For alpha-naphthylamine, methyl chloromethyl ether, 3'-dichlorobenzidine (and its salts), bis-chloromethyl ether, beta-naphthylamine, benzidine, 4-aminodiphenyl, ethyleneimine, beta-propiolacetone, 2-acetylaminofluorene, 4-dimethylaminoazobenzene, and n-nitrosodimethylamine

APPENDIX D

Quick Reference Guide for EPA Emergency Responders: Personal Protective Equipment (PPE) Program

Background Information/Instructions

This appendix provides:

- A checklist of issues concerning PPE that emergency responders must address before going into the field and
- Information about PPE that emergency responders must address when they are working in the field.

This appendix has blank lines (highlighted in yellow) that must be customized with organization-specific information. The Quick Reference Guide must be incorporated into the organization's Field Guide and distributed to emergency responders, who will be instructed to bring the guide with them into the field (see Section 4.4 of the manual's Introduction for further instructions and the Manual's Web site).

Personal Protective Equipment (PPE): Quick Reference Guide for Emergency Responders in Organization Name

Part I: What You Need to Do Before Going into the Field

1.	Have you completed PPE training (Section 3.2)? If so, do you have a copy of your training certificate and is your training documented in TrainTrax? (*Note: PPE training is often incorporated into HAZWOPER 40-hour and 8-hour refresher courses.*)	☐ ☐
2.	Are you up to date on all medical examinations, including, if applicable, exam elements required for responders wearing Level A or B PPE?	☐
3.	Are you familiar with the contents of your organization's (customized) PPE program, including: (a) practices for PPE selection and use (Section 4.0), (b) hazards associated with PPE use (Section 3.5), (c) signs of PPE malfunction (Section 3.5), (d) PPE inspection (Section 3.3.1), (e) donning and doffing PPE (Section 3.4), and (f) decontamination procedures (Section 5.0)? (See also QRG on respirators is in Chapter II-2.)	☐
4.	If available, have you reviewed the site-specific HASP, specifying appropriate PPE by task and PPE decontamination procedures?	☐
5.	Have you inspected your issued PPE to make sure it is free of defects/damage (check for tears, imperfect seams, pinholes, malfunctioning closures, and valves, etc.)? (See Appendix G)?	☐
6.	Does your field bag and/or vehicle contain the required PPE and decontamination materials for the task/operation?	☐
7.	Are you familiar with the site-specific emergency decontamination and egress procedures? If you experience problems related to PPE use (e.g., symptoms of heat stress, PPE breach/exposure), your point of contact is: Supervisor, Medical Monitor, or another designated person.	☐

Part II: Things You Need to Do in the Field

1.	Have you or another designated person conducted a site hazard assessment to determine the appropriate level and type of PPE required for each task (Section 4.1). (Note: The Agency has created Guidelines for PPE Ensemble Selection to assist emergency responders in selecting PPE ensembles for specific activities and tasks.)	☐
2.	Have you or another designated person identified appropriate PPE decontamination procedures (Section 5.0)?	☐
3.	Have you or another designated person implemented engineering, work practice, and/or administrative controls whenever feasible to minimize exposure to identified hazards?	☐
4.	Do you periodically check your PPE for failure or breaches (e.g., stains or other evidence of chemical attack, tears, punctures, or seam breaks)?	☐
5.	If you experience signs or symptoms of PPE failure, promptly leave the site, proceed to decontamination (if an emergency follow emergency egress) and inform your Supervisor or another designated person.	☐
6.	Have you followed the site-specific PPE decontamination procedures specified in the HASP (Section 5.0)?	☐
7.	At the end of the shift, have you placed all single-use PPE in labeled containers for disposal (Section 5.7)? Place contaminated reusable PPE in plastic bags for further decontamination/disposal.	☐
8.	Have you properly treated and disposed of all spent solutions used for decontamination?	☐
9.	If PPE will be reused, have you cleaned and/or sanitized it after each shift and stored it properly (Section 3.3)?	☐

APPENDIX D

Quick Reference Guide for EPA Emergency Responders: Injury, Illness, and Exposure Reporting

Background Information/Instructions

This appendix is a Quick Reference Guide to assist emergency responders with the procedures for incident reporting and investigation. It consists of a checklist of items to address before and after going into the field to ensure proper reporting and follow-up for job-related injuries, illnesses, exposures, motor vehicle accidents, near misses, and hazardous working conditions.

The Quick Reference Guide must be incorporated into the organization's Field Guide and distributed to emergency responders, who will be instructed to bring the guide with them into the field (see Section 4.4 of the manual's Introduction for further instructions and the manual's Web site).

Injury, Illness, and Exposure Reporting
Quick Reference Guide for Emergency Responders in Organization Name

Part I: What You Need to Do Before Going into the Field

1. Have you successfully completed the injury, illness, and exposure reporting training course (Section 8.0)? Do you have a copy of your training certificate with you? ☐

2. Have you reviewed your organization's injury, illness, and exposure reporting program (i.e., the customized version of the Injury, Illness, and Exposure Reporting chapter) and familiarized yourself with: (a) the procedures and forms for reporting injuries, illnesses, exposures, near misses, and motor vehicle accidents; (b) the procedures and forms for obtaining medical treatment and filing a claim for workers' compensation; (c) the procedures for reporting unsafe or unhealthful working conditions; and (d) incident investigation and reporting? ☐

3. Are organization-specific incident reporting and investigation procedures incorporated into the HASP (Appendix E)? ☐

4. Do you know how to contact your immediate supervisor when you are working in the field? ☐

5. Do you know who your local SHEMP Manager is and how to contact him or her? ☐

6. Do you know who your Vehicle Manager (or another designated person) is and how to contact him or her? ☐

Part II: Things You Need to Do in the Field

1. **Report every job-related injury, illness, significant exposure, near miss, and motor vehicle accident to your supervisor as soon as possible.** Have your supervisor complete the *OSHA & EPA 301 Injury, Illness and Near Miss Report* (Appendix G) and submit it to the local SHEMP Manager. If you wish to report a near miss anonymously, complete the applicable sections of the *OSHA & EPA 301 Injury, Illness and Near Miss Report* yourself and forward the completed report to the local SHEMP Manager or, report the near miss through the EPA Reporting Hotline by calling or leaving a message at (877) 301-7233 (8 a.m. to 5 p.m. EST, Monday through Friday). ☐

2. **Obtain first aid or medical treatment as necessary.**

   - **If immediate medical care is required, go to the nearest health care facility or to your private health care provider. Ask your supervisor for assistance in making transportation arrangements or in calling for an ambulance.** ☐

     In a non-emergency situation, if you need medical treatment for an injury, ask your WCC to authorize medical treatment by use of Form CA-16 (Section 3.2.1.3). **(For emergency situations, the WCC or the supervisor must authorize treatment by telephone and then send/fax Form CA-16 to the treating medical facility within 48 hours.)** You may initially select the health care provider to provide the necessary treatment. This may be a private health care provider or, if available, a local federal medical officer/hospital. Take Form CA-16 and Form OWCP-1500 to the health care provider. Form OWCP-1500 is the billing form health care providers must use to submit bills to OWCP. (Hospitals and pharmacies may use their own billing form.) If you need medical treatment for an occupational illness or disease, obtain care directly from a specialist health care provider in the indicated field. Form CA-16 cannot be used for an illness or disease without prior approval from OWCP.

- Complete and submit the appropriate OWCP form for work-related injuries, illnesses, or significant exposures. If you have a traumatic injury (conditions that occur in one work shift), complete the employee's section of Form CA-1 and turn it in to your supervisor within 24 hours from the date of the injury. Provide medical evidence in support of the disability within 10 days of submission of Form CA-1. If you are disabled due to traumatic injury, you may claim continuation of pay (COP) not to exceed 45 calendar days or use leave. (Form CA-1 is designed to serve as a claim for COP.) ☐

- If you have an occupational illness or disease (conditions that occur over more than one work shift), use Form CA-2 instead of Form CA-1, and turn it in with the appropriate checklist from Form CA-35 and supporting medical evidence (if possible) to your supervisor within 24 hours from the date you realized the illness or disease was caused (or aggravated) by your job. ☐

- A "Receipt" is attached to each Form CA-1 and Form CA-2. Your supervisor must complete the receipt and return it to you with a copy of the completed form for your personal records. If it is not returned to you, ask your supervisor for it. ☐

- File a claim for workers' compensation on Form CA-7 or use leave if you are disabled beyond the COP period, or if you are not entitled to COP. If you are disabled due to an occupational illness or disease, you may claim workers' compensation on Form CA-7 or use leave. A claim for compensation for disability must be submitted as soon as possible after it is apparent that you are disabled and will enter a leave-without-pay status. Submit Form CA-7 together with medical evidence (Form CA-20 or a report from a health care provider) to the WCC. ☐

3. **Report the work-related death of any employee or the in-patient hospitalization of three or more employees to the nearest OSHA Area Office or by calling OSHA's toll free number: 1-800-321-6742.** This notification must be made within 8 hours of the incident by the SHEMP Manager or supervisor (or another designated person). ☐

4. **Complete the Exposure, Injury, and Dosimetry Tracking Form on a monthly or quarterly basis.** Have your supervisor review and sign the tracking form and submit a copy to the local SHEMP Manager (or another designated person) at least quarterly. See Section 3.3 for details and Appendix H for the tracking form. ☐

5. **Report motor vehicle accidents to your supervisor and the Vehicle Manager (or another designated person) as soon as possible.** ☐

   - The *OSHA & EPA 301 Injury, Illness and Near Miss Report* (Appendix G) must be completed (by the supervisor with input from the driver) if the driver is injured or the incident meets the definition of a "near miss" (Section 5.0). Copies of the completed report must be provided to the SHEMP Manager and the Vehicle Manager (or another designated person).

   - Motor vehicle accidents must be investigated by the driver's supervisor (or another designated person). The investigation report, SF-91, SF-94, a copy of the employee's authorization to travel (if on travel), a copy of the rental contract (if vehicle is a commercial rental), a copy of the police report (if available), and other applicable documents, receipts, or reports must be provided to the Vehicle Manager or AMC (or another designated person).

   - The rental company must be notified if the vehicle is a commercial rental (see the rental agreement for contact information). If the vehicle is from the GSA fleet, notify the AMC by calling 1-866-400-0411, Option 2 (6:00 a.m. to 7:00 p.m. CST) or 1-800-621-3588 after hours.

- Making or signing a statement as to responsibility for the accident must not be done (except to the employee's supervisor or the government investigator). Legal documents (notice, summons) and telephone calls requesting information about the accident must be forwarded to the employee's supervisor or Vehicle Manager (or another designated person).

See Section 4.0 for details.

6. **Report unsafe or unhealthful working conditions to your supervisor or the Onsite Safety Officer (or another designated person) as soon as possible.** Make your notification orally or through a written report. In an imminent danger situation, make your report by the most expeditious means available. See Section 6.0 for details. ☐

7. **Conduct workplace inspections when employee reports of hazardous working conditions are made.** Notify employees of the inspection results and any abatement plans. See Section 6.0 for details. ☐

8. **Investigate incidents involving work-related injuries, illnesses, near misses, and property damage to determine the root cause and develop corrective actions.** See Section 7.0 for details. ☐

APPENDIX D

Quick Reference Guide for EPA Emergency Responders: Physical Stressors

Background Information/Instructions

This appendix summarizes information that emergency responders need to know in the field about the physical stress management program.

The Quick Reference Guide must be incorporated into the organization's Field Guide and distributed to emergency responders, who will be instructed to bring the guide with them into the field (see Section 4.4 of the manual's Introduction for further instructions and the Manual's Web site).

Physical Stress Management
Quick Reference Guide For Emergency Responders in Organization Name

Fatigue (Section 5)

Why Should You Be Concerned?
Fatigue impairs judgment, effects vision, and slows down reflexes. It also enhances the likelihood of auto accidents, which are the number one cause of workplace fatalities.

What Can You Do to Avoid Fatigue?
- Tell your supervisor if you are starting to feel fatigued.
- Avoid large quantities of caffeine and sugary food.
- Get regular exercise.
- Be aware of the following guidelines that exist for establishing a reasonable work/rest schedule:
  - A 16-hour shift is the MAXIMUM that individuals must be allowed to work. Shorter work shifts (8 to 12 hours) must be established during long-term response activities.
  - Individuals must not drive more than11 hours (including time for rest/meal/fuel stops) during a 14-hour work shift. Upon approval of the local SHEMP Manager (or another designated person), the driving guideline may be exceeded provided the employee is driving with a partner (another eligible driver).

Heat Stress (Section 6)

Why Should You Be Concerned?
- Heat stroke can cause renal failure, brain damage, or death.
- Other heat-related illnesses can cause painful cramping or fainting (which can result in dangerous falls).

First Aid Procedures: See Appendix G.

What Can You Do to Avoid Injury?
- ***Increase preparedness***. Participate in a heat acclimatization program and maintain good physical conditioning.
- ***Wear light clothing (if possible)***. Wear light, loose-fitting, breathable clothing (e.g., cotton). Wearing PPE (semi-permeable or impermeable chemical-resistant suits and respirators) dramatically reduces the ability to dissipate excess body heat and increases the risk of heat strain.
- ***Drink plenty of water***. Drink water BEFORE you get thirsty. Drink frequently (beyond your thirst) when you are working in hot places.
- ***Avoid caffeine and alcohol***.
- ***Acknowledge risk factors***. Inform your supervisor of conditions (e.g., hypertension) or medications that decrease your tolerance to heat exposure.
- ***Eat smaller meals*** before work and avoid lots of sugar.
- ***Take frequent breaks in cool shaded areas with moving air***.
- ***Be observant***. Be aware of how your body is reacting and tell your supervisor you need a break if you are uncomfortable. Work in pairs and stay alert for symptoms of heat stress.
- ***Follow appropriate engineering/administrative controls***

Danger Signs for Heat Stress:
- ***Heat stroke***: Symptoms include: internal body temperatures equal to or exceeding 105.8°F (41°C); altered mental status (irritability, confusion, or inability to think coherently); convulsions, seizures; dry, pale skin with no sweating (although sweating does not rule out heat stroke) or hot, red skin that appears sunburned; rapid, weak pulse; and rapid shallow breathing. *Note: If an employee exhibits any of the danger signs of heat stress it is an immediate, life-threatening emergency requiring immediate emergency medical care and hospitalization.*
- ***Other heat illnesses***. Other illnesses (Appendix G) can be a precursor to heat stroke. Symptoms of heat exhaustion (headache, nausea, dizziness, vertigo, tiredness, weakness, thirst, giddiness, profuse perspiration, or pale or flushed, cool, moist, clammy skin), heat syncope (fainting), or heat cramps (painful muscle spasms) need to be treated quickly.

Cold Stress (Section 7)

Why Should You Be Concerned?
- Hypothermia can be fatal.
- Frostbite can result in amputation.

First Aid Procedures: see Appendix I.

What Can You Do to Avoid Injury?
- ***Wear warm clothes***. Wear several loose, warm layers. Wear a hat and insulated footwear. Keep a change of dry clothes available (Appendix K).
- ***Stay dry***. Moisture reduces clothing's insulating value.
- ***Avoid caffeine, alcohol, and smoking***.
- ***Drink plenty of liquids and eat nutritious food***. Drink water or warm, sweet, non-caffeinated, non-alcoholic drinks or soup. (*Note: Dehydration occurs insidiously in cold weather.) Consume warm, high calorie food, such as pasta, to maintain energy reserves.)*
- ***Get rest***. Avoid fatigue since energy is consumed to keep the body warm. Take frequent breaks in a warm setting.
- ***Be observant***. Be aware of how you are reacting to the cold and tell your supervisor you need a break if you are uncomfortable. Work in pairs and stay alert for signs of cold stress in yourself and coworkers.
- ***Acknowledge risk factors***. Older people are not able to generate heat as rapidly as younger people. Certain nervous system and vascular diseases make some people less tolerant to cold stress. Some medications (e.g., antidepressants, sedatives, or tranquilizers) impair thermoregulation.
- ***Follow appropriate engineering/administrative controls***.

Danger Signs for Cold Stress
- ***Hypothermia***: Symptoms include: uncontrollable shivering (might be diminished in older adults); stomping of feet to generate heat; numbness; glassy stare; a puffy or swollen face; apathy, loss of coordination; slurred speech; confusion; loss of logical thinking; loss of consciousness; and pale cold skin that might be marked with irregular blue or pink spots. As body temperature drops, these symptoms worsen and shivering will stop. Employees might be unable to walk or stand. Significant drops in blood pressure, pulse rate, and respiration are possible.
- ***Frostbite***: Affected body parts will get cold, tingling, stinging or aching, and then will turn numb. The skin will turn red, then purple, then white, and will be cold to the touch. Blisters may form in severe cases.

Noise and Hearing Conservation (Section 8)

Why Should You Be Concerned?
Excessive exposure to noise can cause temporary or permanent hearing loss. It can also cause tinnitus (ringing in ears) and more physiologic reactions, such as a rise in blood pressure or a faster heart rate.

What Can You Do to Avoid Injury?
- Participate in an audiometric testing program.
- Wear hearing protection (e.g., ear plugs or muffs or both). Generally, if you need to raise your voice to be heard, you should wear hearing protection. Sound level measurements or noise dosimetry must be performed to show that noise exposure levels are below the action levels.
- Implement engineering/administrative controls if noise levels exceed OSHA's permissible noise levels. Controls include: installing sound-dampening materials or mufflers, erecting acoustical enclosures and barriers, increasing the distance between employees and noise sources, rotating employees who are operating noisy machines, and keeping windows and doors closed when noisy equipment is nearby.

Vibration (Section 9)

Why Should You Be Concerned?

- Hand-arm vibration can cause circulatory, sensory, motor, and musculoskeletal disturbance.
- Whole-body vibration can create lower back pain.

What Can You Do to Avoid Injury?

- Identify tasks that might pose vibrational stress.
- Use equipment that has built-in vibration controls.
- Eliminate awkward, asymmetric postures when working with tools, sitting, or standing.
- Provide adequate lumbar support, adjustable seat pans, back and arm rests, and other ergonomic modifications to better support and reduce vibration.

Overexertion (Section 10)

Why Should You Be Concerned?

Heavy labor can cause overexertion injuries and result in serious and long-lasting adverse health effects.

What Can You Do to Avoid Injury?

- Identify tasks that might exceed your physical capacities.
- Implement engineering and administrative controls, such as work station redesign, tool redesign, job rotation, and work pacing.

Altitude (Section 11)

Why Should You Be Concerned?

- At high altitudes less oxygen is available for the body to use, the air is colder, and ultraviolet radiation is more intense.
- Working at high altitudes has significant effects on physical and psychological performance and causes altitude illness which may be fatal.

What Can You Do to Avoid Altitude Illness?

- Ascend gradually. Spend several days at 5,000 feet before ascending to 10,000 feet. If not possible, rest for 2 days after arrival at altitude.
- Sleep at a lower altitude than the workplace.
- Drink plenty of water before, during, and after work.
- Use reduced work rates and increased rest periods.
- Avoid salty foods, caffeine, alcohol, tobacco, and depressant drugs.
- Eat low fat, high carbohydrate meals.
- Inform your supervisor of conditions (asthma, heart/lung disorders) or medications that decrease your tolerance to high altitudes.
- Be aware of how your body is reacting and tell your supervisor if you are uncomfortable or do not feel well. Work in pairs and stay alert for symptoms of altitude illness (e.g., headache, loss of coordination, confusion, weakness, lack of appetite, nausea, vomiting, shortness of breath, chest tightness, dizziness, bluish skin color).

APPENDIX D

Quick Reference Guide for EPA Emergency Responders: Confined Space Safety Plan

Background Information/Instructions

This appendix provides tools to assist emergency responders working in confined spaces, including,

- A checklist of items that emergency responders must address before going into the field.
- A summary (provided as a flowchart) of the procedures that emergency responders must follow in the field to minimize or eliminate the hazards associated with confined spaces.

The Quick Reference Guide must be incorporated into the organization's Field Guide and distributed to emergency responders, who will be instructed to bring the guide with them into the field (see Section 4.4 of the manual's Introduction for further instructions and the manual's Web site).

Confined Space Safety Plan
Quick Reference Guide for Emergency Responders in Organization Name

Part I: What You Need to Do Before Going into the Field

1. Have you completed the basic confined space safety training course (Section 3.14.1)? Do you have a copy of your training certificate with you or within TrainTrax? ☐

2. If you are assigned duties as an onsite rescuer, have you completed all of the required training (basic confined space safety; rescue duties, procedures, and equipment; practice rescue drill within the last 12 months; and first aid/CPR) (Table 3; see also Appendix M)? Do you have copies of your training certificates with you or within TrainTrax? ☐

3. Have you reviewed your organization's confined space safety plan (i.e., customized version of the Confined Space Safety Program chapter) and familiarized yourself with: (a) confined space and PRCS definitions and examples; (b) OSHA requirements for PRCS operations; (c) safety practices and procedures for minimizing PRCS hazards; and (d) personnel roles and responsibilities? **The flow chart on the following page provides an overview of the minimum requirements for EPA employees. Employees must also review the information in Section 3.0 and Appendix A.)** ☐

4. Are site-specific PRCS procedures incorporated into the HASP (Appendix E)? ☐

5. Does your field bag and/or vehicle contain the required equipment and supplies for PRCS operations (e.g., respirators and other PPE, rescue equipment (if applicable), air monitoring equipment, calibration gases, ventilators and ductwork, PRCS signs, radios, etc.)? ☐

6. Do you know who to contact if you experience equipment/supplies shortages in the field (Section 3.7)? ☐

Part II: Things You Need to Do in the Field

1. Survey the site to identify and evaluate potential confined spaces and PRCSs (Section 3.2). ☐

2. Inform site workers (by posting danger signs, holding safety briefings, or by any other equally effective means) of the existence, location, and dangers posed by PRCSs (Section 3.2 and Appendix G). ☐

3. Determine if site personnel will enter non-permit confined spaces: ☐

   If **YES**, specify any conditions and precautions that must be in place for safe entry and changes in conditions that would require a re-evaluation of the space. Re-evaluate a non-permit space periodically and when there are changes in the use or configuration of the space that might increase the hazards to entrants. If necessary, reclassify the space as a PRCS (Section 3.2).

   If **NO**, re-evaluate the non-permit space periodically and when there are changes in the use or configuration of the space. If necessary, reclassify the space as a PRCS (Section 3.2).

4. Determine if site personnel will enter PRCSs: ☐

   If **YES**, written site-specific PRCS procedures that EPA has reviewed and determined to be acceptable (i.e., meet all requirements specified in Section 3.3 of the Confined Space Safety Program chapter) must be incorporated into the HASP prior to entry. Any deficiencies noted must be corrected and emergency/rescue procedures must be in place prior to entry.

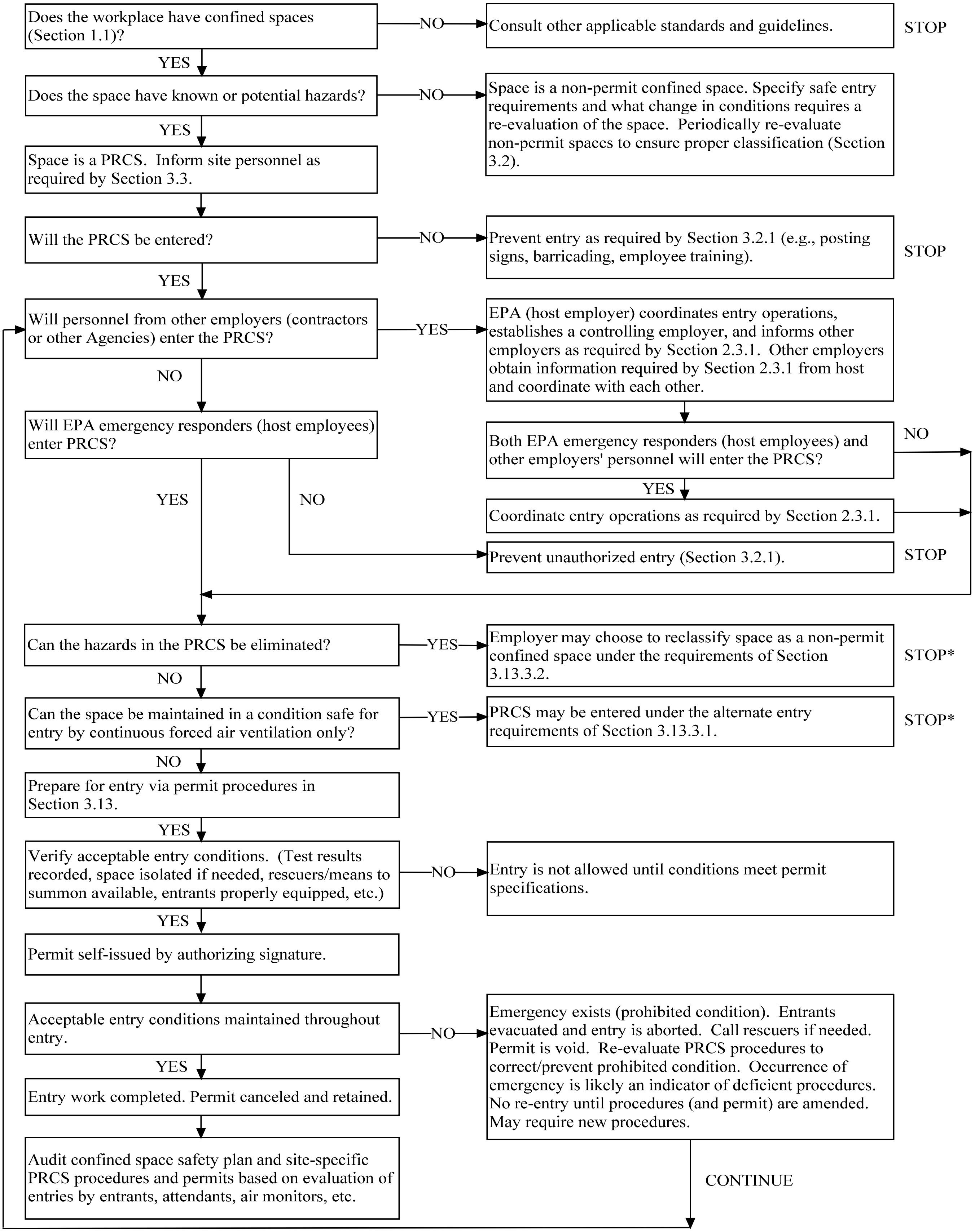
- If emergency responders will enter PRCSs: Adopt and follow the HASP PRCS procedures. These may be existing procedures (developed by an EPA contractor or facility owner) reviewed and deemed acceptable by EPA prior to entry and incorporated in the HASP. Any deficiencies noted must be corrected prior to entry. For large scale responses where no existing procedures are available, enlist the services of the ERT or OSHA through the ICS Liaison Officer to develop written PRCS procedures for the HASP (Section 3.3). Written site-specific PRCS procedures must make provisions for:
    - Preventing unauthorized entry.
    - Identifying, evaluating, and controlling or eliminating all hazards in the space.
    - Specifying and maintaining acceptable conditions throughout the entry.
    - Specifying all equipment needed to safely perform all tasks in the space (including air monitoring and ventilation equipment, PPE, proper lighting, etc.).
    - Providing an attendant outside the space for the duration of the entry.
    - Assuring communications, rescue, and emergency capabilities.
    - Designating and training employees who have active roles.
    - Implementing a permit entry system.
    - Coordinating multi-employer entry operations.
    - Reviewing entry permits and operations and revising as necessary.

- If contractors or other agencies will enter PRCSs: Comply with all host and controlling employer requirements specified in Section 2.3.1 of the Confined Space Safety Program chapter.

If **NO**, take effective measures to prevent PRCS entry (Section 3.2.1) (e.g., permanently closing the space, using physical barriers, bolting and locking the space, notifying employees, and posting danger signs).

5. Immediately evacuate and re-evaluate confined spaces if hazards arise during entry. ☐

Confined Space Decision Flow Chart



*Spaces must be evacuated and re-evaluated if hazards arise during entry.
Source: Adapted from 29 CFR 1910.146 Appendix A.

APPENDIX D

Quick Reference Guide for EPA Emergency Responders: Radiation Safety

Background Information/Instructions

This appendix summarizes information that emergency responders must know about the radiation safety program, including:

- A checklist of radiation safety related issues that emergency responders must address before going into the field, and

- Information that emergency responders need to know in the field.

The Quick Reference Guide must be customized with organization-specific information incorporated into the organization's Field Guide, and distributed to emergency responders, who will be instructed to bring the guide with them into the field (see Section 4.4 of the manual's Introduction for further instructions and the Manual's Web site).

Radiation Safety Program
Quick Reference Guide for Emergency Responders in Organization Name

Part I: What You Need to Do Before Going Into the Field

1. Have you attended (and passed) a basic radiation safety training course? ☐

2. Have you attended (and passed) an advanced radiation safety training course? ☐

3. Do you attend (and pass) radiation safety refresher courses at least once every 2 years? ☐

4. Have you received training on the proper use of radiation detection equipment? ☐

5. Do you have copies of your training certificates and are they available upon request? ☐

6. Have you enrolled in EPA's personal monitoring program? ☐

7. Have you been issued a thermoluminescent dosimeter (TLD) badge? ☐

8. Have you received training on how to use your TLD badge? ☐

9. Have you been issued a self-reading dosimetry (SRD) device? ☐

10. Have you received instructions on how to use SRDs and how to fill out Exposure Record Cards? ☐

11. *Addressing dosimetry data:*
    - Have you been informed of the Agency's Action Reference Level (ARL) and Administrative Control Level (ACL)? ☐
    - If dosimetry data indicate that you have exceeded the Agency's ARL (50 mrem per quarter) or ACL (500 mrem per year), have you talked to your Removal Manager and RSO or SHEMP Manager (or another designated person) about temporarily modifying your job activities? ☐

12. *Exceeding the Agency's ACL of 500 mrem:*
    - Have you received information on the scenarios (i.e., planned special exposures and emergency operations) for which it is acceptable to exceed the Agency's ACL? ☐
    - If you are trying to obtain permission to participate in a planned special exposure event, have you submitted a written request to your RSO or SHEMP Manager (or another designated person)? ☐
    - Have you been informed of the risks and potential health effects associated with exposure levels that exceed the Agency's ACL? ☐

13. If you are pregnant: ☐
    - Have you reviewed NRC Guide 8.13 "Instructions Concerning Prenatal Radiation Exposure?" ☐
    - Have you declared your pregnancy in writing? (This is optional.) ☐
    - Are you exchanging your TLD badge on a monthly basis? ☐
    - Have you talked with your Removal Manager and your RSO or SHEMP Manager (or another designated person) about whether your job functions should be temporarily modified? ☐

14. Have you talked to your RSO or SHEMP Manager (or another designated person) about whether it is necessary to develop an internal monitoring plan? ☐

15. If you plan to transport equipment that contains a radioactive source, have you asked your RSO or SHEMP Manager (or another designated person) to find out what kind of paperwork must accompany the equipment? ☐

Radiation Safety Program
Quick Reference Guide for Emergency Responders in Organization Name

Part II: Things You Need to Do in the Field

Radiation detection instrumentation:
- Perform an initial radiation survey of each field site to measure and evaluate exposure dose rates and/or levels of contamination.

TLD badges:
- TLD badges must be worn at sites where there is potential for exposure to ionizing radiation.
- TLDs are assigned to specific users. It is not acceptable to share your device with a fellow employee.
- TLDs must be worn outside personal protective clothing, between the neck and waist.
- TLD badges must be exchanged on at least a quarterly basis.
- If you have declared that you are pregnant, you must exchange your TLD badge on a monthly basis.
- When your shift is over, store your TLD in a low radiation area and in a location where the badge will not be exposed to elevated temperatures, light, or moisture.
- TLDs must never be deliberately exposed to radiation or exposed to non-occupational sources of radiation.
- Notify your RSO or SHEMP Manager (or another designated person) immediately if your TLD badge has been lost, damaged, or exposed to non-occupational sources of radiation.

SRD devices: SRD devices must be worn at sites where there is a potential for exposure to ionizing radiation. Notify your RSO or SHEMP Manager (or another designated person) immediately if:
- Your whole body $H_p(10)$ alarm sounds (e.g., if radiation is detected at a dose rate of 1 mrem/hour).
- You have reached a one-time shift dose limit of 50 mrem.
- You have reached a dose limit of 50 mrem over several shifts.

What to do in the event of exposure:
- If dosimetry data indicate that you have exceeded the Agency's ARL (50 mrem per quarter) or ACL (500 mrem per year), communicate with your Removal Manager and your RSO or SHEMP Manager (or another designated person) about modifying your duties and/or implementing special protective measures.
- Notify your direct supervisor immediately if you know (or suspect) that you have been exposed to radiation.

Situations where EPA allows employees to exceed the Agency's Administrative Dose Limits:
- *Planned special exposure*. You may ask for permission to temporarily exceed the Agency's ACL if doing so will allow you to complete a long-term site project. Requests must be submitted in writing. Official approval must be granted before any planned special exposure is allowed to occur.
- *Emergency operations*. EPA employees may perform a variety of emergency response activities that could result in exposure doses up to 5 rem. If efforts are needed to protect major property or human life, exposure levels higher than 5 rem may be allowed on a voluntary basis. Contact the senior EPA official on site (or another designated person) and the RSO or SHEMP Manager (or another designated person) in advance if you think you might receive a dose greater than the ACL.

Recordkeeping requirements:
- Submit *Exposure Record Cards* after each incident response, or at least quarterly to your RSO or SHEMP Manager (or another designated person).

Handling equipment that contains radioactive sources (e.g., gas chromatographs):
- When in the field, you are responsible for the storage and security of this equipment.
- Alert (Insert Name) immediately if this equipment is damaged, lost, or stolen.
- Before returning equipment back to the office, ask your RSO or SHEMP Manager (or another designated person) whether any paperwork needs to accompany the equipment.

APPENDIX D

Quick Reference Guide for EPA Emergency Responders: Bloodborne Pathogens

Background Information/Instructions

This appendix provides tools to assist emergency responders, including:

- A checklist of items that emergency responders must address before going into the field,
- Information on the procedures that must be followed if emergency responders know (or suspect) that they have been exposed to infectious materials, and
- A summary (provided as a flowchart) of the procedures that emergency responders must follow in the field to minimize or eliminate their risk of occupational exposure to bloodborne pathogens.

This appendix has some blank lines (highlighted in yellow) that must be customized with organization-specific information. This same organization-specific information must be incorporated into the organization's Field Guide and distributed to emergency responders, who will be instructed to bring the guide with them into the field (see Section 4.4 of the Introduction for further instructions and the Manual's Web site.

Bloodborne Pathogen Exposure Control Plan
Quick Reference Guide for Emergency Responders in Organization Name

Part I: What You Need to Do Before Going Into the Field

1. Have you attended a bloodborne pathogen exposure control training course within the year? ☐
2. If so, do you have proof that you are up-to-date on your training requirements? ☐
3. Have you reviewed your Bloodborne Pathogen Exposure Control Plan (i.e., customized version of this BBP chapter) and familiarized yourself with the onsite safety controls that you must follow? *(Note: The flowchart on the following page provides an overview of the minimum requirements that EPA employees must follow. While the flowchart serves as a useful field guide, employees must also review the detailed information that is presented in Section 3.2 and Appendix B of their Bloodborne Pathogen Exposure Control Plans.)* ☐
4. Is your field bag stocked with the PPE (as well as other equipment) that you might need to protect yourself from bloodborne pathogens in the field and do you know who to contact if you experience equipment shortages in the field? ☐
5. Are bloodborne pathogen exposure control procedures incorporated into the site-specific HASP? ☐
6. Have you received the hepatitis B vaccine? ☐
7. If not, have you signed a *Hepatitis B Vaccine Declination Statement?* ☐

Part II: What to Do If You Know (or Suspect) That You Have Contacted Blood or Other Potentially Infectious Materials

Step #1: Implement procedures to mitigate the risk of acquiring disease. For example:

- If your hands (or any other part of your body) contacted blood or other potentially infectious materials, **IMMEDIATELY** wash the exposed part of your body for at least 60 seconds with potable water and soap (germicidal soap is desirable). If a washing station is not available, use a waterless antiseptic cleanser until a thorough washing can be performed.
- If the mucous membranes of the mouth, eye, or nose contacted blood or other potentially infectious materials, flush these body parts with water **IMMEDIATELY**.

Step #2: Contact Name of your direct supervisor at (xxx) xxx-xxxx **IMMEDIATELY** (or at least within 24 hours) upon being exposed to blood or other infectious materials. If your supervisor cannot be reached, contact Name of backup contact at (xxx) xxx-xxxx.

Step #3: Working with your supervisor, fill out EPA Form 1340-1 *(OSHA & EPA 301—Injury, Illness & Near Miss Report)* and make sure that the following is documented on that form:

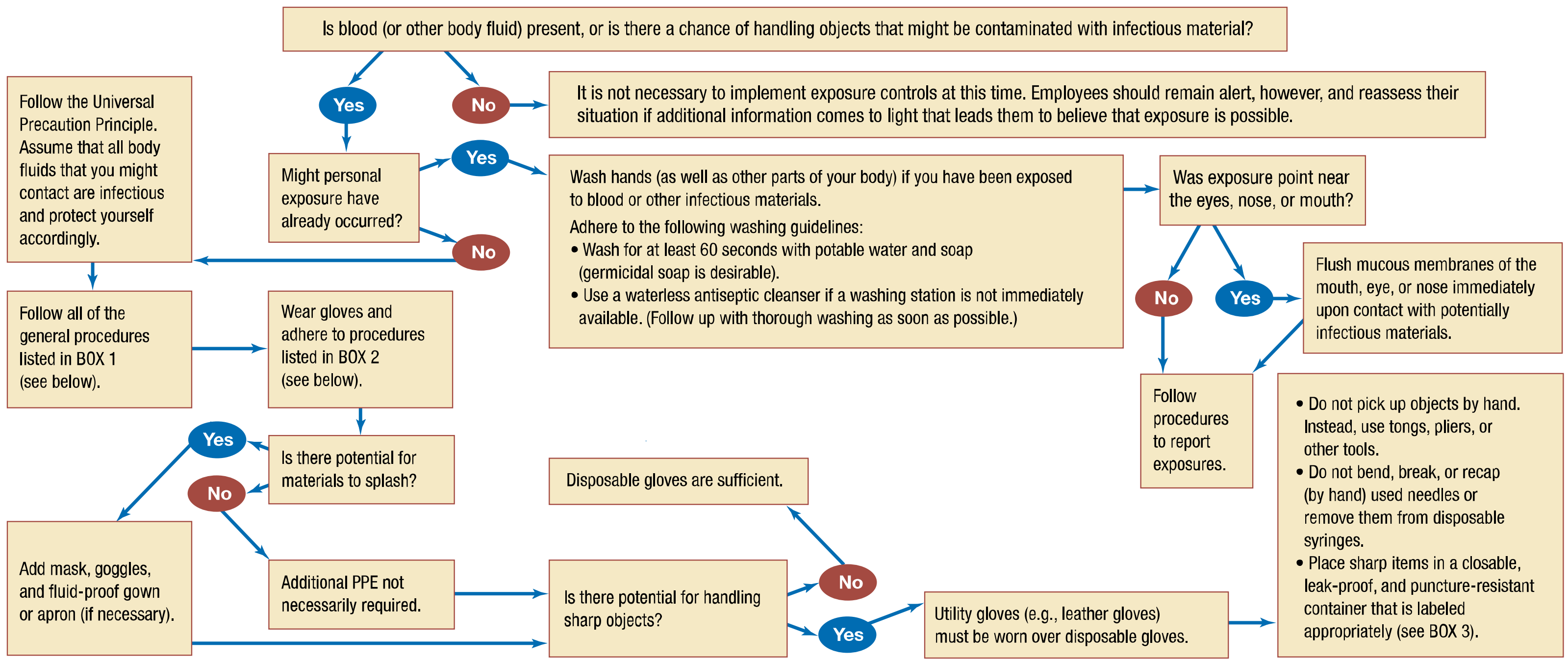
- The time, date, and location of the exposure.
- The routes of exposure.
- The HBV and HIV antibody status of the source individual (if known).
- The circumstances under which exposure occurred.

Step #4: Working with your supervisor, communicate with Name of SHEMP Manager (or other designated person) at (xxx) xxx-xxxx about obtaining post-exposure medical support (at no charge to yourself) **IMMEDIATELY OR AS SOON AS FEASIBLE** since prompt prophylactic measures can reduce the chance of developing disease.

Step #5: Contact your healthcare provider (or ask your SHEMP Manager [or another designated person] to do so) and ask for a copy of his/her written opinion and recommended course of action if you have not received such information within 15 days of your initial medical evaluation.

Step #6: Following your healthcare provider's advice, work with Name of SHEMP Manager (or other) or your Workers' Compensation Coordinator to set up follow-up evaluations and post-exposure counseling at no cost to yourself.

Part III: Procedures Designed to Minimize or Eliminate Occupational Exposures to Bloodborne Pathogens



BOX 1: General Procedures

- **Cover breaks in the skin** before going into the field. For example, bandage body areas marked by cuts, severe acne, rash, etc.
- **Avoid reaching into hidden areas.** If necessary, use long-handled mirrors and flashlights to search hidden areas.
- **Do not keep food or drink** in the vicinity of potentially infectious objects.
- **If clothing becomes contaminated,** place it in a labeled (see BOX 3) leak-proof bag, and don a new set of clothes. (Note: Keep an extra set of clothes available at ALL times.)

BOX 2: PPE

ALL PPE:
Wash hands upon removing gloves or any other PPE (follow the washing guidelines presented in flowchart).
GLOVES:

- Wear disposable gloves ONLY once and dispose of as regulated waste (see BOX 3). Decontaminate (see BOX 3) non-disposable gloves.
- Replace torn or soiled gloves immediately.
- Do not smoke, eat, drink, apply cosmetics (or lip balm), handle contact lenses, or touch eyes, nose, mouth, or broken skin while wearing gloves.
- Removal techniques: Peel off one glove from the wrist toward the finger tips. Then, using the exposed hand, peel the second glove off from inside, tucking the first glove inside the second. Never touch the outsides of the gloves with bare skin. Also, do not use teeth to remove (or put on) gloves.

BOX 3: Disposal, Labeling, Decon

- **Disposing of regulated waste.** Disposable item must be bagged (or in the case of contaminated sharps, placed in a container), labeled, and disposed of as regulated waste in accordance with Federal, State, and local regulations.
- **Labeling requirements.** Affix labels to bags and containers used to store, transport, or dispose of potentially infectious materials. Labels must display the biohazard symbol, be fluorescent orange or orange-red in color, and use letters or symbols in a contrasting color. (A biohazard label is not required, however, if red bags or containers are used.)
- **Decontaminating reusable equipment.** A solution of 1 part liquid household bleach to 10 parts water is sufficient to decontaminate equipment.

BOX 4: Other Procedures

- **Packaging objects/evidence.** Place objects in leak-proof plastic bags (as long as objects are not sharps). Air-dry objects if possible before sealing in bags. If objects can't be dried, double bag them. Label bags appropriately (see BOX 3). (Note: When packaging objects, use only tape. Heat-sealing clear plastic envelopes are also acceptable.)
- **Cleaning up bodily fluid spills.** Wear appropriate PPE. Remove visible material with a towel. Clean with approved germicide or a solution of 1 part liquid household bleach to 10 parts water. Pour cleaning solution into spill, let stand for 20 minutes, and mop it up. Clean the mop.

APPENDIX D

Quick Reference Guide for EPA Emergency Responders: Chemical and Biological Threat Agents

Background Information/Instructions

This appendix provides:

- A checklist of issues concerning emergency response to chemical and biological threat agents that employees must address before going into the field.
- Information that emergency responders need to know when they are in the field and immediately after they leave the site.

The Quick Reference Guide must be incorporated into the organization's Field Guide and distributed to emergency responders, who will be instructed to bring the guide into the field (see Section 4.4 of the manual's Introduction for further instructions and the Manual's Web site).

(Note: This checklist addresses the safety and health elements described in the Chemical and Biological Threat Agents chapter. ***It does not, by itself, provide comprehensive guidance on emergency response to incidents involving chemical or biological threat agents.*** *Before going into the field, emergency responders must receive information on the specific threat agent involved in the incident, including signs and symptoms of exposure, as well as the appropriate PPE and protective measures specific for the agent. Refer to the site-specific HASP for details.)*

Chemical and Biological Threat Agents
Quick Reference Guide for Emergency Responders in Organization Name

Part I: What You Need to Do Before Going Into the Field

1. Have you received awareness training on chemical and biological threat agents? ◘
2. Have you received the initial 40-hour OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) training and annual refresher training, as prescribed in 29 CFR 1910.120? ◘
3. Have you received training on the selection and use of personal protective equipment (PPE)? ◘
4. Do you have copies of your training certificates and are they available upon request? ◘
5. If the potential exists to be exposed to a biological agent, have you received all available prophylaxis measures (e.g., vaccine and/or antibiotics)? ◘
6. Are you familiar with the site-specific health and safety plan (HASP) for the response? ◘
7. If applicable, have you received instructions on how to operate the chemical or biological agent detection equipment to be used during the incident? ◘
8. Is your PPE appropriate for the nature and magnitude of the hazard, as specified in the HASP? ◘
9. Do you know the signs and symptoms of exposure to the chemical or biological agent involved in the response? (The following Web sites provide agent-specific information: CDC site, National Response Team site) ◘

Part II: Things You Must Do in the Field

1. Report to the appropriate checkpoint for onsite medical monitoring, if applicable. ◘
2. Assist in implementing and/or inspecting the exposure controls in place, including engineering controls, work practices, and administrative controls, if applicable. ◘
3. Periodically check your PPE to ensure that it is functioning properly, in accordance with field inspection protocols. ◘
4. If you know (or suspect) you have been exposed to a chemical or biological threat agent, notify your direct supervisor immediately. ◘

   If you know (or suspect) you have been exposed to a biological agent, consult with the Medical Monitor concerning the need for additional prophylaxis or immediate treatment. ◘
5. When performing decontamination, make sure to use potable or clean water, in accordance with standard decontamination procedures. ◘
6. Make sure that all decontamination fluids and other materials are captured for appropriate treatment and disposal. ◘

Part III: What You Need to Do After the Incident Response

1. If you develop any signs or symptoms that may be related to your field activities, seek immediate medical attention. ◘
2. Report any chronic or latent health problems to your supervisor and complete appropriate forms. ◘
3. In the case of a biological threat agent, continue to take any antibiotics or other prophylaxis medicine that has been prescribed to you. Take the full antibiotic course prescribed by the health professional. ◘
4. Attend any follow-up medical evaluations scheduled. ◘

HAZARD RECOGNITION

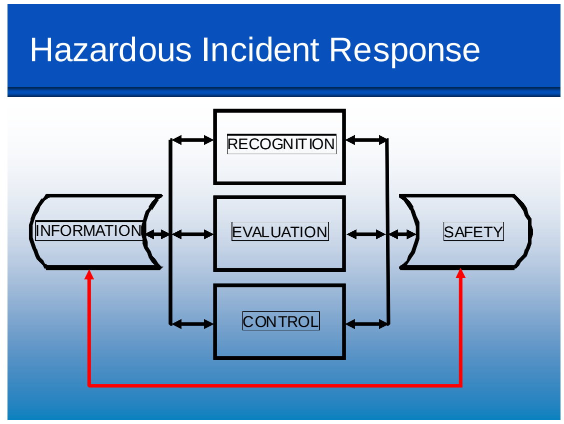
Student Performance Objectives

1. Describe the components of the Incident Response Model.
2. Identify and describe the chemical and physical hazards that may be present or occur at a hazardous waste site.
3. Identify the applicable governing regulation.
4. State the elements of a spill control plan.

THIS PAGE INTENTIONALLY BLANK

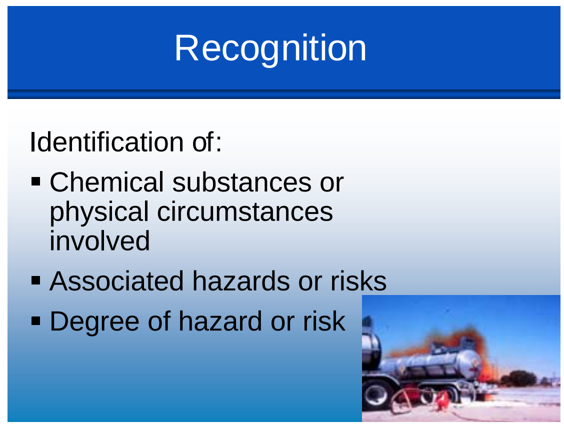
INCIDENT RESPONSE MODEL

There are many different types of chemical and physical hazards at a hazardous waste site. Safeguards and controls need to be established to prevent them from causing harm. The *Incident Response Model* is a systematic approach to handling hazardous situations. This model has five major components. Components are interrelated, but do not necessarily occur in sequential order.



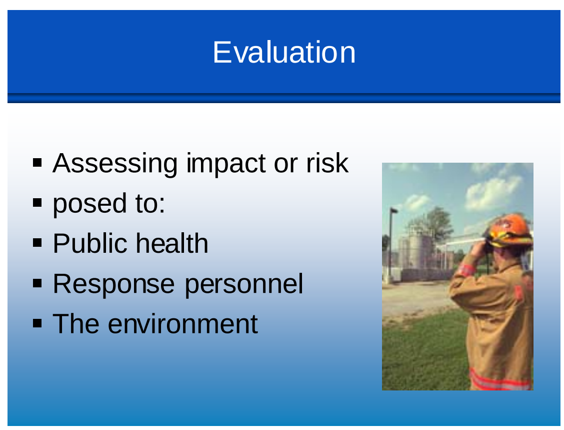
RECOGNITION

Questions to ask are: What is the hazard? What is the risk or impact of the incident? What measures can be taken to eliminate the hazards and reduce the risks? Thousands of substances exhibit one or more characteristics of flammability, radioactivity, corrosiveness, toxicity, or other properties which classify them as hazardous.

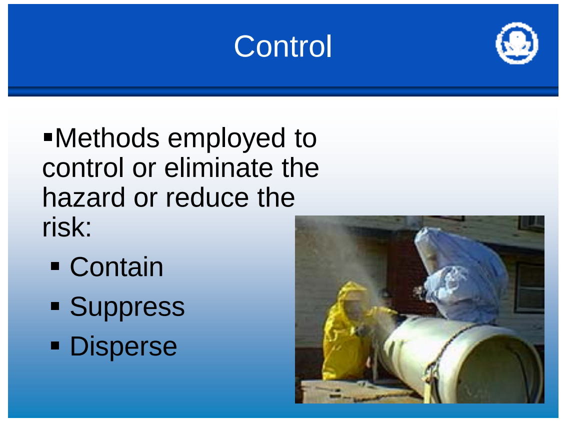


EVALUATION

In gathering information to answer these questions, (1) refer to current or historical investigations, (2) contact suppliers and customers of the facility or site, (3) conduct interviews of employees and site management, (4) collect data from air monitoring, and (5) perform site sampling. To evaluate completely the effects of a hazardous materials incident, all substances must be identified, their dispersion pathways established, and for toxic chemicals, concentrations determined. A constant flow of information is required to characterize the incident and to make decisions.



CONTROL



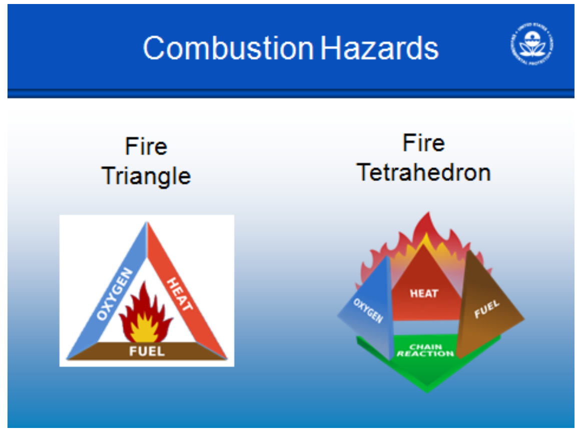
Each response organization must have an effective health and safety program including medical surveillance and health monitoring, appropriate safety equipment, standardized safety procedures, and an active training program.

In addition to workers, public health and the environment must be safeguarded. Each of these three parties has different exposure hazards, exposure limits, and risks. Hazards can be eliminated or controlled – risks can only be reduced. Careful assessment needs to be performed to ensure all hazards are identified.

Control measures include physical, chemical, and biological treatment and cleanup techniques for restoring the area to prerelease conditions. It also includes public health countermeasures, for example, evacuation or the shutdown of a drinking water supply to prevent contact by people with the substance.

REACTIVE CHEMICALS

Many strongly reactive chemicals can pose hazards to human health, such as chemical substances that detonate from shock, heat, or friction. Explosions are rapid reactions that release thermal energy, shockwaves, and heat. A material may elicit more than one chemical hazard. For example, toxic vapors can be released during chemical fires. The hazard may be a result of the physical/chemical properties of the material or of its chemical reactivity with other materials or the environment to which it is exposed.

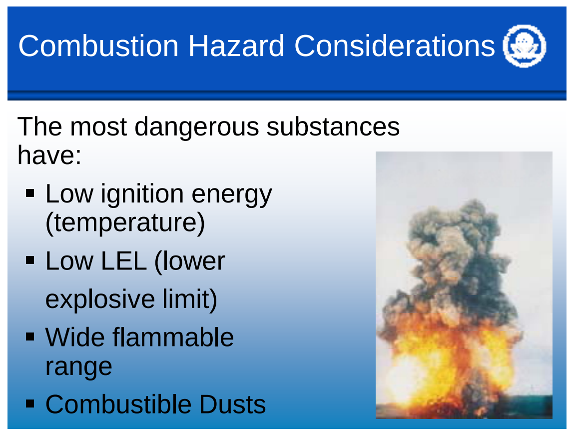


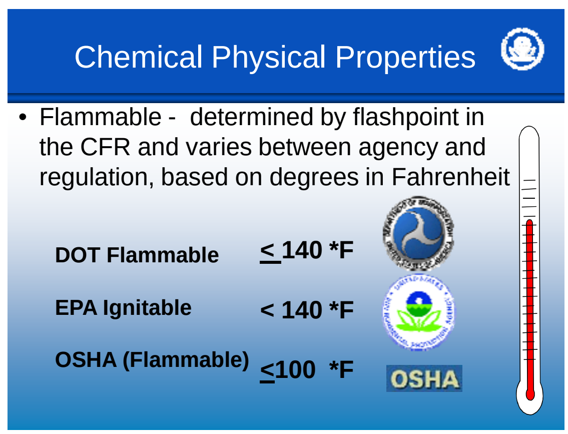
FIRE AND EXPLOSIVE HAZARDS

Materials that can be readily ignited and sustain a fire are considered flammable or combustible. Three components are required: fuel, oxygen, and heat. The concentrations of fuel and oxygen must be high enough to allow ignition and to maintain the burning process.

Combustion is a chemical reaction that requires heat to proceed. Most fires can be extinguished by removing one of the three components.

While oxygen is the usual oxidizing agent during the combustion process, there are chemicals that can burn without oxygen being present. For example, calcium and aluminum will burn in nitrogen. Therefore, the model has changed to a tetrahedron, which includes the uninhibited chemical reaction as a fourth element.





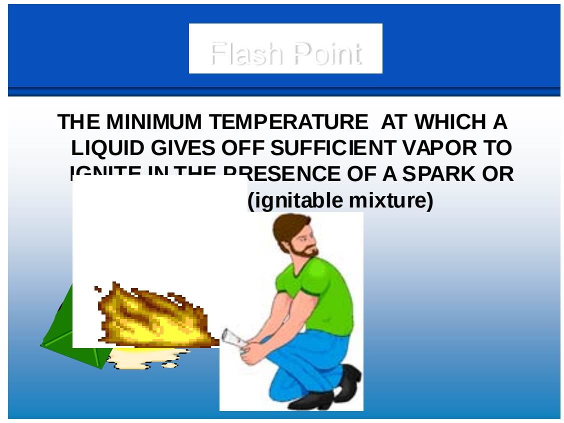
Temperature is the quantity of the disordered energy. With the development of the tetrahedron model and the inclusion of the uninhibited chain reaction, the extinguishing capabilities of the halons and certain dry chemicals were possible.

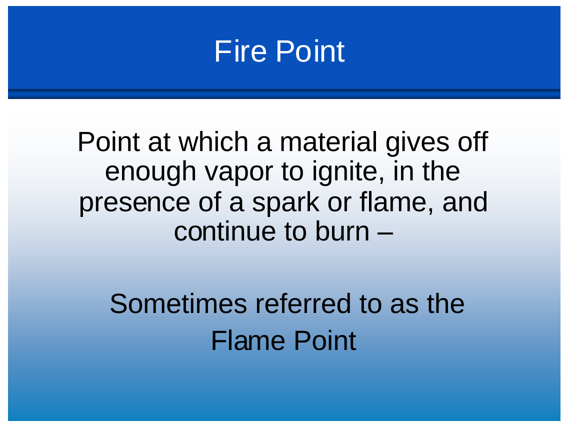
A material (liquid or gas) is flammable when it generates enough concentration of combustible vapors at or below 100°F (OSHA) to be ignited and produce a flame. It is necessary to have a proper fuel-to-air ratio (expressed as the percentage of fuel in air) to allow combustion. There is a range of fuel concentrations in air for each material that is optimal for the ignition and the sustenance of combustion. This is the Explosive (Flammable) Range. The lowest concentration of fuel in this range is the Lower Explosive Limit (LEL). Concentrations less than the LEL are not flammable because there is too little fuel – that is, the mixture is too "lean." The highest ratio that is flammable is the Upper Explosive Limit (UEL).

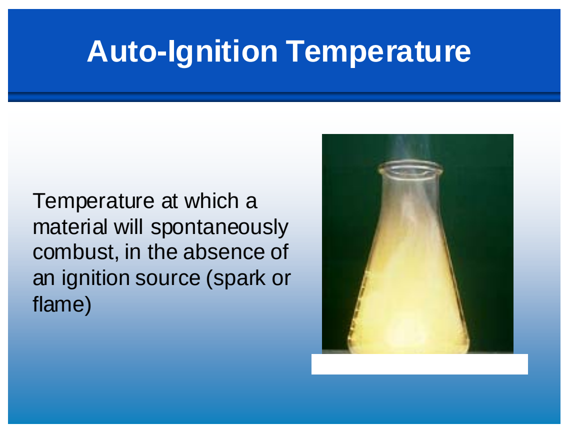
Concentrations greater than the UEL are not flammable because there is too much fuel displacing the oxygen (resulting in too little oxygen). This mixture is too "rich."

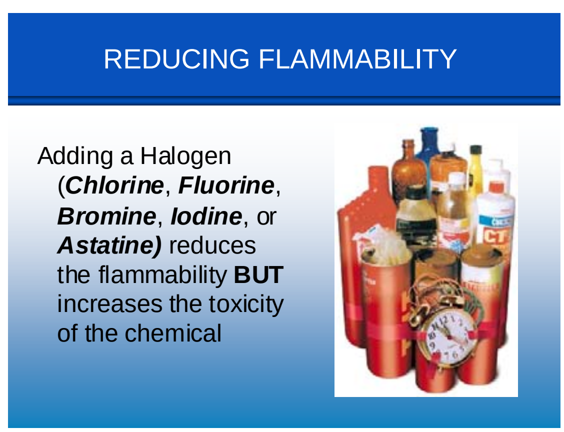
Fuel concentrations between the LEL and UEL are optimal for starting and sustaining fire. Example: the LEL for benzene is 1.2% (12,000 ppm), the UEL is 7.8% (78,000 ppm), and thus the flammable range is 1.2% to 7.8%.

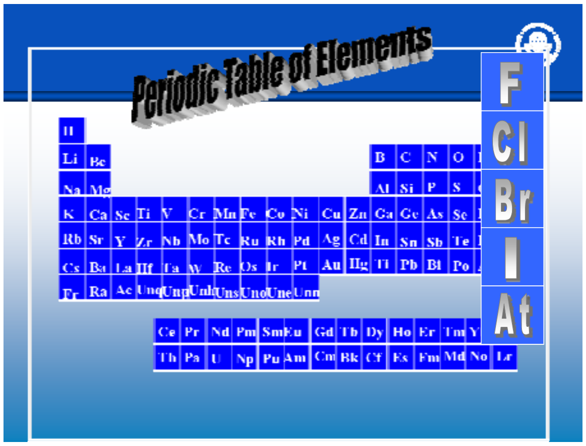
It is important to note that the U.S. Department of Transportation (DOT), the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), and the National Fire Protection Association (NFPA) have established strict definitions for flammability based on the flash point of a material. When flammable and explosives hazards are present the use of a remote opener may be necessary for use to minimize human risk.

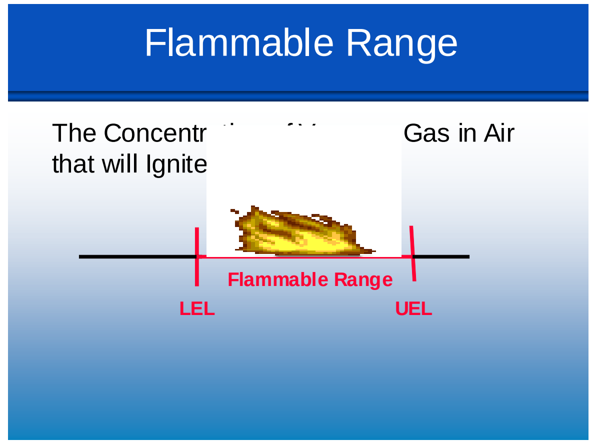


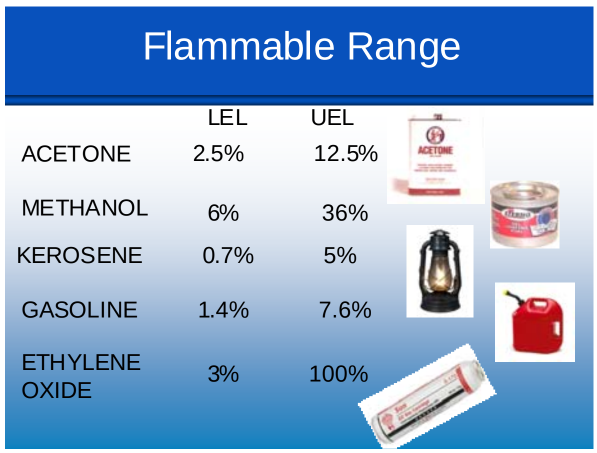




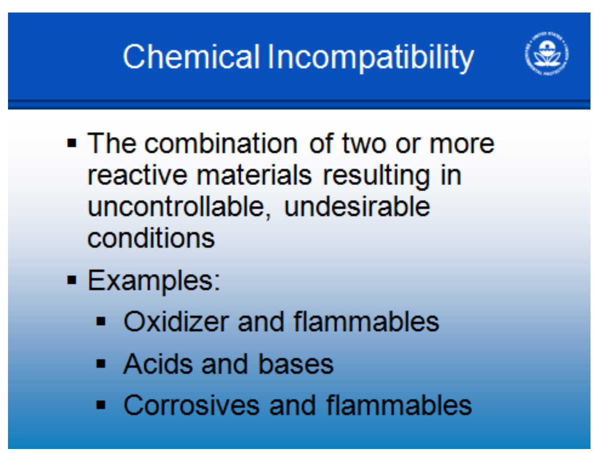






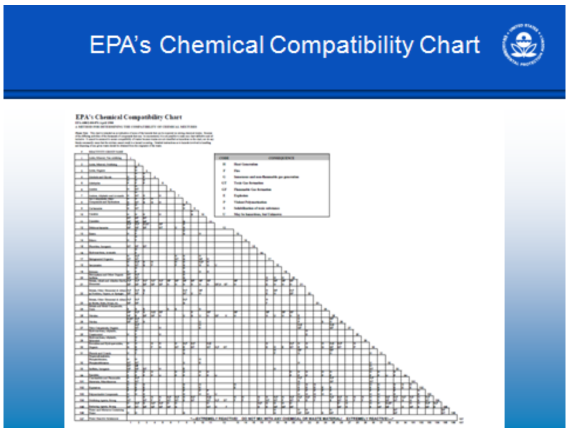


INCOMPATIBILITY REACTIONS



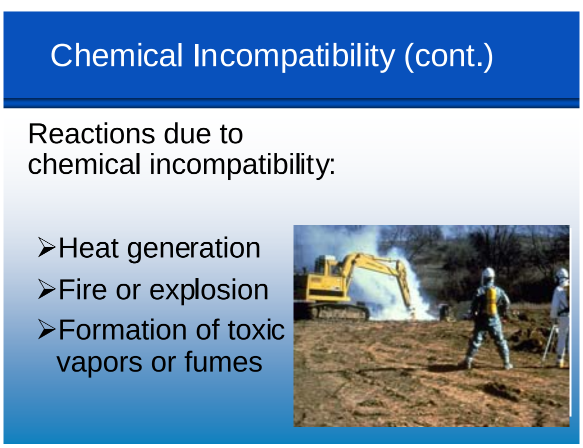
A reactive material is one that undergoes a chemical reaction under certain specified conditions. Generally, the term “reactive hazard” is used to refer to a substance that undergoes a violent or abnormal reaction in the presence of either water or normal ambient atmospheric conditions. Chemical incompatibility or the interaction of two or more reactive materials results in uncontrollable and undesirable reactions. A chemical reaction can result in chemical changes due to incompatibility.

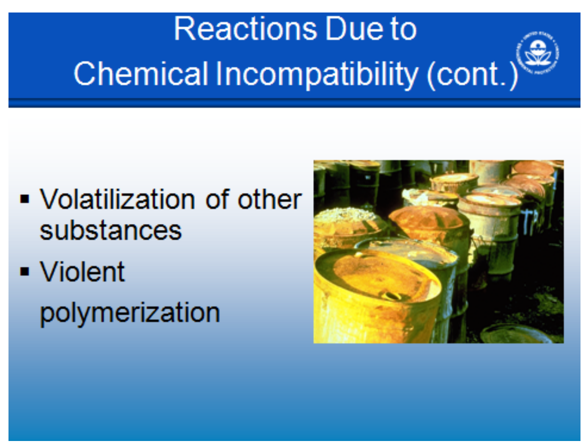
A gas or vapor explosion may occur resulting in a very rapid, violent release of energy. If combustion is extremely rapid, large amounts of kinetic energy, heat, and gaseous products are released. The major factor contributing to the explosion is the confinement of a flammable material. The EPA Chemical Compatibility Chart was developed in 1980 to help the regulated community for Hazardous Waste Management to determine HW compatability.



INCOMPATIBILITY/OXIDIZERS

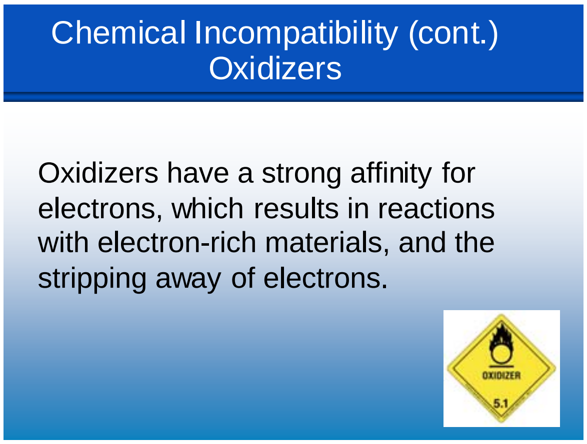
Toxic fumes or vapors can result from sulfuric acid on plastic. Volatilization of other toxic or flammable substances may result from chemical reactions. Also, violent polymerization may result. This is where many small molecules join to make macromolecules which produce both heat and a change in volume (e.g., acrylonitrile when exposed to heat). This reaction is common in plastics manufacturing.

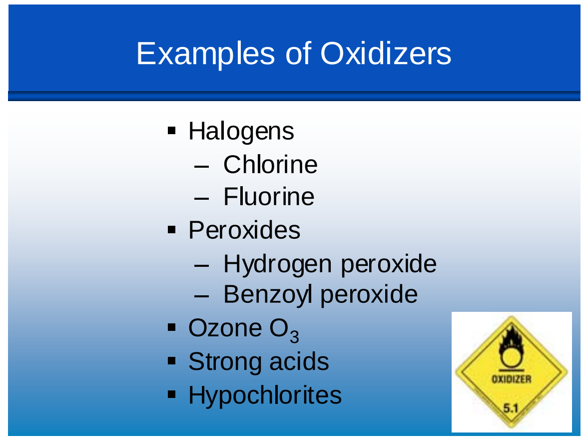




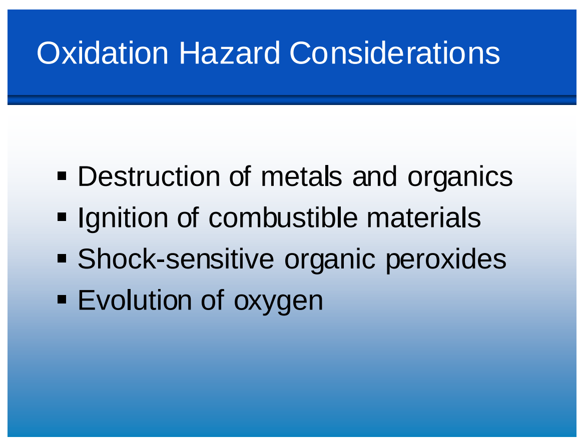
EXAMPLES OF OXIDIZERS

Oxidizing reactions are usually violent exothermic (heat releasing) chemical reactions and can be the most dangerous. A separate source of heat is required to maintain endothermic chemical reactions. Removing the heat source stops the reaction.





HAZARD CONSIDERATIONS



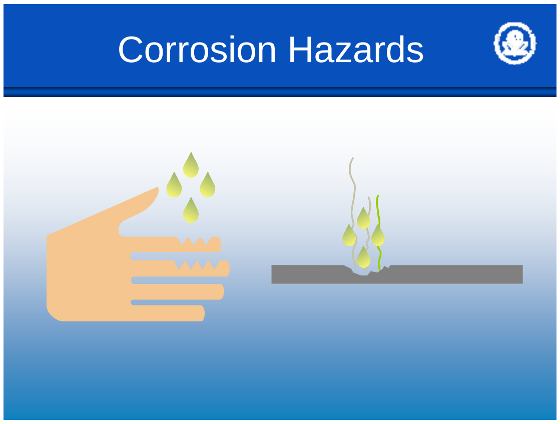
Simple tests must be performed to determine the nature of the material or mixture. Tests such as pH, oxidation-reduction potential, and flashpoint are useful. Very small amounts of the reactants may be carefully combined to determine compatibility. Final decisions about compatibilities should only be made by an experienced chemist.

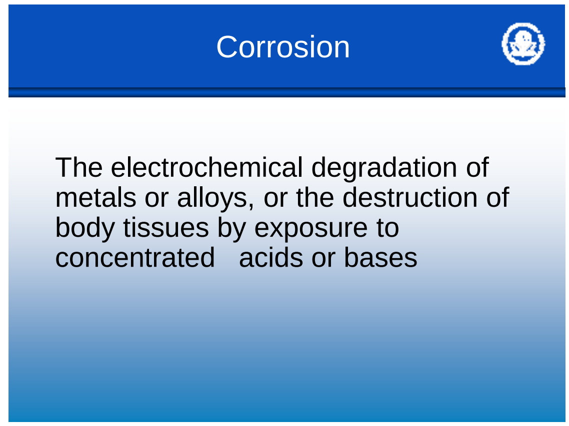
Compatibility information is very important in the ultimate handling and treatment of the materials. If materials are compatible, they may be stored together in bulk tanks or transferred to tank trucks for ultimate disposal.

Chemical incompatibility, however, does not necessarily indicate a hazard. For example, acids and bases (both corrosive) react to form salts and water, which may not be corrosive. Response personnel who must determine compatibilities should refer to “A Method for Determining the Compatibility of Hazardous Wastes” (EPA 600/2-80-076), USEPA, ORD, 1976.

CORROSION HAZARDS

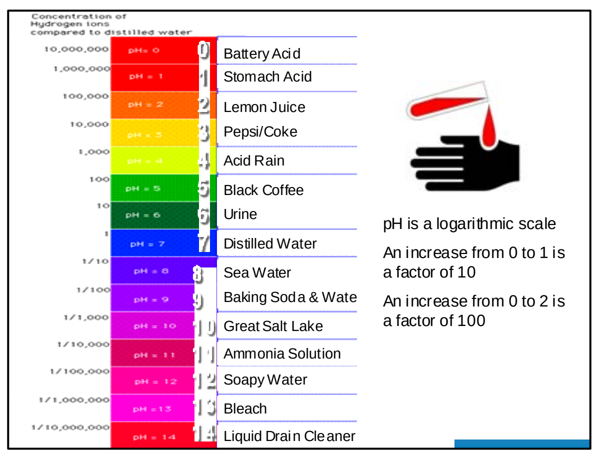
The corrosiveness of acids and bases can be compared based on their ability to dissociate (form ions) in solution. Those that form the greatest number of hydrogen ions (H^+) are the strongest acids, while those that form the most hydroxide ions (OH^-) are the strongest bases.

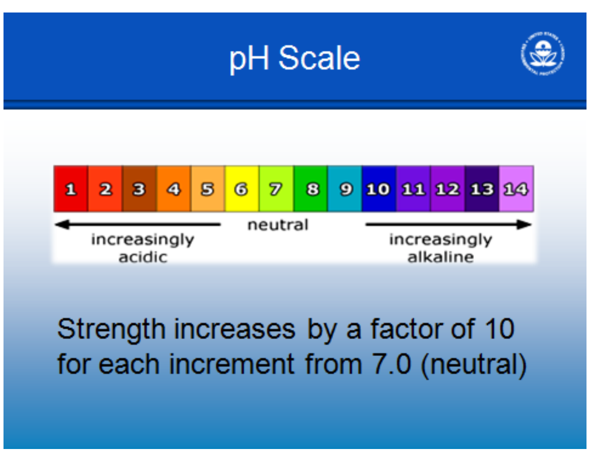




THE pH SCALE

The pH (powers of Hydrogen) scale is used to measure the concentration of an acid or base. The H^+ ion concentration in solution is called pH. The pH reading represents the relative number of hydrogen ions (H^+) or hydroxide ions (OH^-) in solution. Strong acids have a low pH (many H^+ in solution) while strong bases have a high pH (few H^+ in solution; many OH^- in solution). The pH scale ranges from 0 to 14.





The concentration of ions increases by a factor of ten with each whole number change in pH. Measurements of pH are valuable because they can be quickly done onsite, providing immediate information on the corrosive hazard.

CORROSIVE EXAMPLES AND CONSIDERATIONS

When dealing with corrosive materials in the field, it is imperative to determine:

- How toxic is the corrosive material? Is it an irritant or does it cause severe burns?
- What kind of structural damage does it do, and what other hazards occur? For example, will it destroy containers holding other hazardous materials, releasing them into the environment?

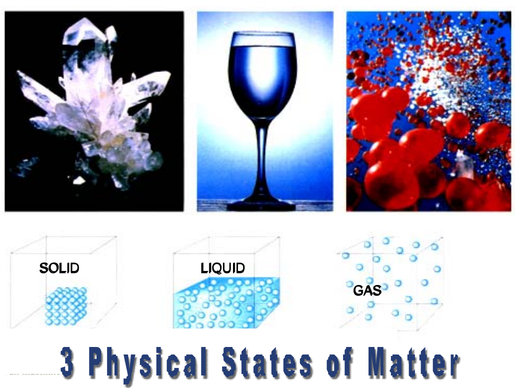
Examples of Corrosives

<u>Acids</u>
- Sulfuric acid
- Hydrochloric acid
- Nitric acid

<u>Bases</u>
- Sodium hydroxide
- Potassium hydroxide
- Ammonia, aqueous

Corrosive Hazard Considerations

- Damage to tissue or containers from direct contact
- Highly toxic and flammable gases are often reaction products
- Can cause fires or explosions when mixing with flammables



Vapor Density

- **Mathematical ratio based on Air = 1**
- ***Vapor Density > 1*** = Heavier Than Air, (will sink to the floor and accumulate in low areas and concentrate)
- ***Vapor Density < 1*** = Lighter Than Air, (will rise in air and dissipate)

Ex: Chlorine has a vapor density of 2.5. Where can it be found if leaking?

The 11 Gases/Vapors That Rise in Air

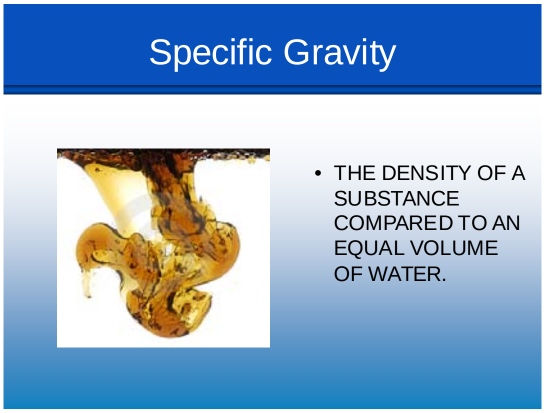
– Diborane
– Acetylene
– Methane
– Nitrogen
– Neon
– Hydrogen
– Helium
– Hydrogen Cyanide
– Carbon Monoxide
– Ammonia
– Ethylene

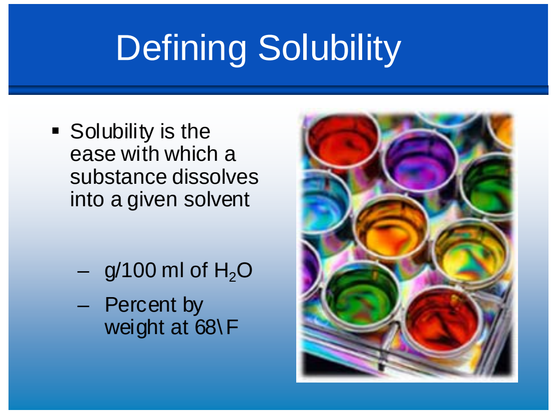
Molecular Weight

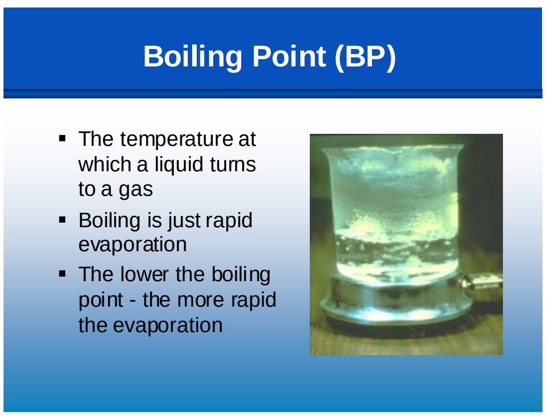
The sum of atomic weights of all the atoms in a molecule. (AKA Formula Weight)

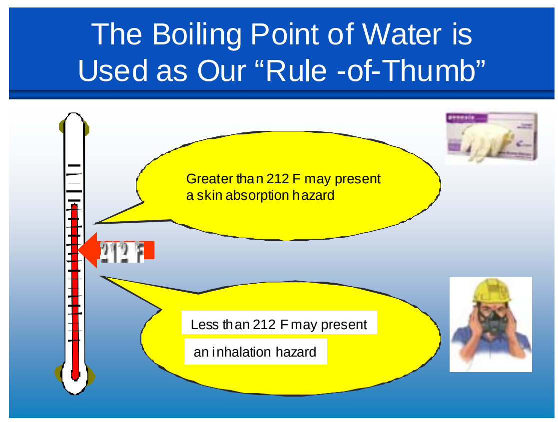
Carbon Dioxide MW = 44

The molecular weight (MW) of air is 28.9









PROPERTIES OF CHEMICAL HAZARDS

Chemical compounds possess inherent properties which determine the type and degree of the hazard they represent. Evaluating risks of an incident depends on understanding these properties and their relationship to the environment.

The density of a substance is its mass per unit volume, commonly expressed in grams per cubic centimeter (g/cc). The density of water is 1 g/cc because 1 cc has a mass of 1 g.

Numerically, specific gravity (SpG) is equal to the density in g/cc, but is expressed as a pure number without units. If the SpG of a substance is <1 (the SpG of water), it will float on water. The substance will sink in water if its SpG is >1. This is important when considering mitigation and treatment methods.

The density of a gas or vapor can be compared to the density of the ambient atmosphere. If the density of a vapor or gas is greater than that of the ambient air, then it will tend to settle to the lowest point. If vapor density is close to air density or lower, the vapor will tend to disperse in the atmosphere. Vapor density is given in relative terms similar to specific gravity.

In settling, dense vapor creates two hazards. First, if the vapor displaces enough air to reduce the atmospheric concentration of oxygen below 19%, hypoxia may result, and at 16% and less asphyxia may result. Second, if the vapor is toxic, then inhalation problems predominate even if the atmosphere is not oxygen deficient. If a substance is explosive and very dense, the explosive hazard may be close to the ground rather than at the breathing zone (normal sampling heights).

VAPOR PRESSURE

Vapor pressure is the pressure exerted by a vapor against the sides of a closed container. It is temperature dependent. As temperature increases, so does the vapor pressure. Thus, more liquid evaporates or vaporizes. The lower the boiling point of the liquid, the greater the vapor pressure it will exert at a given temperature.

Vapor Pressure (VP)

- The pressure exerted by a chemical against the sides of a closed container
- VP can also be used to identify evaporation rates
- VP is measured in mm/Hg

The ability of a gas, vapor, solid, or liquid to dissolve in a solvent is independent of its density or specific gravity. An insoluble substance can be physically mixed or blended in a solvent for a short time but is unchanged when it finally separates. The solubility of a material is important when determining its reactivity, dispersion, mitigation, and treatment.

Vapor Pressure

- **High Vapor Pressure (>10 mm/Hg) = Inhalation Hazard**
- **Low Vapor Pressure (<10 mm/Hg) = Skin Absorption Hazard**
- **mm/Hg = TORR**

Vapor Pressure

- High Vapor Pressure >10 mm/Hg = Inhalation Hazard

- Low Vapor Pressure <10 mm/Hg = Skin Absorption Hazard

Chlorine gas

- Chlorine has a vapor pressure > 1 ATM
- 1 ATM = 760 mm/Hg
- The actual vapor pressure of chlorine is 5,000 mm/Hg
- Pure chlorine exists as a gas

Vapor Pressures

- Water = 25 mm Hg
  Evaporates in days - week
- Gasoline = 300 mm Hg
  Evaporates in minutes - hours
- Ethyl Ether = 440 mm Hg
  Evaporates in seconds
- Chlorine = 5168 mm Hg
  Evaporates in seconds

Vapor Pressure

- Bulging can be caused by freezing/thawing or release of gas
- Requires special training and equipment

Vapor Pressure

- Boiling Liquid Expanding Vapor Explosion (BLEVE)
  - Example: flammable gas exposed to fire

B. P. - V. P. RELATIONSHIP

212˚F

SKIN

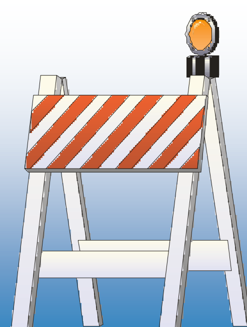
INHALATION

10 mm/Hg

Is it Time for a Break Yet?

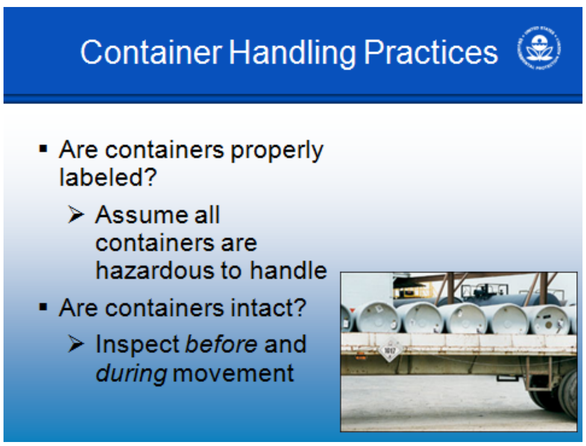
Next Section: Physical Hazards

Physical Hazards

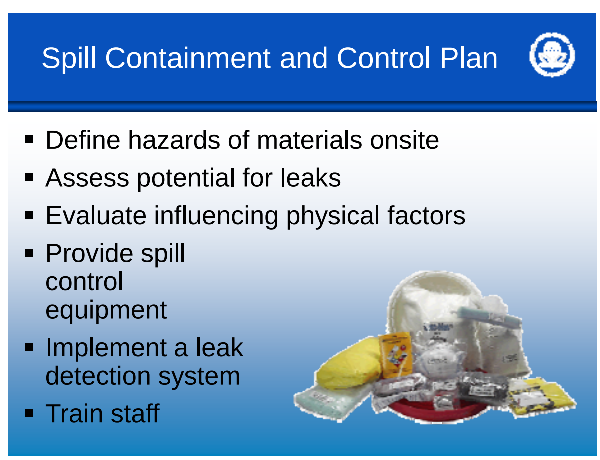


PHYSICAL HAZARDS ASSOCIATED WITH DRUM HANDLING

When dealing with "lab packs," assume there are explosives or shock-sensitive materials. Be aware of the dangers of moving containers. Leaking, open, and/or deteriorated drums should either have the contents transferred to a sound container or the drum overpacked. The establishment of secondary containment is required by 29 CFR 1910.120 (j). This is established as a part of a Spill Prevention and Containment Plan.



For other physical hazards, care must be taken so that actions to protect or reduce accident potentials for one person do not set up conditions ("booby traps") for subsequent accidents by others.



Spill Prevention Goals

- Prevent operational errors
  - Minimized through training and awareness
- Prevent equipment failures
  - Minimized by selecting proper equipment and performing proper maintenance

Other Hazards

- Kinetic
- Electrical
- Acoustical
- Biological
- Radiological
- Heat/cold-related illness

ELECTRICAL HAZARDS

Electrical hazards may occur from downed power lines or improper use of electrical equipment. The presence of underground electric lines must be checked before any digging or excavating. Ensure that machinery does not come into contact with any energized lines. There should be a clearance of 10 feet between a crane and electric power lines unless the lines have been de-energized or an insulating barrier has been erected. Shock is the primary hazard from electrical tools. Although electrical shock may cause death, it can cause burns or falls that lead to injury.

In 2007 OSHA updates the electrical standard to require a Ground Fault Circuit Interrupter (GFCI) at the source of the power because 15 amp fuses and circuit breakers will not protect personnel from shock.

What is wrong here?

Electrical hazard?

NOISE

Excessive acoustic energy or noise can (1) tire out the inner ear, causing hearing loss; (2) put stress on other parts of the body, such as the heart, due to quickening pulse rate, increasing blood pressure, and narrowing blood vessels; and (3) cause abnormal secretion of hormones which tense muscles. Workers exposed to noise sometimes complain of nervousness, sleeplessness, and fatigue which can reduce job performance and may cause high rates of absenteeism. There is no cure for most effects of noise; therefore, prevention is the only way to avoid health damage. The damage depends mainly on the intensity and length of exposure. The frequency or pitch can also have some effect – high-pitched sounds being more damaging than low-pitched ones.

OSHA regulation 29 CFR 1910.95 limits a worker's *noise exposure* to 90 decibels; A-weighted (dBA) for an 8-hour exposure. Time limits are shorter for higher noise levels. Instruments generally are designed to use an A-weighted scale so that the instrument responds to the different sound frequencies in the same way as the human ear. When daily noise exposure is composed of two or more periods of different noise levels, their combined effect should be considered, rather than the individual effect of each.

BITES/STINGS

Animal bites/stings, contact with plants and microbes, and exposure to medical/infectious wastes are examples of biological hazards that response personnel may encounter. Animal bites or stings are usually nuisances (localized swelling, itching, and minor pain) that can be handled by first-aid treatments. The bites of certain snakes, lizards, spiders, and scorpions contain sufficient poison to warrant medical attention.

The biggest hazard and most common cause of fatalities from animal bites – particularly bees, wasps, and spiders – is a sensitivity reaction. *Anaphylactic shock* due to stings can lead to severe reactions to the circulatory, respiratory, and central nervous systems, and it can result in death. There are diseases that can be transmitted by animal bites. Examples are Rocky Mountain spotted fever (tick), rabies (mainly dogs, skunks, and foxes), malaria, and equine encephalitis (mosquitoes). Another source of infection for response workers is poor sanitation. Waterborne and food borne diseases can be a problem if adequate precautions are not taken, both at the source of water as well as during the transport of water and food to the site. Also, avoid sanitation problems with properly designed lavatory facilities.

Microbial hazards can occur when the materials the workers are handling have biological as well as chemical contamination. This can be a problem if a chemical spill is into or mixed with sewage. Most bacteria that affect humans prefer a neutral environment (pH 7). Thus, an extremely acid or alkaline environment would destroy or inhibit bacterial growth. However, during neutralization, the environment could become more conducive to bacteria growth. In these situations, the normal decontamination procedures will usually alleviate the problem.

Medical/infectious wastes are regulated by OSHA 29 CFR 1910.1030, which addresses proper engineering controls, work practices, and PPE to reduce the risk of contact with blood-borne pathogens.

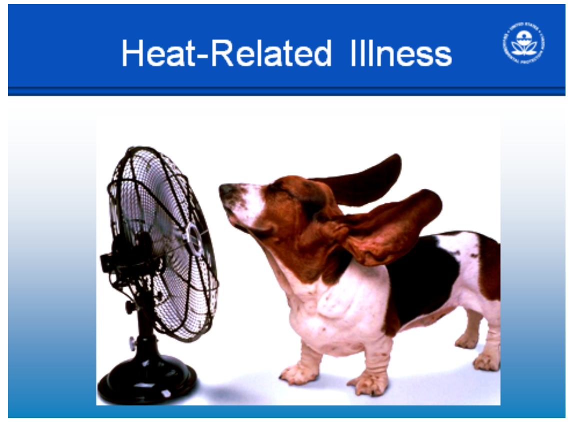
RADIOACTIVE MATERIALS

Radioactive materials that may be encountered at a site can emit harmful radiation. Due to the nature of this hazard, it is required by 29 CFR 1910.120, that monitoring *must* be performed upon initial entry. Unlike many hazardous substances that possess certain properties which can alert response personnel to overexposures (odor, irritation, or taste); radiation has no such warning properties. Therefore, preventing radioactive material from entering the body or protecting against external radiation is the best protection. As with biological and chemical hazards, the use of respiratory and personnel protective equipment, coupled with scrupulous personal hygiene, will afford good protection against radioactive particulates.

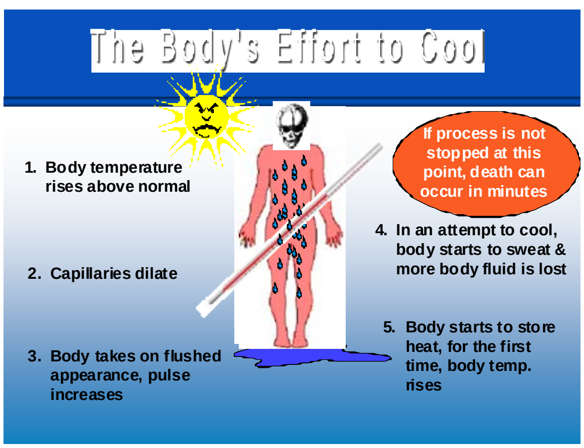
HEAT-RELATED ILLNESS

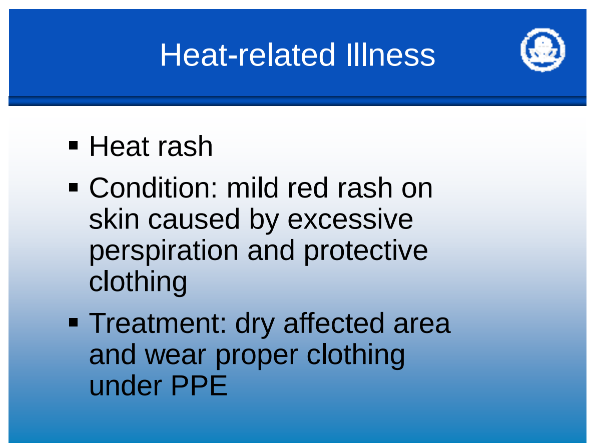
The human body is designed to function at a certain internal temperature. When metabolism or external sources (fire, hot day) cause the body temperature to rise, the body seeks to protect itself by triggering cooling mechanisms. Excess heat is dissipated by two means:

- Changes in blood flow to dissipate heat by convection, which can be seen as "flushing" or reddening of the skin in extreme cases.
- Perspiration, the release of water through skin and sweat glands. While working in hot environments, evaporation of perspiration is the primary cooling mechanism.



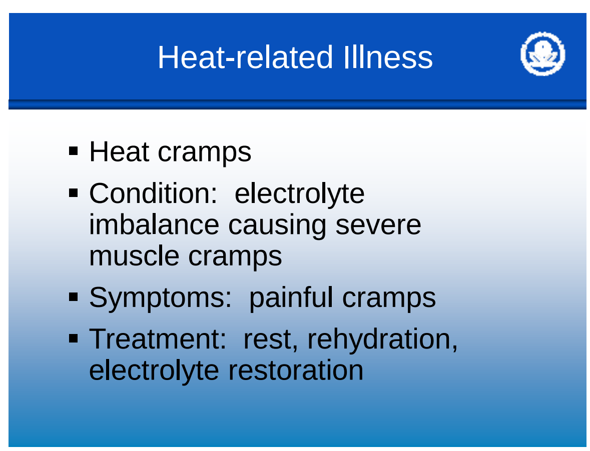
Protective clothing worn to guard against chemical contact effectively stops the evaporation of perspiration. Thus the use of protective clothing increases heat stress problems.





HEAT STRESS

The major disorders due to heat stress are heat cramps, heat exhaustion, and heat stroke. Wearing protective clothing in humid conditions can cause excessive perspiration which may create heat rash. Proper clothing worn under PPE will aid in the prevention of heat rash.



Drinking water while continuing to lose salt tends to dilute the body's extra cellular fluids, causing heat cramps. Soon, water seeps by osmosis into active muscles and causes pain. Muscles fatigued from work are usually most susceptible to cramps.

HEAT EXHAUSTION

In serious cases of heat exhaustion, a person may vomit or lose consciousness. The skin is clammy and moist, complexion pale or flushed, and body temperature normal or slightly higher than normal. Left untreated, heat exhaustion can progress to heat stroke.

Heat-related Illness

- Heat exhaustion
- Condition: body's ability to dissipate heat is pressed to its limits
- Symptoms: profuse sweating, drawn appearance, clumsiness, disorientation, low urine volume with deep color
- Treatment: rest in cool place, rehydration

HEAT STROKE

Heat stroke is a very serious condition caused by the breakdown of the body's heat regulating mechanism. This is a medical emergency. The skin is very dry and hot with a red, mottled, or bluish appearance. Unconsciousness, mental confusion, or convulsions may occur. Without quick and adequate treatment, the result can be death or permanent brain damage. Body heat should be reduced artificially, but not too rapidly, by soaking the person's clothes with water and fanning them.

Heat-related Illness

- Heat stroke (medical emergency)
- Condition: body has lost ability to regulate its temperature
- Symptoms: dry red skin, clumsiness, disorientation, nausea, convulsions
- Treatment: contact EMS, cool by any means possible

Steps that can be taken to reduce heat stress are:

- Acclimatize the body. Allow a period of adjustment to make further heat exposure endurable. It is recommended that a new worker start at 50% of the anticipated total workload for the first day and increase the work load gradually each succeeding day for about a week. Acclimatization can be "lost" if a worker is away from the heat for two weeks.

- Drink more liquids to replace body water lost through perspiration.

- Rest frequently.

- Increase salt intake. Sweat is mostly water with smaller amounts of sodium and potassium salts. Replacement fluids should be similar in composition. Thus, salt tablets usually are not necessary and can be harmful. It is better to increase salt on food, or drink commercially available preparations that provide the proper balance of water and salts.

- Wear personal cooling devices. There are two basic designs: units with pockets for holding frozen packets, and units that circulate a cooling fluid from a reservoir through tubes to various parts of the body. Both designs can be in the form of a vest, jacket, or coverall. Some circulating units also have a cap for cooling the head.

- Wear supplied-air suits or respirators that are equipped with a vortex tube that either cools or warms the air being supplied. The vortex tube is not used with self-contained breathing apparatus because it uses large amounts of compressed air during operation.

- Wear cotton long underwear under chemical protective clothing. The cotton will absorb perspiration and will hold it close to the skin. This will provide the body with the maximum cooling available from the limited evaporation that takes place beneath chemical resistant clothing. It also allows for rapid cooling of the body when the protective clothing is removed.

COLD EXPOSURE

Cold Exposure

- Frostbite
- Condition: frozen skin and extremity tissue due to exposure to severe cold
- Symptoms: pale color, tissue hard to the touch, pain, and numbness
- Treatment: slowly increase temperature of tissue

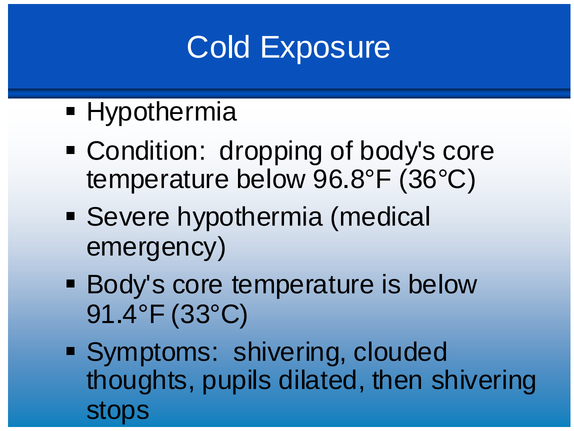
Cold temperatures can also cause medical problems. The severe effects are frostbite and hypothermia.

Frostbite is the most common injury resulting from exposure to cold. The extremities of the body are most often affected. The signs of frostbite are: the skin turns white or grayish-yellow, pain is sometimes felt early but subsides later (often there is no pain), and the affected part feels intensely cold and numb.

Standard first aid for frostbite includes getting the victim to a warm shelter; putting frozen parts in warm, but not hot, water (100–105°F); and gently handling the affected body parts – *do not* rub or massage them. If toes or fingers are affected, put dry, sterile gauze between them after warming them. Loosely bandage the injured parts. If the part has been thawed and refrozen, re-warm it at room temperature.

HYPOTHERMIA

Hypothermia is characterized by shivering, numbness, drowsiness, muscular weakness, and a low internal body temperature when the body feels warm externally. This can lead to unconsciousness and death. In the case of hypothermia, professional medical care should be sought immediately. The body should be warmed slowly.

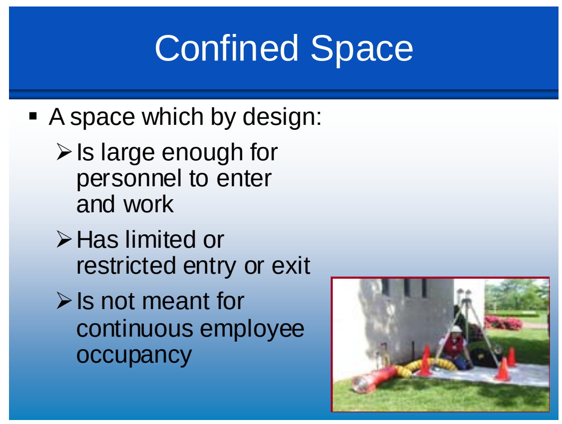


To prevent cold exposure, wear appropriate clothing, schedule rest periods, monitor physical conditions of workers, and remove wet clothing immediately.

CONFINED SPACE HAZARDS

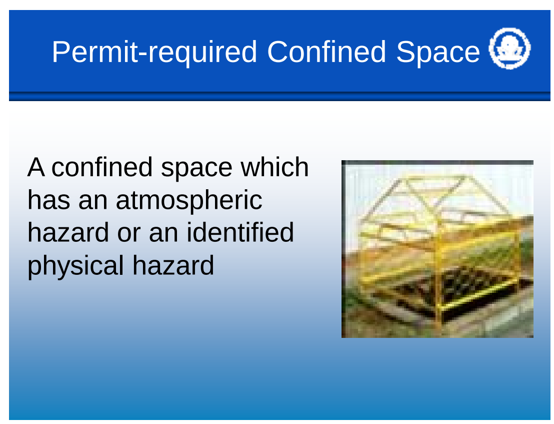
Work in confined spaces may present a variety of hazards. Since potentially rapid changes in atmospheric conditions hamper the worker's ability to escape; these hazards can pose a greater danger. The two basic types of hazards are atmospheric and physical.

The Occupational Safety and Health Administration (OSHA) issued a final rule on Permit-Required Confined Spaces for General Industry (29 CFR 1910.146) on January 14, 1993, having an effective date of April 15, 1993.



This rule requires the establishing of a permit-required confined space entry program, an entry permit system, emergency procedures, and engineering and procedural controls to protect employees performing work within confined spaces.

PERMIT-REQUIRED CONFINED SPACE



A permit-required confined space (PRCS) is a confined space that has one or more of the following hazards: (1) contains or has known potential to contain a hazardous atmosphere; (2) contains a material with potential for engulfment; (3) has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or a floor which slopes downward and may taper to a smaller cross section; or (4) contains any other recognized serious safety or health hazard (e.g., rotating machinery, electrical hazards).

To ensure adequate protection for worker safety and health while performing activities in PRCS, a permitting program must be in place. An example of a confined space entry permit is on page 136 of the Standard Operating Safety Guide (SOSG). There are procedures for identifying confined space hazards. A hazard evaluation should be conducted before any work is started in a confined space.

Permit-required Confined Space

- Atmospheric hazards and limits:
  - Oxygen deficient: <19.5%
  - Toxic: permissible exposure
  - Flammable: 10% of LEL

Permit-required Confined Space

- Physical hazards:
  - Eliminated by physical removal, or
  - Controlled through Energy Control Program 29 CFR 1910.147

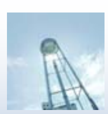
Types of physical safety hazards in confined spaces include: (1) slips, trips, falls; (2) mechanical or electrical; (3) limited entry and exit; (4) physiological stress; and/or (5) entrapment. Elimination of hazards by physical removal and 29 CFR 1910.147, *Control of Hazardous Energy*, known as “lock out/tag out,” are effective mitigation.

When working in confined space, atmospheric and physical conditions will be monitored and a rescue plan must be in place.

Confined Space Precautions

- Atmospheric and physical workplace conditions closely monitored
- Provisions for adequate rescue provided

Questions?



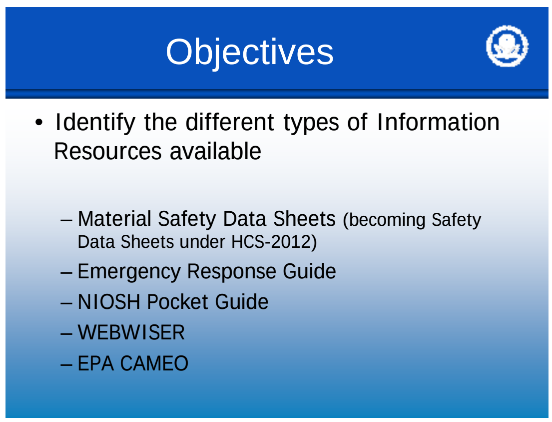
THIS PAGE INTENTIONALLY BLANK

REFERENCE MATERIALS AND RESOURCES

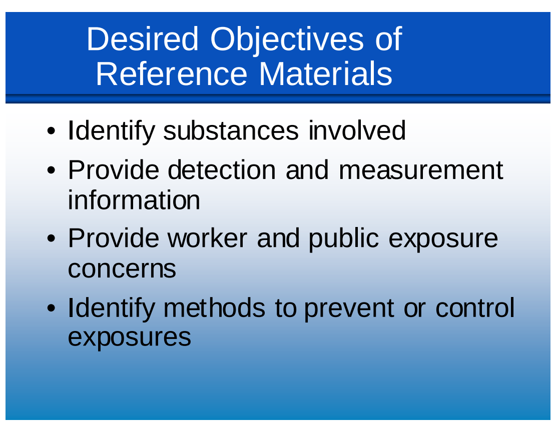
Student Performance Objectives

1. Name the references and agencies available to assist in identifying and evaluating chemical hazards.

2. Identify the different types of information resources available.



3. Understand the desired objectives of the reference materials.



THIS PAGE LEFT INTENTIONALLY BLANK.

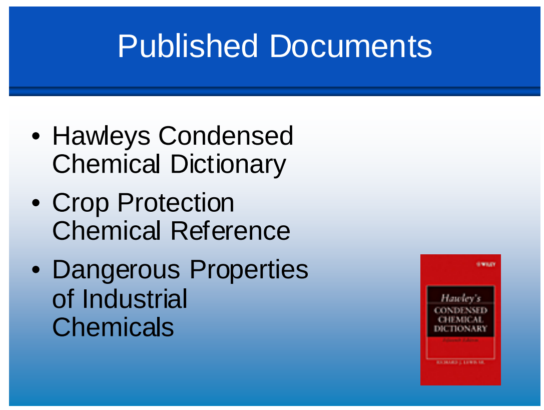
REFERENCE MATERIALS AND RESOURCES

There are many sources of information that can be accessed for a variety of purposes. These documents address hazards that might be encountered, and suggest control methods that can be applied at a work site or in an emergency situation.

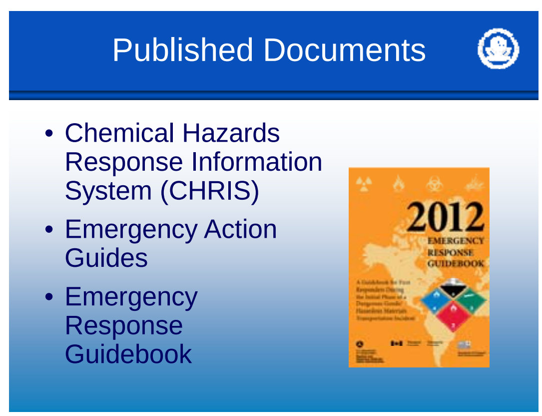
- *Hawley's Condensed Chemical Dictionary* has technical data and descriptive information on many chemical substances. It is useful in assessing a hazardous waste site or spill.

- *Crop Protection Chemical Reference* lists pesticides and herbicides used in farming.

- *Dangerous Properties of Industrial Chemicals* has 13,000 common industrial and lab chemicals. It includes descriptive information; hazard analyses for toxicity, fire and explosives; and countermeasures for handling, storage, shipping, first aid, fire-fighting, and personal protection.



CHEMICAL HAZARD RESPONSE INFORMATION SYSTEM



- Chemical Hazard Response Information System (CHRIS) was developed by the U.S. Coast Guard for first responders and On-Scene Coordinators. CHRIS has four manuals:

  - Volume 1 – *Condensed Guide to Chemical Hazards* is designed for first responders at the scene of an incident. The chemicals must be identified before the manual can be used.

  - Volume 2 – *Hazardous Substance Data Manual* contains chemical, toxicological, and physical information on chemicals shipped by water in large quantities. It is designed for port security personnel and others who may be first on the scene of a spill.

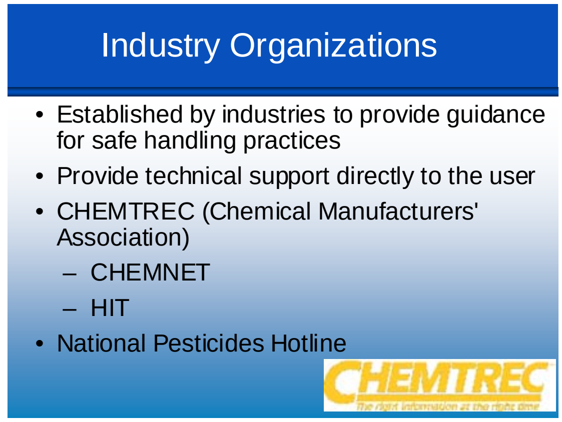
  - Volume 3 – *Hazard Assessment Handbook* is used to estimate the quantity of material released into the environment during a spill. It is used to evaluate the rate of dispersion and toxicity, fire, and explosive hazards.

- Volume 4 – *Response Methods Handbook* describes methods of handling and containing spills of hazardous materials. It was designed for Coast Guard OSCs.

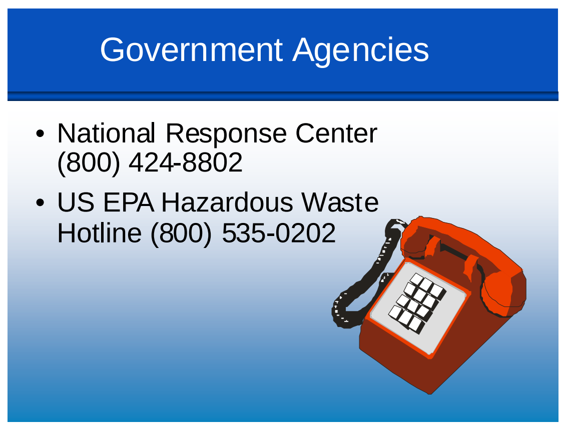
- Emergency Action Guides are published by the Association of American Railroads. These guides provide information about hazardous materials carried by railroads, and are designed for first responders to an accident. They provide techniques for handling spills, consequences of the techniques to the surrounding public and environment, and ways to mitigate any threats posed to the public and environment.

INDUSTRY ORGANIZATIONS

The Chemical Transportation Emergency Center (CHEMTREC) provides immediate assistance to accident scenes with chemical hazards. If pre-registered with the Hazard Information Transmission (HIT) program, developed by CHEMTREC, documents will be provided on specific products during an emergency.

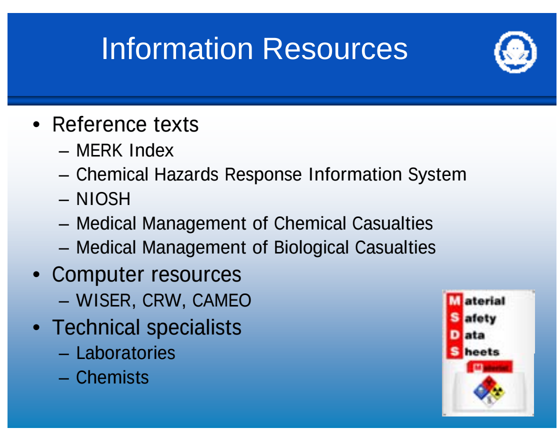


The National Response Center operated by the Coast Guard's National Strike Force requires notification for spills above reportable quantities and for oil spills. The Agency for Toxic Substances and Disease Registry (ATSDR) provides guidance on exposures to the public. The Centers for Disease Control (CDC) provides information on infectious diseases. Government-agency internet sites are also a good resource.



Material Safety Data Sheets (Becoming SDS)

Chemical manufacturers and importers are required to obtain or develop a material safety data sheet (MSDS) for each hazardous chemical they produce or import (becoming SDA under new OSHA GHS). Distributors are responsible for ensuring that their customers receive a copy of these MSDSs. Employers must have an MSDS for each hazardous chemical they use.



The role of MSDSs under the Hazard Communications Standard (HCS) is to provide detailed information on each hazardous chemical, including its potential hazardous effects, its physical and chemical characteristics, and recommendations for appropriate protective measures. MSDSs must be readily accessible to employees when they are in their work areas during their work shifts. This requirement is satisfied in many different ways. The Employer must decide what is appropriate for their particular workplace. Some employers keep the MSDSs in a binder in a central location (e.g., in the pick-up truck on a construction site). Others, particularly in workplaces with large numbers of chemicals, computerize the information and provide access through terminals.

One difference between this rule and many others adopted by OSHA is that this one is performance-oriented. That means that employers have the flexibility to adapt the rule to the needs of their workplace, rather than having to follow specific, rigid requirements. It also means that employers have to exercise more judgment to implement an appropriate and effective program.

Material Safety Data Sheets (Becoming Safety Data Sheets)

- Required under OSHA 1910.1200
  - Hazard Communication Standard
- Are for the employee
- Chemical-specific
- Vary from manufacturer to manufacturer (standardized as part of HCS-2012)
- Vary from very specific to non-specific (standardized as part of HCS-2012)

HAZCOM Requirements

- MSDS (SDS) for Each Hazardous Chemical
- Label Containers of Hazardous Chemicals
- Master Chemical Inventory List
- Written HAZCOM Plan
- Train Employees in Identification and Protection

Chemical manufacturers, importers, and distributors of hazardous chemicals are all required to provide the appropriate labels and MSDSs to the employers to which they ship the chemicals. The information is provided automatically. Every container of hazardous chemicals received must be labeled, tagged, or marked with the required information. Suppliers must also send employers a properly completed MSDS at the time of the first shipment of the chemical, and with the next shipment after the MSDS is updated with new and significant information about the hazards.

Chemical information is available through a variety of sources, including the MSDS just covered, those carried on emergency apparatus or information sources available via telephone, fax, or computer. Knowing what information is available and knowing how to interpret this information is a valuable tool for your protection.

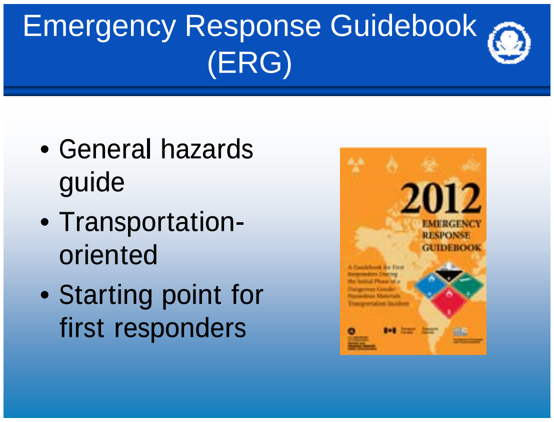
Material Safety Data Sheet (becoming SDS)

1. Chemical Product & Company Information
2. Hazards Identification
3. Composition/Information on Ingredients
4. First Aid Measures
5. Fire Fighting Measures
6. Accidental Release Measures
7. Handling and Storage
8. Exposure Controls/Personal Protection
9. Physical and Chemical Properties
10. Stability and Reactivity
11. Toxicological Information
12. Ecological Information
13. Disposal Considerations
14. Transport Information
15. Regulatory Information
16. Other Information

Reference Texts

- Emergency Response Guidebook (ERG)
- NIOSH Pocket Guide to Chemical Hazards
- Medical Management of Chemical Casualties
- Medical Management of Biological Casualties

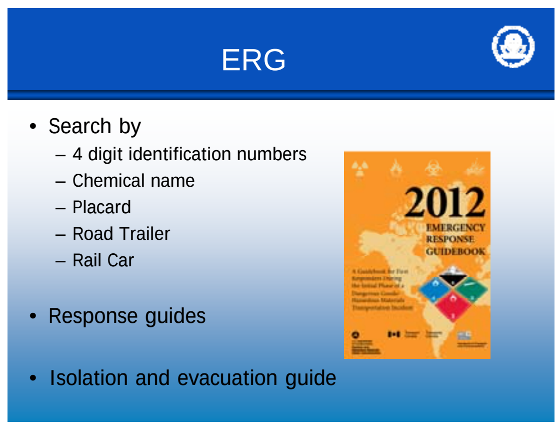
Emergency Response Guidebook



The *Emergency Response Guidebook* is a well-known book for emergency responders. Formerly referred to as the *DOT book*, the guidebook is updated every four years, and contains information regarding the most commonly transported chemicals regulated by the DOT. Originally intended as a guidebook for first responders to incidents involving hazardous materials, it provides information regarding the greatest potential hazards of responding to these materials, one of few books that provide specific evacuation recommendations. Although an excellent book for first responders, it does have limitations for the more advanced responder, who requires specific chemical information.

The guidebook consists of these major sections:

- Placard information
- Silhouettes of tank trucks and train cars
- Listing by UN/NA identification number (ID)
- Alphabetical listing by shipping name
- Response guides
- Table of initial isolation and protective action distances
- List of dangerous water reactive materials



The 2012 Emergency Response Guidebook was developed jointly by Transport Canada (TC), the U.S. Department of Transportation (DOT), the Secretariat of Transport and Communications of Mexico (SCT) and with the collaborations of CIQUIME (Centro de Informatión Química para Emergencies) of Argentina. In the U.S., according to the requirements of the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA, 29 CFR 1910.120), and regulations issued by the U.S. Environmental Protection Agency (EPA, 40 CFR Part 311), first responders must be trained regarding the use of this guidebook.

On the inside-cover of the guidebook, an example of a shipping paper used in truck transportation is given. The example further provides information on the proper written preparation of the shipping paper. It also provides an example of a placard with an identification number panel. The first page outlines all of the actions the first responder should take. It provides a decision tree process that advances systematically through the incident. It also has an important listing of the guides for explosives. The next few pages provide information on safety precautions and contacts to call for assistance. First responders should already know where the closest local assistance would be coming from and how to request state assistance if required. The guidebook provides a contact number for federal assistance; the standard is to proceed by requesting local, state, and finally federal assistance.

The emergency response information services shown above have requested to be listed as providers of emergency response information and have agreed to provide emergency response information to all callers. They maintain periodically updated lists of state and Federal radiation authorities who provide information and technical assistance on handling incidents involving radioactive materials.

MILITARY SHIPMENTS

For assistance at incidents involving materials being shipped by, for, or to the Department of Defense (DOD) call one of the following numbers (24 hours):

703-697-0218 (call collect) (U.S. Army Operations Center) for incidents involving explosives and ammunition

1-800-851-8061 (toll-free in the U.S.) (Defense Logistics Agency) for incidents involving dangerous goods other than explosives and ammunition

NATIONWIDE POISON CONTROL CENTER (United States Only)

Emergency and information calls are answered by the nearest Poison Center (24 hours):
1-800-222-1222 (toll-free in the U.S.)

The above numbers are for emergencies only.

NATIONAL RESPONSE CENTER (NRC)

The NRC, which is operated by the U.S. Coast Guard, receives reports required when dangerous goods and hazardous substances are spilled. After receiving notification of an incident, the NRC will immediately notify the appropriate Federal On-Scene Coordinator and concerned Federal agencies.

Federal law requires that anyone who releases into the environment a reportable quantity of a hazardous substance (including oil when water is, or may be affected), or a material identified as a marine pollutant, must immediately notify the NRC. When in doubt as to whether the amount released equals the required reporting levels for these materials, the NRC should be notified.

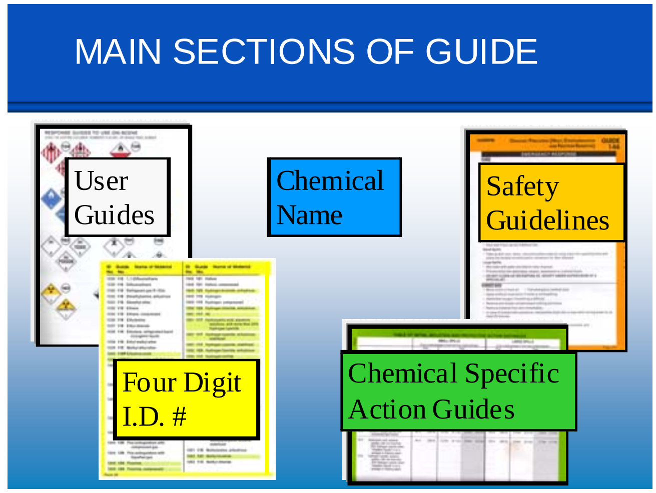
CALL NRC (24 hours)

1-800-424-8802

(Toll-free in the U.S., Canada, and the U.S. Virgin Islands)

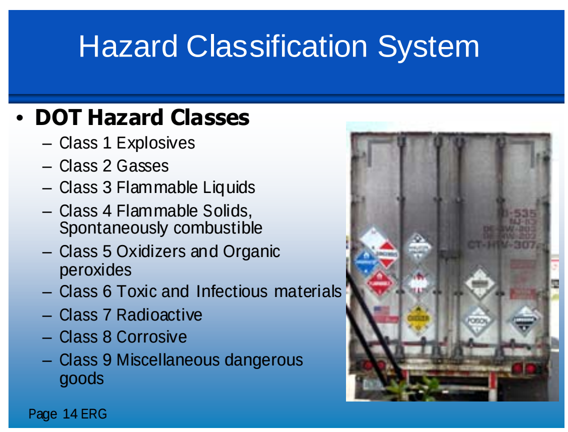
202-267-2675 in the District of Columbia Calling the emergency response telephone number, CHEMTREC®, CHEMTEL, INC., INFOTRAC or 3E COMPANY, does not constitute compliance with regulatory requirements to call the NRC.

This guidebook will assist responders in making initial decisions upon arriving at the scene of a dangerous goods incident. It should not be considered as a substitute for emergency response training, knowledge or sound judgment. ERG does not address all possible circumstances that may be associated with a dangerous goods incident. It is primarily designed for use at a dangerous goods incident occurring on a highway or railroad. Be mindful that there may be limited value in its application at fixed facility locations.



HAZARD CLASSIFICATION SYSTEM

The hazard class of dangerous goods is indicated either by its class (or division) number or by name. Placards are used to identify the class or division of a material. The hazard class or division number must be displayed in the lower corner of a placard and is required for both primary and subsidiary hazard classes and divisions, if applicable. For other than Class 7 or the OXYGEN placard, text indicating a hazard (for example, “CORROSIVE”) is not required. Text is shown only in the U.S. The hazard class or division number and subsidiary hazard classes or division numbers placed in parentheses (when applicable), must appear on the shipping document after each proper shipping name.



USE THIS TABLE ONLY IF YOU HAVE NOT BEEN ABLE TO IDENTIFY THE MATERIAL(S) IN TRANSPORT BY ID NUMBER OR SHIPPING NAME

If **GUIDE 111** is being used because only the DANGER/DANGEROUS placard is displayed or the nature of the spilled, leaking, or burning material is not known, as soon as

possible, get more specific information concerning the material(s) involved.

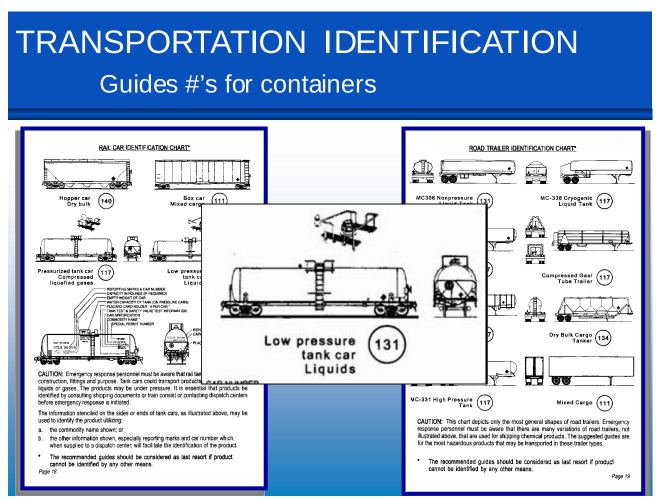
The placard section provides information as how to proceed at an incident where the only information is a placard. All of the possible placards are listed with their pictures, and the reader is referred to the accompanying guide page. Much like the placard section, included in the ERG is silhouettes of tank trucks and rail cars. Some international shipments use additional hazard markings.

Emergency response personnel must be aware that rail tank cars vary widely in construction, fittings and purpose. Tank cars could transport products that may be solids, liquids or gases. The products may be under pressure. It is essential that products be identified by consulting shipping documents or contacting dispatch centers before emergency response is initiated.

The information stenciled on the sides or ends of tank cars, as illustrated above, may be used to identify the product utilizing:

a. the commodity name shown; or

b. the other information shown, especially reporting marks and car number which, when supplied to a dispatch center, will facilitate the identification of the product.



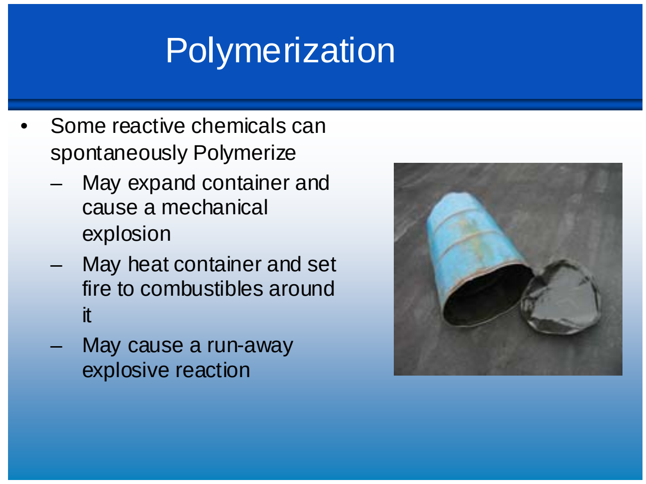
The highway-vehicle chart depicts only the most general shapes of road trailers. Emergency response personnel must be aware that there are many variations of road trailers, not illustrated, that are used for shipping chemical products. The suggested guides are for the most hazardous products that may be transported in these trailer types.

*** The recommended guides for rail cars and tank/van should be considered as last resort if the material cannot be identified by any other means.**

PIPELINE TRANSPORTATION

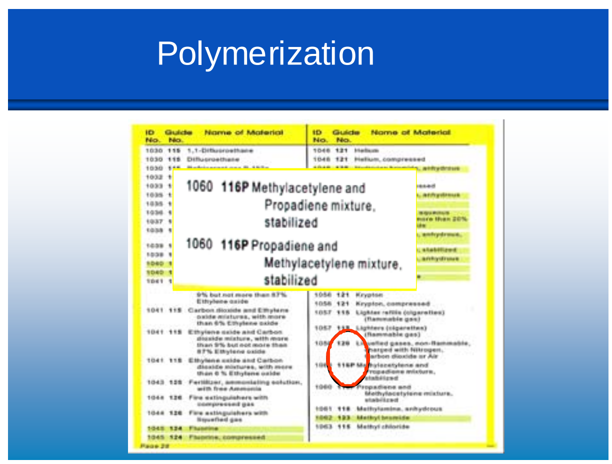
Hazardous materials are transported in North America through millions of miles of underground pipelines. Products commonly transported through these pipeline systems include natural gas, crude oil, gasoline, diesel fuel, and jet fuel. Although the pipelines are buried, there are aboveground structures and signs indicating the presence of underground pipelines.

Those substances designated with a "P" may polymerize explosively when heated or involved in a fire. In chemical compounds, polymerization occurs via a variety of reaction mechanisms that vary in complexity due to functional groups present in reacting compounds. Alkenes can be formed in reaction mechanisms; they form useful compounds such as polyethylene and polyvinyl chloride (PVC) when undergoing radical reactions, which are produced in high tonnages each year due to their usefulness in manufacturing processes of commercial products, such as piping, insulation and packaging.



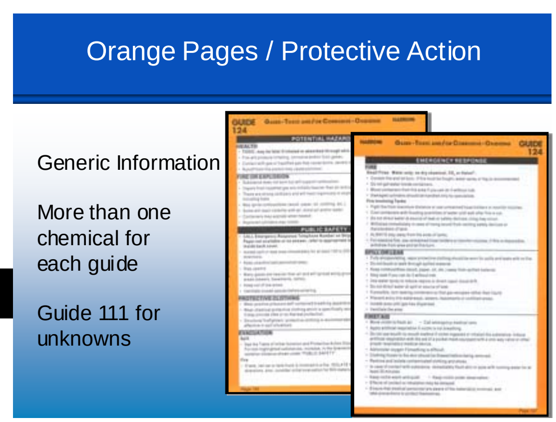
Polymerization that is not sufficiently moderated and proceeds at a fast rate can be very hazardous. This phenomenon is known as hazardous polymerization and can cause fires and explosions.

The yellow section is a numerical listing by the identification or ID number. This number is assigned by the DOT to identify a material being shipped. This number takes two forms -- North American (NA) of United Nations (UN) number -- but is always a four-digit number. Although one would think that this number would specifically identify a material, in some cases it may not. Depending on the material, it may be lumped into a general category such as Hazardous Waste, Liquid, or Not Otherwise Specified (NOS), but in most cases, it will identify a specific substance.



The blue section of the guidebook is an alphabetical listing by shipping name. These shipping names are assigned by DOT and for the most part are identical to the chemical name, although they may vary in some cases. Chemicals may go by several names including chemical name, synonym, trade name, and shipping name.

In both the yellow and blue pages, chemicals highlighted in green are toxic inhalation hazards and are listed in the table of initial isolation and protective action distance, located at the back of the guidebook in the green section.



The middle of the book, the orange section, is the actual guide pages. They are listed from guide 111 to guide 172, a total of 61 guides for the more than 4,000 chemicals listed by DOT. This generalization makes this book more valuable to initial responders and less valuable to an advanced responder, such as a HAZMAT technician, HAZWOPER/RCRA/TSDF site worker. A HAZMAT technician or HAZWOPER/RCRA/TSDF site worker needs more specific information, which the ERG does not provide. Each guide is on two pages and is divided into three major sections: potential hazards, public safety, and emergency response. The guide may also provide some additional information about specific chemicals. It is important for everyone using the ERG to read the entire guide and the table of initial isolation and evacuation distance, if referred to that section.

The potential hazards section lists the predominant hazard on the top line. If fire is the major concern, then it will be listed on top; if health is the major concern, then it will be listed first.

The information regarding the health effects provides the route of exposure and any major signs and symptoms of exposure. It will detail other potential health and environmental concerns with fire products and runoff. The fire section is not as detailed as the health section but does provide some assistance in identifying potential hazards. It provides information related to the flammability of the product and will identify if the vapors will stay low to the ground or will rise in air. Depending on the product, it may also describe the material's ability to float on water. Products shipped at an elevated temperature will have a notation as will those materials that have the ability to polymerize. One of the problems with the ERG is that gasoline, which is highly flammable, is under the same guide that is provided for diesel fuel, which the fire service classifies a combustible. Although the DOT and the NFPA use 141 °F as the difference between flammable and combustible, some reference sources specify 100 °F as the differentiating temperature. By using the guide as intended, the reader has no way of differentiating between the two products. Although one could say that taking this route is safer, as it assumes the worst-case scenario, there are times when this action is inappropriate and can lead to other problems, such as an unnecessary evacuation for a diesel fuel spill.

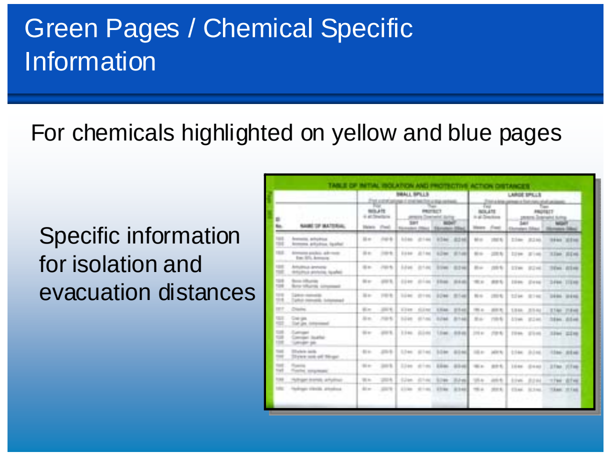
The public safety section provides information for initial public protection options and key issues for the safety of the responders.

This section and the Table of Initial Isolation and Protective Action Distance make this book a necessary tool in the mitigation of a chemical release. It also recommends responders contact the emergency contact listed on shipping papers or, if this is not available, one of the contacts listed on the inside back cover. It provides some tactical objectives for handling radioactive substances and discusses additional considerations regarding these types of incidents.

The public safety section also lists PPE recommendations and provides four basic PPE scenarios. It promotes the use of positive pressure SCBA, which is mandatory when responding to chemical releases.

This section provides information regarding initial evacuation distance for large spills and fires. If the material is listed in the table of initial isolation and protective action distances, the reader will be referred to this section located at the back of the guidebook in the green section. The isolation distances listed vary from approximately 9 meters (30 feet) to 244 meters (800 feet). The minimums are derived for materials that are solid or present little risk to responders. The higher the toxicity or the risk, the greater the isolation distance; the average is 100 meters (330 feet), which is the distance to use for establishing an isolation zone for an unknown material. Further information on distance for explosives, urban areas, etc, are discussed.

The emergency response section provides information regarding fires, spills and first aid.

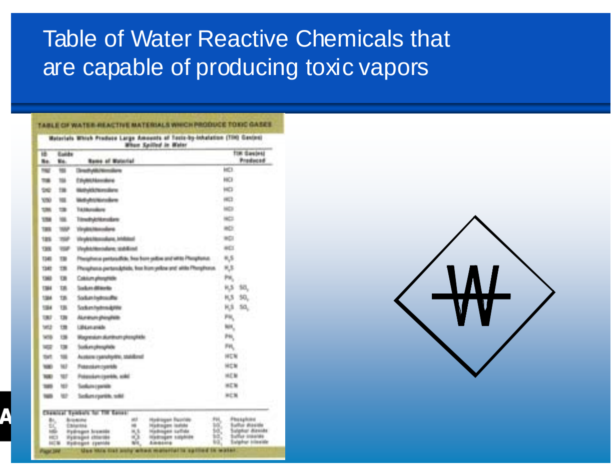


The table of initial isolation and protective action distances is the green section in the back of the guidebook. This section provides specific isolation and evacuation distances for the materials highlighted in the yellow or blue sections. This section is further subdivided between small spills and large spills, and both are divided between day and night distances. The criteria used to establish these distance includes the following information: the DOT incident database (HMIS) typical package size, typical flow rate from a ruptured package, and the release rate of vapors form a spill. The DOT chose the average day as being warm and sunny with a temperature of 95 °F. The agency conducted a five-year study of the weather in sixty-one cities to establish a pattern. It was during this study that it was determined that materials will travel farther at night than during the day. The DOT also chose to use an evacuation distance that in 90 percent of incidents would be too large. In this scenario, in 10 percent of the incidents the distance would be too small. The distances are a guide for the *first thirty minutes on an incident* and use a typical day as defined by the DOT.

The ERG is a guide to get an evacuation started; as soon as possible, air monitoring must be initiated to definitively establish evacuation distances. In addition, an emergency response software package (Computer-Aided Management of Emergency Operations – CAMEO) is available from the EPA. CAMEO provides an Air Transport Dispersion (ATD) modeling module, ALHOA (*Areal Locations of Hazardous Atmospheres*). This program can assist with evaluating potential downwind evacuations, using real-time weather and other data.

The DOT defines a small spill as a leaking container smaller than 200 liters (53 gallons, or a 55-gallon container), or a leak from a small cylinder, while a large spill is coming from a container larger than 200 liters or a large cylinder. Leaks from several small containers may be considered a large leak. A small leak from a large container may also be considered a small leak.

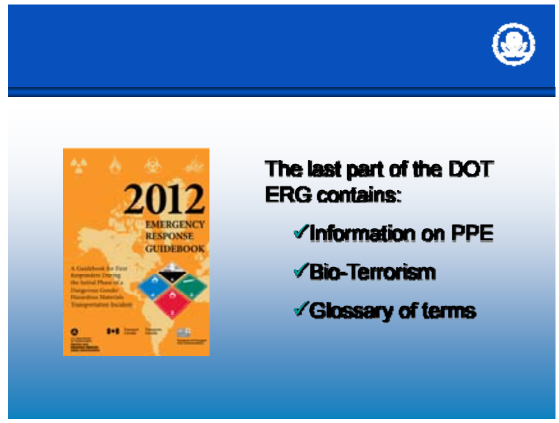
The last information included in the green section is the list of water reactive materials capable of producing toxic vapors. This section provides the evacuation distances for these materials if they contact water; the distance varies from 483 meters (0.3 miles) to 9.7 kilometers (6 miles). One helpful item that this



section provides is the chemical that a material forms when contacting water.

The last pages are definitions, glossary and explanations. The back section also has several pages on the Use of Chemical/Biological Agents in the terrorist or criminal incidents. The inside back cover provides a listing of additional emergency contacts for the ERG support countries.

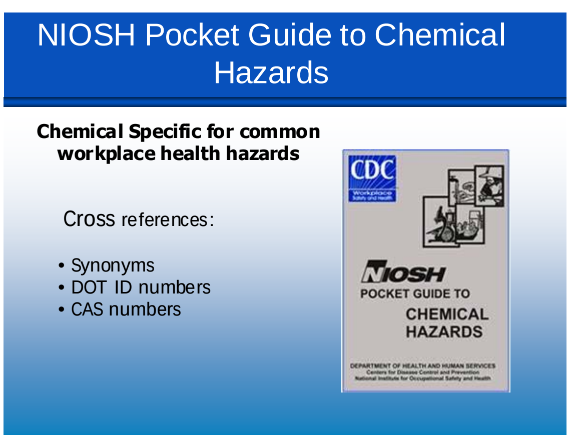
Some general reminders when using the ERG:

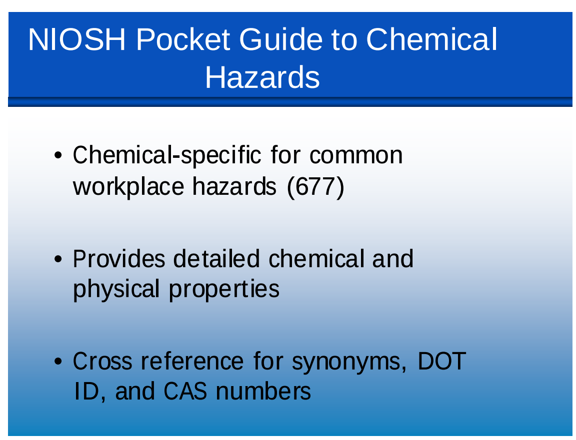


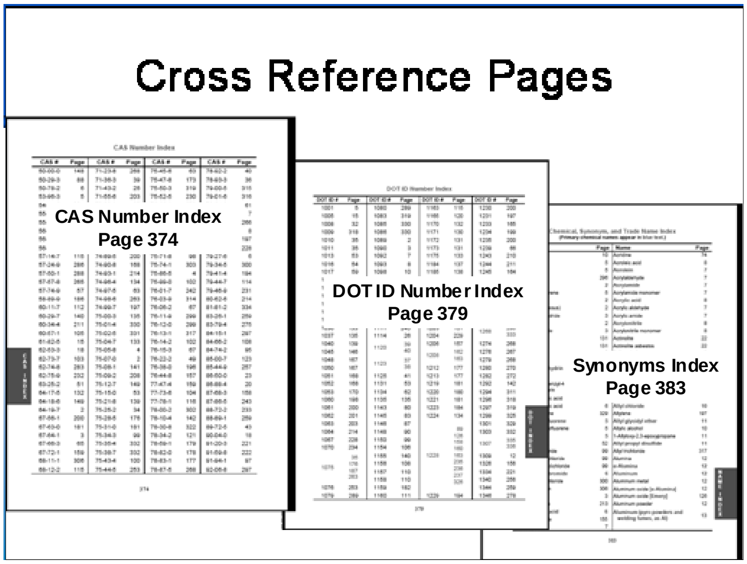
1. It is an excellent source for evacuation and isolations distances.
2. It is an excellent source for water reactive hazards
3. It is an excellent first responder document.
4. It is a great starting point for the first 30 minutes of an incident.
5. The specific chemical information is limited, and in some cases too general for a HAZMAT team, although it is well suited for the first responder level.
6. Specific identification of the product is essential for the safety of responders, workers and the public.

NIOSH Pocket Guide to Chemical Hazards

The NIOSH Pocket Guide to Chemical Hazards (NPG) is intended as a source of general industrial hygiene information on 677 chemicals/classes for workers, employers, and occupational health professionals. The NPG presents key information and data in abbreviated or tabular form for chemicals or substance groupings (e.g. cyanides, fluorides, manganese compounds) that are commonly found in industry. Information contained in the NPG should help users recognize and control occupational chemical hazards.





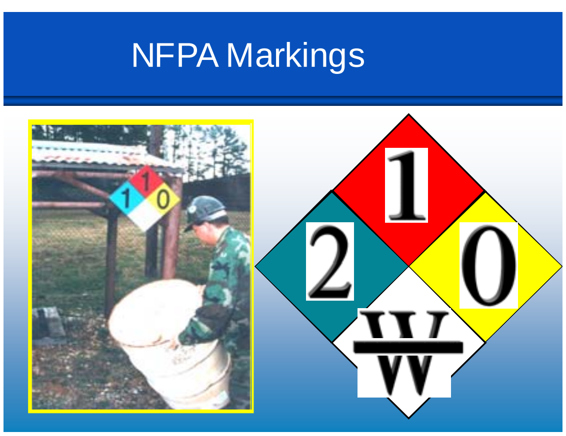


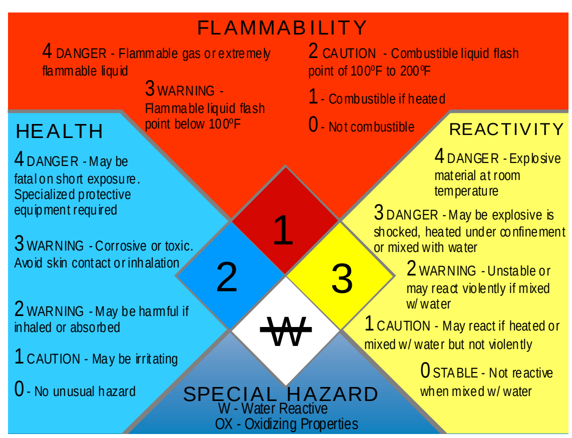
NFPA 704 MARKING SYSTEM

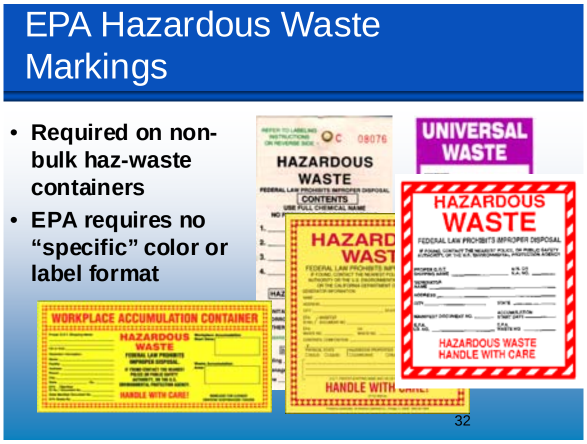
The NFPA 704 Marking System is a system developed by the National Fire Protection Association to alert emergency personnel of the type and degree of hazards within an area enabling them to more easily decide whether to evacuate the area or to commence control procedures.

When displayed: Used for hazards in facilities and may be found on non-bulk packaging.
How displayed: The system uses a diamond shaped symbol, positioned on point, divided into four smaller diamonds.
Symbol description: The four smaller diamond shapes or quadrants have specific meanings as follows:

- Blue quadrant (left) indicates health hazard
- Red quadrant (top) indicates flammability hazard
- Yellow quadrant (right) indicates reactivity hazard
- Lower quadrant (bottom) contains symbols indicating special hazards, such as OXY for oxidizers, radioactive trefoil (propeller), W for water reactive materials







A crucial requirement in safely handling *hazardous waste* is to mark and label containers. Uniformity in marking and labeling containers while the waste is being accumulated, to its ultimate disposal, is critical. Both the US DOT and US EPA offer specific regulatory guidance (49 CFR 172, 173, 178 and 179) for hazardous waste generators to follow. It is important to note that these requirements are different from the OHSA Hazard Communication Standard (29 CFR 1910.1200), which offers labeling guidance for *hazardous materials* that have not been designated as waste.

Bulk vs. Non-bulk Packages

Because the labeling and marking requirements are different based on the size of the container, it is important to distinguish between bulk and non-bulk packages.

Non-bulk Packages

Under 49 CFR 173.115A a non-bulk package is defined as a package which has

1. A maximum capacity of 450 L (119 gallons) or less as a receptacle for a liquid;
2. A maximum net mass of 400 kg (882 pounds) or less and a maximum capacity of 450 L (119 gallons) or less as a receptacle for a solid;
3. A water capacity of 454 kg (1000 pounds) or less as a receptacle for a gas.

Bulk Packages

Under 49 CFR 171.8, a bulk package is defined as a packaging, other than a vessel or a barge, including a transport vehicle or freight container, in which hazardous materials are loaded with no intermediate form of containment and which has:

1. A maximum capacity *greater than* 450 L (119 gallons) as a receptacle for a liquid;
2. A maximum net mass *greater than* 400 kg (882 pounds) and a maximum capacity *greater than* 450L (119 gallons) as a receptacle for a solid; or
3. A water capacity *greater than* 454 kg (1000 pounds) as a receptacle for a gas as defined in 173.115 of this subchapter (49 CFR 173).

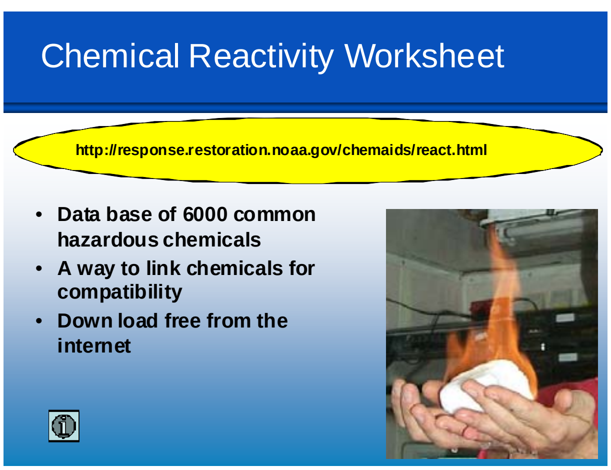
While the guidelines for properly identifying non-bulk and bulk containers are similar, they are not the same. This discussion is limited to rules for non-bulk packaging.

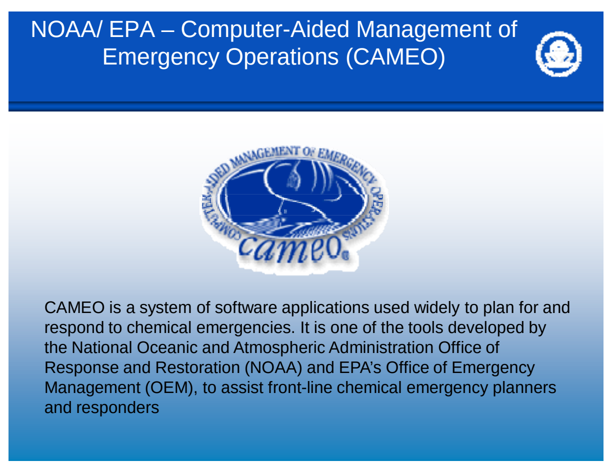
Wireless Information System for Emergency Responders (WISER)

WISER is a system designed to assist first responders in hazardous material incidents. WISER provides a wide range of information on hazardous substances, including substance identification support, physical characteristics, human-health information, and containment and suppression advice.

CAMEO is a system of software applications used widely to plan for and respond to chemical emergencies. It is one of the tools developed by EPA's Office of Emergency Management (OEM) and the National Oceanic and Atmospheric Administration Office of Response and Restoration (NOAA), to assist front-line chemical emergency planners and responders. They can use CAMEO to access, store, and evaluate information critical for developing emergency plans. In addition, CAMEO supports regulatory compliance by helping users meet the chemical inventory reporting requirements of the EPCRA, (also known as SARA Title III). CAMEO also can be used with a separate software application called LandView to display EPA environmental databases and demographic/economic information to support analysis of environmental justice issues.

The CAMEO system integrates a chemical database and a method to manage the data, an air dispersion model, and a mapping capability. All modules work interactively to share and display critical information in a timely fashion. The CAMEO system is available in Apple and Windows formats.





REFERENCES

U.S. DHHS, *Occupational Safety and Health in Vocational Education: A Guide for Administrators, Faculty, and Staff.* Publication No. 79-138. U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health, Cincinnati, OH, 1979

49 CFR 172.101 Subpart B, *Purpose and use of hazardous materials table and Table of Hazardous Materials*

49 CFR 172.102, *Special provisions*

49 CFR 172.300 *Subpart D, Marking and Applicability*

49 CFR 172.400 *Subpart E, Labeling*

49 CFR 172.400(b), *General Labeling Requirements Table*

49 CFR 172.402, *Additional labeling requirements*

49 CFR 173, *Definitions, Classifications, Packing Group Assignments and Exceptions for Hazardous Materials Class 1 and Class 7*

40 CFR 260, *Hazardous Waste Management System*

AIR MONITORING

Student Performance Objectives

Air Monitoring Instruments I

1. State how the data collected from three types of direct-reading air monitoring instruments is used for initial entry.
2. State the desired characteristics of field-portable air monitoring instruments.
3. Discuss the following:
   a. Reasons for use
   b. Theory of operation
   c. Instrument limitations
4. Given the description of a hazardous location as described in the National Electric Code (NEC), identify the correct approval criteria for that location.
5. Define the following terms:
   a. Intrinsically Safe
   b. Explosion Proof
   c. Purged System

Air Monitoring Instruments II

6. Describe photo ionization detector (PID) theory of operation.
7. List the limitations of PIDs.
8. Describe flame ionization detector (FID) theory of operation.
9. List the limitations of FIDs.
10. Identify the range of operation and the uses of supersensitive combustible gas indicators (CGIs)
11. Given a list of chemicals and atmospheric conditions, choose the correct instrument (PID or FID) that should be used to perform air monitoring.

THIS PAGE INTENTIONALLY BLANK

AIR MONITORING INSTRUMENTS I

Airborne contaminants can present a significant threat to human health. Identifying and quantifying these contaminants by air monitoring are essential components of a health and safety program at a hazardous waste site.

29 CFR 1910.120

- Paragraph (c) – initial entry
  - Ionizing radiation
  - IDLH conditions
- Paragraph (h) – employee exposure
  - Proper selection of engineering controls, work practices, and personal protective equipment (PPE)
  - Periodic monitoring when IDLH or flammables arise
  - High-risk employees

29 CFR 1910.120

If there is not enough information about the site to eliminate the potential hazards found during initial entry, Paragraph c requires that monitoring be conducted with direct-reading instruments for both ionizing radiation and other IDLH conditions that may cause death or serious harm.

FIELD AIR MONITORING INSTRUMENTS

Some of these “early warning devices” can detect concentrations as low as one part of contaminant per million parts of air (ppm). This provides information at the time of monitoring that enables rapid, onsite, decision-making.

Field Air Monitoring Instruments

Collection of "real time" data to aid in decisions concerning:

- Hazards and risks to public and response personnel
- PPE selection
- Site work zones
- Effects on environment
- Mitigative actions

FIELD INSTRUMENTS DESIRED CHARACTERISTICS

Selecting instruments that have reinforced shells or frames, shock-mounted electronic packages, or padded containers for shipment, anodized or coated finishes, weather-resistant packaging, and remote sensors are effective both in reducing downtime from repeated use in adverse conditions or as long-term monitors, as well increasing their portability. Some instruments use replaceable or rechargeable batteries, and some do not require a power supply, which also increases their portability.

Field Instruments Desired Characteristics

- Portable and rugged
- Easy to operate
- Inherently safe
- Reliable and useful results

Workers must consider how easy it is to use the instrument while wearing gloves or how difficult it is to read the meter while wearing a respirator. Also, how quickly a worker can learn to operate the instrument correctly should be considered. Preparation time for using the instrument should be short. Rapid warm-up, easy attachment of accessories, and quick instrument checks shorten preparation time.

Instruments used in potentially hazardous atmospheres must be approved for use under such conditions to prevent the instrument itself from creating a fire or explosion hazard. The potential sources of ignition could be an arc generated by the power source or associated electronics, or from a flame or heat source required for the instrument to function.

RELIABLE AND USEFUL RESULTS

Reliable and Useful Results

- Response time
- Sensitivity
- Selectivity
- Accuracy
- Precision

The *response time* of the instrument must be fast enough to properly assess the atmospheric conditions. Instruments with slow response times cannot identify rapidly changing atmospheric conditions.

Sensitivity is the ability of an instrument to accurately measure changes in concentration. The *lower detection limit* at one end of the operating range of an instrument and the *saturation concentration* at the other end determine sensitivity. Although there is no legally mandated detection limit, they must be able to quantitatively measure 50% of the exposure limit, though 10% would be more practical.

Selectivity is the ability of an instrument to detect one chemical from others in a mixture. Chemicals that give false responses in an instrument are called “interference chemicals.”

Accuracy is the difference between the instrument reading and the true concentration.

Precision refers to consistency of results, which is not related to accuracy.

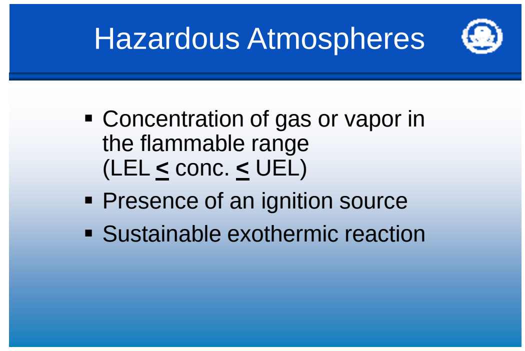
INSTRUMENT TYPES

Instrument Types

- Exterior passive sensors
- Internal active sensors
  - Automatic or manual pump
  - Allow remote sensing
- May have single or multiple detectors

An exterior passive sensor is directly exposed to the atmosphere and does not require a sample pump to obtain an ambient air reading. They cannot be used for remote monitoring, however, without attaching some type of sample pump.

HAZARDOUS ATMOSPHERES



The National Electric Code (NEC) defines hazardous atmosphere as containing:

-concentration of a flammable substance that is within the flammable range
-ignition source
-potential for an exothermic reaction

Flammable range is the concentration of a vapor that is ignitable. Below the flammable range the mixture is “too lean” and above it, the mixture is “too rich” to burn. The minimum concentration is the LEL or “lower explosive limit” and the maximum concentration is the UEL or “upper explosive” limit. Therefore, the concentration must be 100% of the LEL to be flammable; if it is greater than the UEL, it is not flammable.

INHERENT SAFETY APPROVAL

Inherent safety approval is given when equipment and wiring of an instrument is not capable of releasing sufficient electric or thermal energy to cause ignition.

SAFETY STANDARDS FOR INHERENT SAFETY

The standard that classifies hazardous atmospheres is National Electric Code NEC-70, adopted from the National Fire Protection Association (NFPA) standard NFPA-497M, in which:

-definition of classification of potentially ignitable atmospheres

-specifications for approval ratings for instruments used in each classification of hazardous atmosphere

A classification method for hazardous atmospheres starts with the type of flammable material that produces the hazard.

Each class as two divisions (discussed later in this section). In addition, Class I and Class II further divides into several groups. Class III (fibers) has no Group subdivisions.

Class I, Groups A, B, C and D are gases and vapors.

The basis for Group designations is chemical behaviors such as maximum explosion pressure or the temperature. For instance, both acetylene and hydrogen are explosive, but the explosive effect is substantially different. For instance, when acetylene burns, the temperature is above 3000 degrees Celsius (7000 degrees F), compared to hydrogen, which burns at 1900 degrees Celsius (3452 degrees F).

Safety Standards Inherent Safety

Group		Class
A, B, C, D	Gases and Vapors	I
E, F, G	Combustible Dusts	II

Groups E, F and G are combustible dusts and contained in Class II.

Next level based on whether the chemical(s) is normally present in the atmosphere, is Division. The Divisions relate to the probability of a hazardous atmosphere occurring under normal operating conditions at a specific location.

Safety Standards Inherent Safety

Division

1 Location in which hazardous concentrations exist continuously, intermittently, or periodically under NORMAL operating conditions

A Division 1 location may have gases or vapors present under normal conditions. Examples of a Division 1 location would be a gasoline station, a propane station or drum-filling facility for flammable liquids.

Division 1 means that it is normal for this chemical to be present in the atmosphere during routine operations. Example: opening containers or sampling of containers.

Safety Standards Inherent Safety

Division

2 Location in which hazardous concentrations DO NOT exist under normal operating conditions

Class, Division and Group define safety-standard certifications for explosion-proof or intrinsically safe instruments. Class I, Group A, Division 1 has the greatest flammability hazard. Class III has the least flammability hazard.

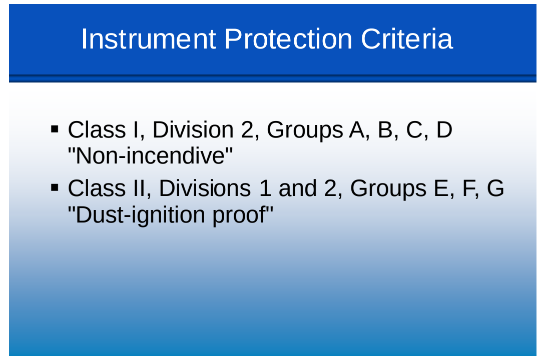
Instruments certified for use in a Class I atmospheres may be used in Class II Atmospheres.

Instrument Protection Criteria

- Class I, Division 1, Groups A, B, C, D
- "Intrinsically safe" "Explosion-proof" "Purged system"

Instrument Protection Criteria

To meet the NEC for Class I Division 1 (Class I includes Groups A, B, C, D), an instrument (or equipment) must be *intrinsically-safe*, *explosion-proof* or constructed as a *purged system*. These recognized designs meet the protection criteria for operating in hazardous atmospheres designated as Class I, Division 1.

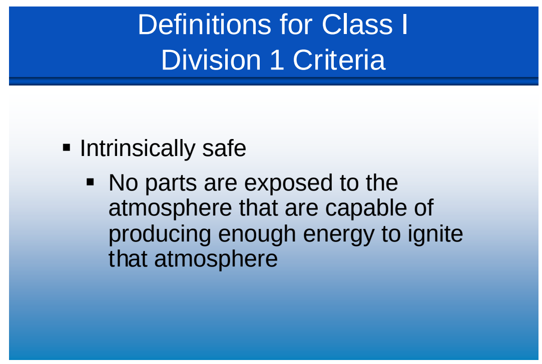


If an environment is less hazardous, the design criteria are not as stringent.

Instruments used in Class I, Division 2 need only be non-incendive. Non-incendive refers to circuits that, under normal operating conditions, have no arcing, sparking, or exposed surfaces that operate hotter than the auto-ignition temperature of a surrounding hazardous or explosive atmosphere.

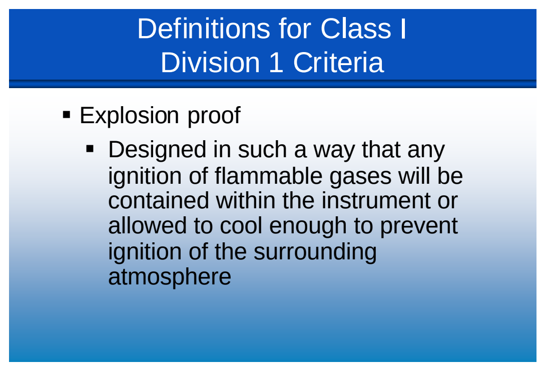
Instruments used in Class II, Division 1 or 2 needs only be dust ignition-proof.

Dust ignition-proof instruments are constructed to exclude ignitable amounts of dust from the instrument enclosure and overheating of surface components that
could ignite dust.



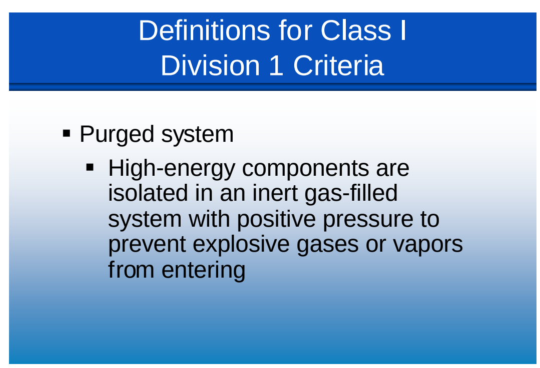
Intrinsically Safe

Incapable of releasing electrical or thermal energy or has insufficient energy to cause ignition



Explosion-Proof

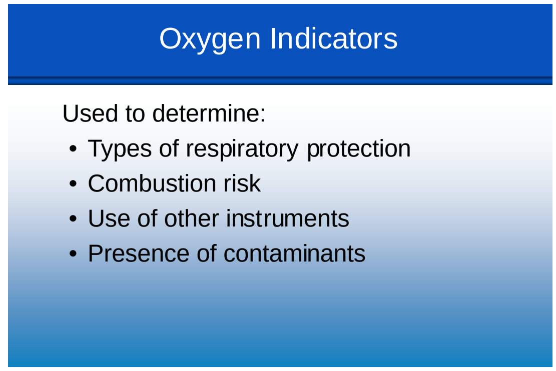
Capable of containing an internal explosion and maintaining a safe temperature or preventing propagation of the flame outside the instrument



Purged System

Has fresh air or an inert gas under enough positive pressure to exclude ignitable quantities of gas from accumulating. Purged system commonly refers to operational equipment or machinery used
for a specific manufacturing process.

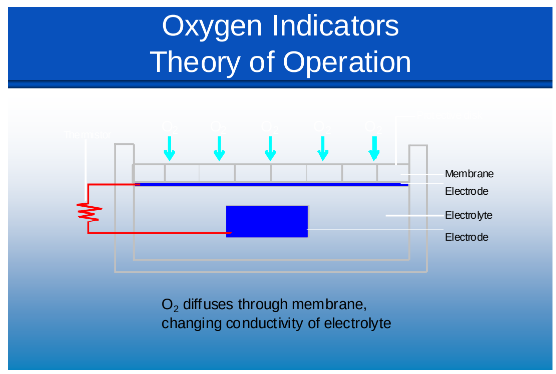
OXYGEN INDICATORS



Oxygen indicators use sensors known as electrochemical cells. The electrochemical sensor determines the oxygen concentration in air. The cell consists of:

- A membrane permeable to the chemical(s) of interest.
- An electrolyte solution, usually potassium or sodium hydroxide (KOH or NaOH).
- Two electrodes of dissimilar metals (lead and gold are commonly used).

PRINCIPLE OF OPERATION



Oxygen indicators have two principal components for operation, the oxygen sensor and the meter readout. In some units, air is drawn into the oxygen detector with an aspirator bulb or pump, while in other units; the ambient air is allowed to diffuse to the sensor.

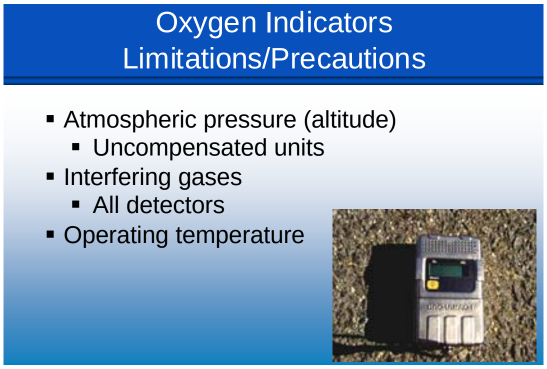
Oxygen molecules (O_2) permeate through the cell membrane into the electrolyte solution and react chemically. Reactions between the oxygen, the solution, and the electrodes produce a minute electric current that is proportional to the oxygen content. The amount of oxygen diffusing through the membrane is a function of its partial pressure, which is proportional to the concentration of oxygen. The current passes through the electronic circuit and the resulting signal is shown as a needle deflection on a meter or a digital readout.

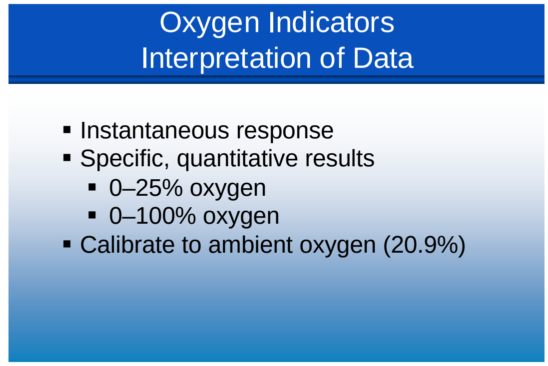
ADDITIONAL OXYGEN INDICATORS

Thinner air at higher altitudes has fewer oxygen molecules to diffuse through the membrane, so the instrument will indicate a lower oxygen concentration if it is not recalibrated for the new altitude.

The instrument measures changes in conductivity, which is a function of the number of oxygen molecules diffusing through the membrane. Ozone and other oxidizers, such as chlorine and fluorine, tend to increase readings on the meter because they react with the electrolyte the same as oxygen does. Acid gases or higher concentrations of CO_2 will suppress instrument response by expending the electrolyte.

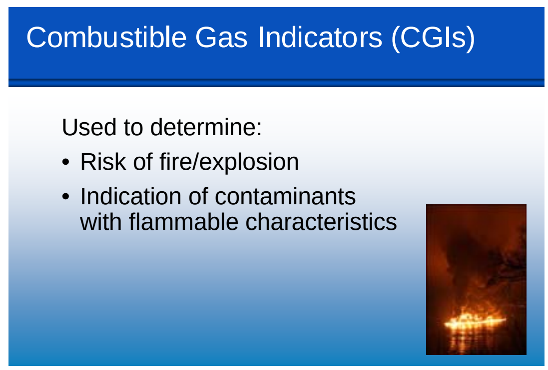
Response time slows as the temperature decreases until freezing, at which point the detector becomes inoperative.





COMBUSTIBLE GAS INDICATORS (CGI)

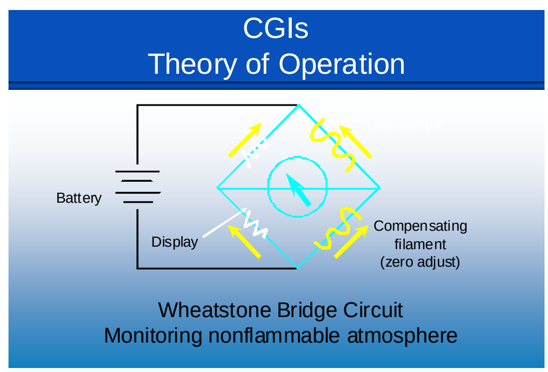
Normally, CGIs cannot be used to determine the contaminant or its concentration. The CGI will not operate without sufficient oxygen to support combustion.

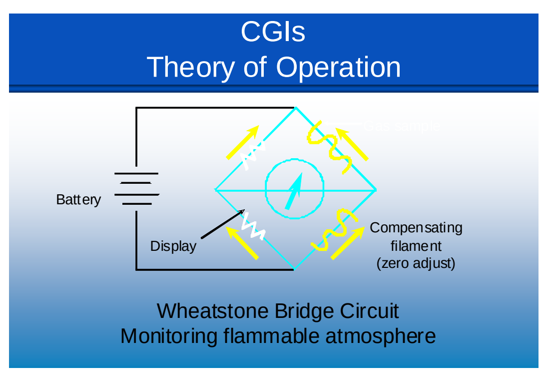


PRINCIPLE OF OPERATION

Combustible gas indicators are battery-powered and use a compensating filament to correct for changes in ambient air temperature. The filament is part of a balanced resistor circuit called a "Wheatstone Bridge." In a "clean" atmosphere, the bridge is balanced so no current flows through the meter, thus resulting in a "0" reading.

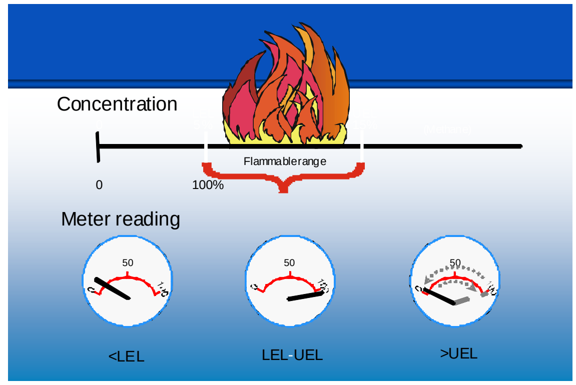
As a flammable gas is drawn into the instrument, a combustion chamber containing the filament combusts the flammable gas. To facilitate combustion, the filament is heated or is coated with a catalyst like platinum or palladium, or both. The hot filament combusts the gas on the immediate surface of the element, thus raising the temperature of the filament. As the temperature of the filament increases, so does its resistance. This change in resistance produces an





imbalance in the Wheatstone Bridge, which, in turn, causes a portion of the current to be redirected through the meter circuit. Thus, as the chemical's concentration increases, so does the meter response.

CONCENTRATION

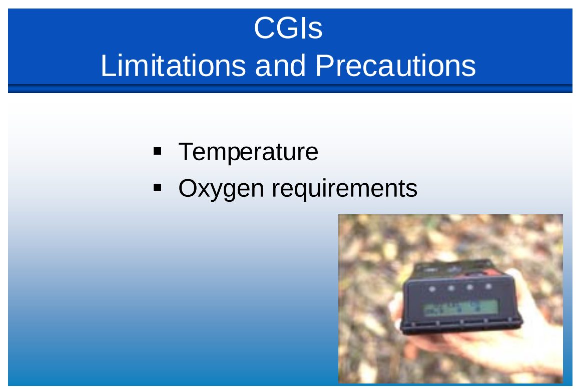


As the ambient methane concentration increases, the meter response will increase proportionally until it reaches 100% of the LEL. Methane = 5%.

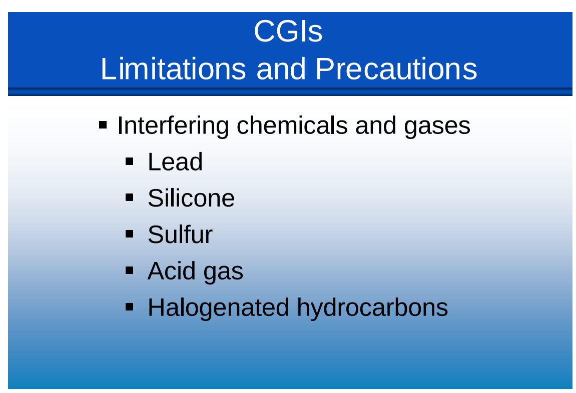
At a methane concentration of 5%–15%, the meter will stay "pegged" at or above 100%. Some instruments electronically "lock in" at this point and can only be unlocked by leaving the area, turning off the instrument, then turning it back on.

With a methane concentration above 15%, combustion stops, thus causing the meter reading to drop to "0." Those instrument alarms that "lock in" at 100% of LEL have to be manually reset.

LIMITATIONS AND PRECAUTIONS



If the temperature at which the instrument is zeroed differs from the sample temperature, the accuracy of the reading is affected. Higher temperatures raise the temperature of the filament and produce a higher than actual reading. Cooler temperatures reduce the reading. *Always* "zero" a meter in an uncontaminated environment with a temperature close to the one in which you will be working, otherwise changes in ambient temperature will cause changes in meter response.

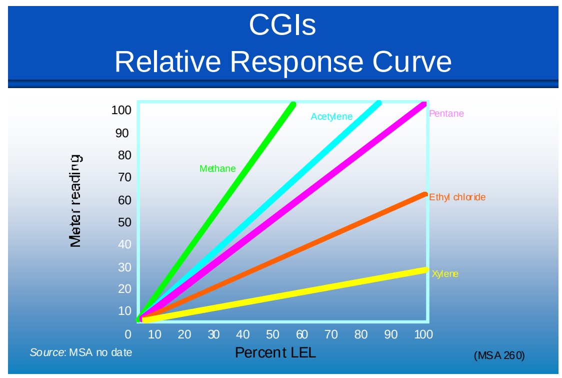


CGIs detect temperature change from burning gases or vapors, so if there is insufficient oxygen to burn properly, the meter will not indicate correctly. Oxygen-deficient atmospheres will produce readings that are lower than actual concentration. Also, the safety guards that prevent the combustion source from igniting a flammable atmosphere are not designed to operate in an oxygen-enriched atmosphere.

There is no differentiation between petroleum vapors and combustible gases. If the flammability of the combined vapors and gases in an atmosphere is the concern, this is not a problem. However, if the instrument is being used to detect the presence of a released flammable liquid—like gasoline—in a sewer system where methane may be present, the operator cannot tell if the reading is the contaminant or the methane.

A pre-filter can be used to remove the vapors but will not remove the methane. Thus, if readings are made with and without the filter, the user can compare the readings and can conclude that differences in the values indicate that a petroleum vapor (contaminant) is present.

RELATIVE RESPONSE CURVE



The CGI measures the change in thermal energy. Because some chemicals burn "hotter" and others "colder," the response of the instrument will vary significantly for different chemicals due to the differences in thermal energy output. For example, on this curve for the MSA-260 calibrated to pentane, methane over responds because it burns hotter than pentane. It under-responds to xylene because it burns colder than pentane.

CGIs are available in many styles and configurations. All units have some type of pump to draw the air sample into the detector. The pumps are either hand-operated aspirator bulbs or automatic (battery-powered) diaphragm types. Flashing and audible alarms are options on many units. Many units are "combination meters" which means they can measure both oxygen and combustible gases. The alarms go off at a preset concentration to warn the instrument operator of potentially hazardous concentrations. Other options, such as larger sampling lines, moisture traps, and dust filters, are also available.

MSA-245

MSA-245 is a passive detector for oxygen monitoring. There are no automatic features or alarms. The remote sensing probe with an aspirator bulb accessory is available. Although it is no longer manufactured, many are still in use.

MSA-2A

MSA-2A is an active detector with an aspirator bulb attachment. It has no automatic features or alarms.

MSA-260/261

MSA-260/261 models are active detectors with automatic pumps. They detect both oxygen and combustible gases and have alarm functions for both. The combustible gas meter "locks" at 100% LEL and must be turned off to reset. These units are no longer manufactured, but are still in common use.

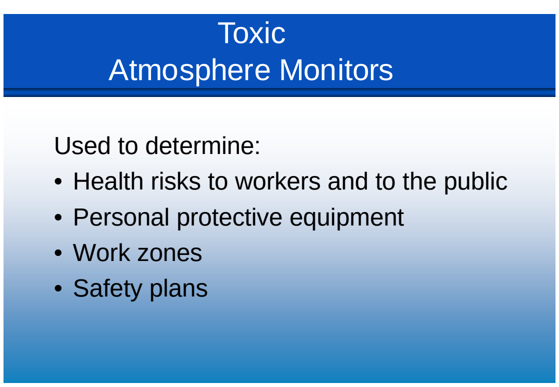
LTX-310

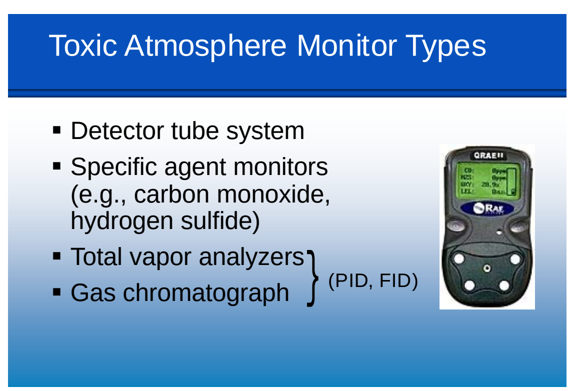
LTX-310 units are passive detectors with automatic sample pumps as a separate unit for remote monitoring. They measure oxygen, combustible gases, and one toxic gas of choice. There is a programmable alarm which has set points for all sensors. The combustible gas indicator "locks" at 100% LEL and must be turned off to reset.

SPECIFIC CHEMICAL MONITORS

Detector tubes allow the versatility of being able to measure a wide range of chemicals with a single pump. Also, there are some chemicals for which detector tubes are the only direct-reading indicators available**.**

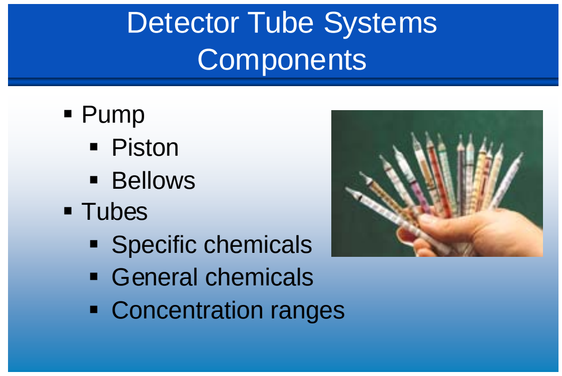
The tube systems, sometimes called "colorimetric indicators," show the presence and concentration of the toxic airborne chemical(s) they are designed to detect. Most are for single chemicals. The specific agent monitors are usually electrochemical cells or metal oxide semi-conductors that are designed to measure a specific chemical. The gas chromatographs use *photoionization detectors* (PID) and *flame ionization detectors* (FID) discussed later in this section) in conjunction with columns that provide some chemical separation.



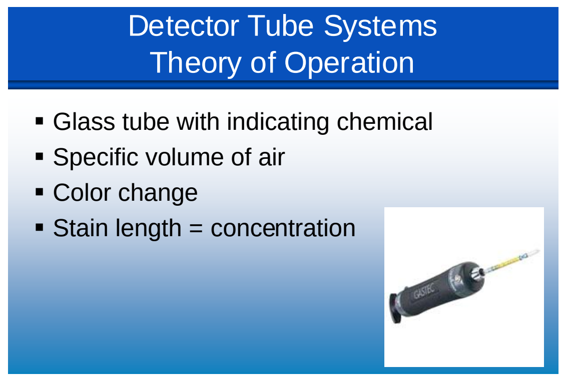


TUBE SYSTEMS

The tube systems were formerly certified for an accuracy of ±25%, but field studies indicate that actual concentrations may vary by as much as a factor of 2. Some manufacturers provide correction formulas for using the tubes outside of the normal range. However, some "standards" organizations advise not to use the tubes outside of their design parameters. Special studies have reported error factors >50% for some tubes.

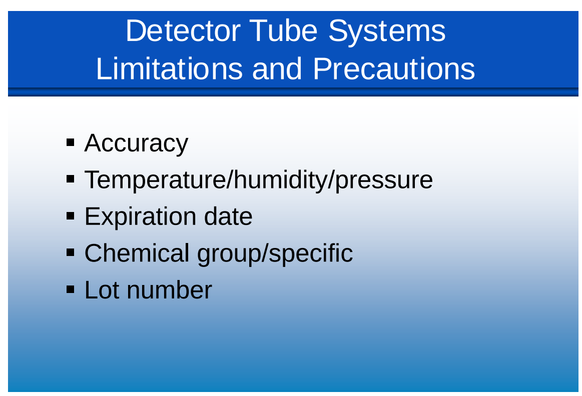


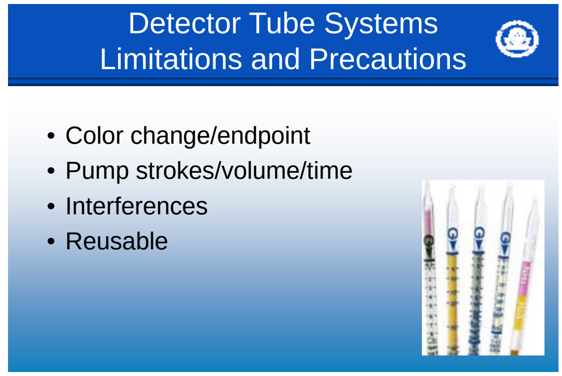
The chemical reactions involved in the use of the tubes are affected by temperature. Cold weather slows the reactions and thus the response time. Hot temperatures increase the reaction and can cause a problem by discoloring the indicator when a contaminant is not present. This can happen even in unopened tubes. Therefore, the tubes should be stored at a moderate temperature or even refrigerated.



The tubes are assigned a shelf-life, usually between 1 and 3 years.

Know what the expected color change should be because some color changes do not have good contrast, making it difficult to read the endpoint accurately. Because the length of color change indicates the contaminant concentration, the user must be able to see the end of the stain. Some stains are diffused and are not clear-cut, while others may have uneven endpoints. Larger diameter tubes tend to have less distinct endpoints due to the diffusion of the chemical at the endpoint. When in doubt, use the highest value that would be obtained from reading the different aspects of the tube.





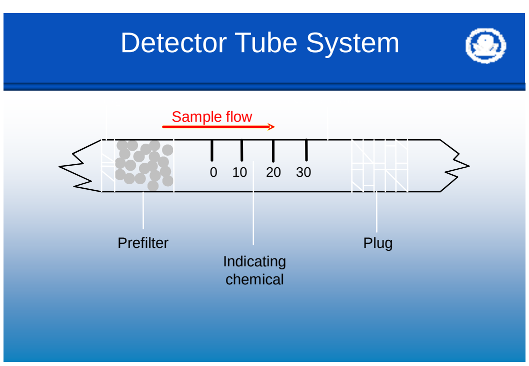
Know the number of pump strokes required for a given test, because some tubes have multiple scales and require a different number of pump strokes for each. Most tubes draw about 100 ccs of air with each stroke; however, some require partial strokes to obtain a particular volume. These are only the piston-type pumps. Some tubes have indicators to show when the pump has finished drawing air, while others say to wait a predetermined time. It may take from 1 to 2 minutes for each stroke to be completely drawn. Therefore, sampling times can vary from 1 to 30 minutes per tube. This can make the use of detector tubes time-consuming.

Know which chemicals cause interference and either give a “false positive” indication or suppress the response. While some tubes are reusable, most are for single-use and are disposable.

Because of these many considerations, it is very important to read the instructions provided for, and specific to, a set of tubes. The information includes the number of pump strokes needed, time for each pump stroke, interfering gases and vapors, effects of humidity and temperature, shelf life, proper color change, and whether the tube is reusable.

DETECTOR TUBE SYSTEM

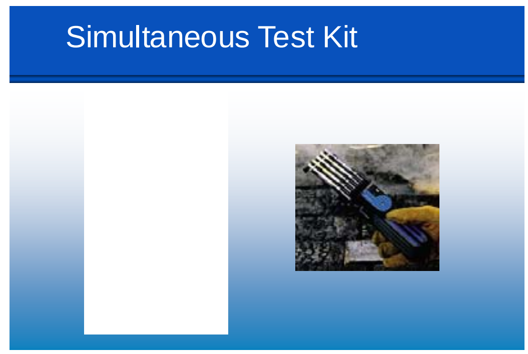
The Accuro 2000 bellows pump is the newest version from Draeger. The Draeger CHIP System, with nine (9) detection tubes per chip, can automatically read the tube and provide readout. The CHIP System uses an optical reader that measures the rate of color change rather than stain length. Its results are accurate and precise.



DRAEGER CMS

Has nine detection tubes per chip. Automatically reads the tube and provides digital readout of the concentration. Uses an optical reader that measures the rate of color change, as opposed to stain's length. Results are both accurate and precise.

SIMULTANEOUS TEST KIT



This Simultest kit has five (5) separate tubes in a manifold arrangement to allow simultaneous monitoring of multiple chemicals. Four different kits are available with different chemical combinations, including chemical warfare agents.

REFERENCES

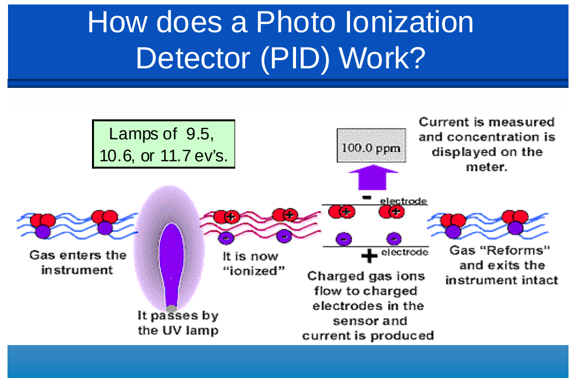
National Fire Protection Association Fire Protection Guide, NFPA 497M, Classification of Gases, Vapors, and Dusts for Electrical Equipment in Hazardous (classified) Locations. National Fire Protection Association, Quincy, MA. 1991.

THIS PAGE INTENTIONALLY BLANK

AIR MONITORING INSTRUMENTS II

PHOTOIONIZATION DETECTORS (PIDS)

These instruments detect concentrations of gases and vapors in air, using an ultraviolet light source to ionize the airborne contaminant. PIDs use a fan or pump to draw air into the detector of the instrument, where the contaminants are exposed to UV light and the resulting negatively charged particles (ions) are collected and measured. Once the gas or vapor is ionized in the instrument, it can be detected and measured.



All atoms and molecules are composed of particles: electrons, protons, and neutrons. Electrons, negatively charged particles, rotate in orbit around the nucleus, the dense inner core. The nucleus consists of an equal number of protons (positively charged particles) as electrons found in the orbital cloud.

High frequency radiation (ultraviolet and above) is capable of causing ionization and is hence called "ionizing radiation." The energy required to remove the outermost electron from the molecule is called the "ionization potential" (IP) and is specific for any compound or atomic species.

Photoionization

$$R + h┼ \rightarrow R^+ + e^-$$

R = chemical absorbing UV

h = Planck's Constant (4.136×10^{-15} eV/sec)

┼ = light frequency (sec $^{-1}$)

e^- = free electron

R^+ = ionized analyte

Lamp energy = h┼ IP (ionization potential)

THEORY OF OPERATION

Energy comes from the ultraviolet light. When a photon of ultraviolet radiation strikes a chemical compound, it ionizes the molecule if the energy of the radiation is equal to or greater than the IP of the compound. Because ions are charged particles, they may be collected by electrodes on a charged plate to produce an electrical current. The current is amplified, measured, and displayed as a meter response. The current generated is directly proportional to the number of ionized molecules or the concentration of the chemical being detected.

INSTRUMENT TYPES

Exterior passive sensors are found on the outside of the instrument and require that gases penetrate into the sensor (no pump is used). Internal active sensors usually use a small fan or diaphragm pump to draw samples, though some passive instruments have an optional aspirator bulb. Some instruments may have a PID combined with a CGI, chemical cell, or FID mounted in the same instrument to detect a wider range of airborne contaminants.

Instrument Types

- Exterior passive sensors
- Internal active sensors
  - Manual pump
  - Automatic pump
- May have single detector or combination units

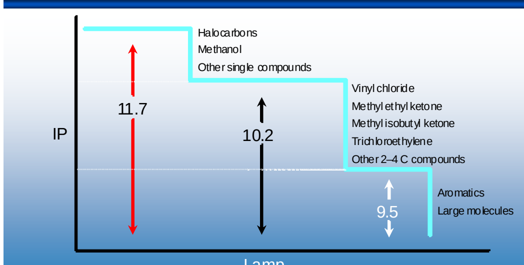
LAMP ENERGIES

The reported energy of the lamp is its predominant energy. It is possible for a 10.2 eV lamp to have some energy output higher or lower than 10.2, but its intensity will be low. Therefore, it may be possible to detect chemicals with an IP slightly greater than the rated energy of the lamp, but the instrument response will be inadequate.

Ionization Potentials

Chemical	IP(eV)	Chemical	IP(eV)
Carbon monoxide	14.0	Hydrogen sulfide	10.5
HCN	13.6	Hexane	10.2
Methane	13.0	Ammonia	10.2
HCl	12.7	Acetone	9.7
Water	12.6	Trichloroethylene	9.45
Oxygen	12.1	Benzene	9.2
Chlorine	11.5	Triethylamine	7.5
Propane	11.1		

Examples of Lamp Energies and Detectable Chemicals



Source: HNU 1985

PID LIMITATIONS

Because the instrument's ability to detect a chemical depends on its ability to ionize it, the ionization potential (IP) of a chemical, to be detected, must be less than or equal to the energy generated by the UV lamp. Limits are imposed by the components of air, in that the lamp cannot be too energetic or oxygen and nitrogen will ionize, causing interference with readings for contaminants.

Photoionization Detector (PID) Limitations

- Lamp energy / chemical IP
- Dust
- Humidity
- High methane
- Electromagnetic radiation
- Lamp aging
- Relative response
- High concentrations
- Low oxygen concentrations

One use of the different lamps is for selective determination of chemicals. For example, if a spill involving both propane and vinyl chloride were to be monitored with a PID, the first check would be to see whether either or both could be detected. The IP of propane is 11.1 eV and the IP of vinyl chloride is 10.0 eV. To detect both, a lamp with energy greater than 11.1 eV is needed (e.g., 11.7 or 11.8). If vinyl chloride were the chemical of concern, then a lamp with energy greater than 10.0 but less than 11.1 (such as 10.2 or 10.6) could be used. The propane would be neither ionized nor detected. Thus, propane would not interfere with the vinyl chloride readings.

The sample drawn into the instrument passes over the lamp to be ionized. Errors in response can be caused by a number of conditions. First, dust on the lamp window can block the transmission of UV light, thus reducing the instrument response. This problem is usually detected during calibration, but even so, the lamp should be cleaned regularly.

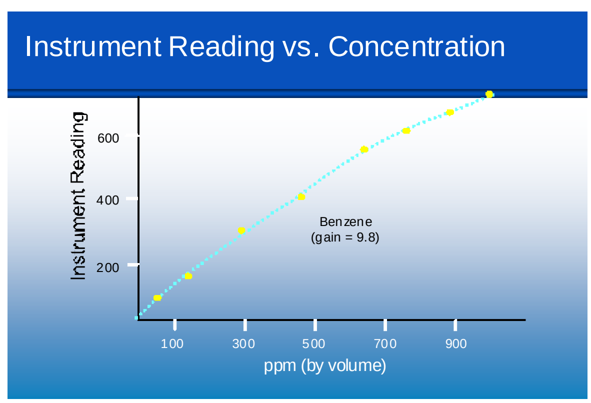
Lastly, humidity can cause two problems. The first occurs when a cold instrument is taken into a warm, moist atmosphere, condensation can fog the lamp. The second is that moisture in the air reduces the ionization of chemicals because water molecules, being bipolar, scavenge ions from the sample, and absorb UV light. This causes a reduction in readings. *A relative humidity (RH) of 90% can reduce response by as much as 50%*.

Relative Responses for HNU PI-101 with 10.2 eV Probe

Chemical	RR	IP(eV)
m-Xylene	1.12	8.56
Benzene	1.00	9.25
Phenol	0.78	8.50
Isobutylene	0.55	9.25
Acetone	0.63	9.69
n-Hexane	0.22	10.18
Ammonia	0.03	10.18

Because an electric field is generated in the sample chamber of the instrument, radio frequency (RF) interference caused by pulsed DC or AC power lines, transformers, generators, and/or radio transmitters may produce erratic and erroneous readings.

Light intensity of the lamp decreases with age. It will still have the same ionization energy, but the reduced intensity causes a decline in response. This condition should be detected during calibration in order to make compensating adjustments. However, the lamp will eventually burn out.



Photoionization detectors are calibrated to a single chemical. The instrument's response to chemicals other than the calibration gas/vapor can vary.

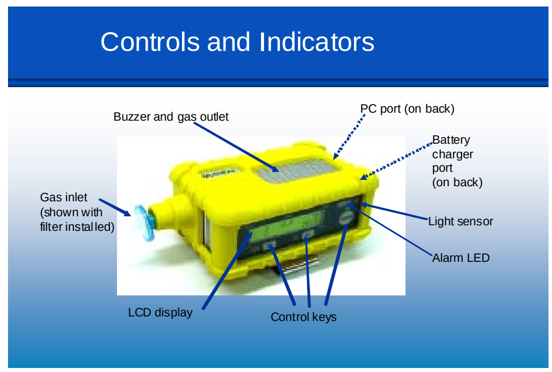
In some cases, at high concentrations the instrument response can decrease. While the response may be linear (i.e., 1-to-1 response) from 1 to 600 ppm for an instrument, a concentration of 900 ppm may only give a meter response of 700. These instruments are *trace* gas analyzers, and are not designed to handle high concentrations.

Oxygen concentrations less than 10% decrease the oxygen quenching effect and cause an increased response on the meter.

MultiRAE PLUS MULTI-GAS MONITOR

The MultiRAE Plus combines a PID (Photoionization Detector) with the standard four gases of a confined space monitor (O_2, LEL, and two toxic gas sensors) in one compact monitor with sampling pump.

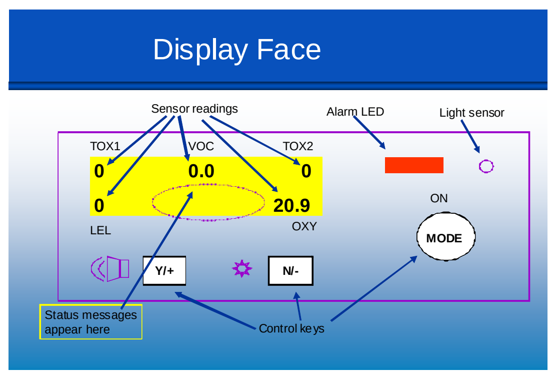
CONTROLS AND INDICATORS



The inlet is the entry point for gases and vapors into the instrument. All accessory tubing or filters attach to the inlet.

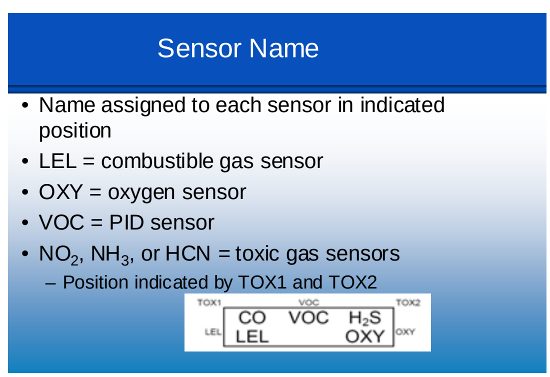
The alarm buzzer sound and gases from inside the meter will exit at the outlet area.

The PC port connects the PC cable to the instrument for data transfer.



This slide depicts other features on the face of the meter. The MultiRAE Plus quickly and easily changes from a sophisticated technician instrument to a simple text-only monitor. Other uses include personal monitoring, a hand-held sniffer, or as a continuous operational area monitor.

SENSOR NAME



This display shows the names of each sensor without the gas readings. Sensor abbreviations appear on the slide. Two of the three toxic gas sensors shown are installed in each instrument; the display will indicate which ones are installed.

ALARM CONDITIONS

Alarm Conditions

Alarm Condition	Signal
Exceed high alarm limit	3 beeps and flashes per second, sensor name
Exceed low alarm limit	2 beeps and flashes per second, sensor name
Exceed STEL limit	1 beep and flash per second, sensor name
Exceed TWA limit	1 beep and flash per second, sensor name
Negative drift or over range	3 beeps and flashes per second, NEG 3 beeps and flashes per second, OVR
Pump failure	3 beeps and flashes per second, PUMP
LEL sensor off	3 beeps and flashes per second, LEL OFF
PID lamp failure	3 beeps and flashes per second, LAMP
Low battery	1 flash per second, 1 beep per minute, BAT
Memory full	1 flash per second, MEM

This table of alarms shows the number of beeps and flashes for each type of alarm condition. In general, three beeps and flashes per second indicate a dangerous condition, two per second is a warning, and one per second is for information.

The table lists the displayed Screen Message during an alarm, in uppercase letters under the "Signal" heading. This word, or the appropriate sensor name, will flash on the display during the alarm. Touching the "Yes" key will only silence the horn. Clearing the alarm condition extinguishes the Red LED and stops flashing display.

"BUMP" TESTING

"Bump" Testing

- Done before daily use after fresh-air calibration
- Check that meter is reading expected values
- Procedure:
  1. Return to instant reading after fresh-air calibration
  2. Expose meter to span gas via calibration adapter
  3. If meter reads within 10% of listed values, OK
  4. If not, perform calibration on sensors that failed

A bump test is a quick check of the instrument to verify that it is working properly, much like a confidence test in some instruments. Do this immediately after the fresh-air setup during the preparation for operation procedures before every use.

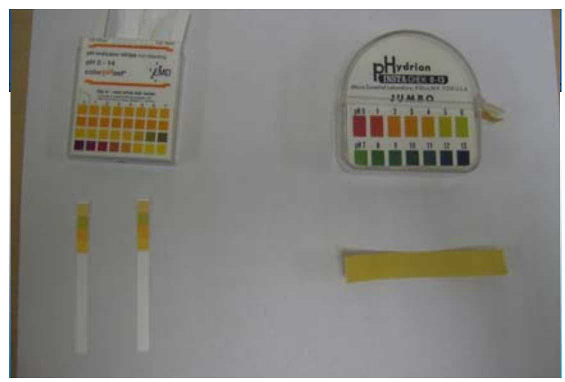
The bump test exposes the meter to the span gases in the calibration bottles. If the meter sensors read within 10% of the expected concentration values of the span gases, the operator should not have to calibrate the meter.

Perform the Bump test procedures in accordance with manufacturer's instructions. A typical procedure would be to obtain the calibration kit and set up the span gas. After completing the fresh-air setup, return to normal gas reading. Press "Mode" until the display shows the instant readings. Expose the meter to the span gas for at least 30 seconds. If the meter readings are within 10% of the concentration values on the bottle, the meter passed the test. If not, calibrate the sensors that failed. Repeat with every span gas bottle as needed to test every sensor, including the PID.

Here are several examples of passive and active multi-gas instruments. Selecting the instrument, which will meet the atmospheric testing requirements of your projects, may come down to personal preference. Manufacturers are developing faster, small and more cost effective instruments yearly.

We have already discussed corrosivity and the power of hydrogen (pH). As a review, in chemistry, pH is a measure of the acidity or alkalinity (basic) of an aqueous solution. Water is neutral, with a pH close to 7.0 at 25 °C (77 °F). Solutions with a pH less than 7 are acidic and solutions with a pH greater than 7 are basic or alkaline. pH measurements are important in several areas of science, not only chemistry, but medicine, biology, environmental science, oceanography, civil engineering and many other applications.

Litmus is a water-soluble mixture of different dyes extracted from lichens, especially Roccella tinctoria. It is often absorbed onto filter paper to produce one of the oldest forms of pH indicator, used to test materials for acidity.



One of the easiest of multiple chemical tests is the chemical test strip. Several strip types are on the market, Chemical Classifyer, and a similar version for wastewater is examples. Similar to litmus, these strips are for testing unidentified liquid samples and can assist in identifying unknown materials. There are five tests on each strip. Dipping the strip into the unidentified materials is the manufacturer's intent. However, a preferable method is to draw a sample with a pipette and place a small drop onto each test area. In this way, a closer observation of the results can be obtained.

ORGANIC VAPOR METER - 580A

Controls
Built-in data logger

Similar to others, the major difference in this unit is the built-in data logger that can either play back through the instrument or be downloaded to a computer. The controls are push-button, rather than dials. The internal electronics compensate for response at high concentrations. Although it is not considered a continuous survey meter because it takes readings at preset intervals, the interval can be set as low as 1 second if continuous monitoring is desired.

The OVM-580S is intrinsically safe, but operating it is more complicated than other survey instruments.

THERMO-ENVIRONMENTAL INSTRUMENT MODEL 580EZ

This is an alternative to the Organic Vapor Meter (OVM). It is user-friendly, especially for HazMat work. The quick-change probes include a water trap filter, dilution for high concentrations, a charcoal scrubber, and extensions. It allows the user to preset alarms.

PHOTOVAC MODEL

Photovac
Model 2020

This unit is small, lightweight, and easy to use. It has preset alarms and data storage.

TOXIRAE

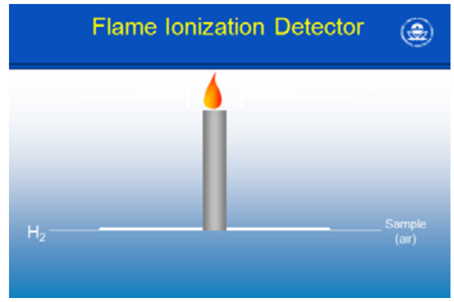
Photo Rae Corp.
ToxiRae

This is a passive PID that is used as a personal dosimeter. Because it is a passive device with no pump, its response time is slower than instruments with active detectors. It has preset alarms.

MSA PASSPORT

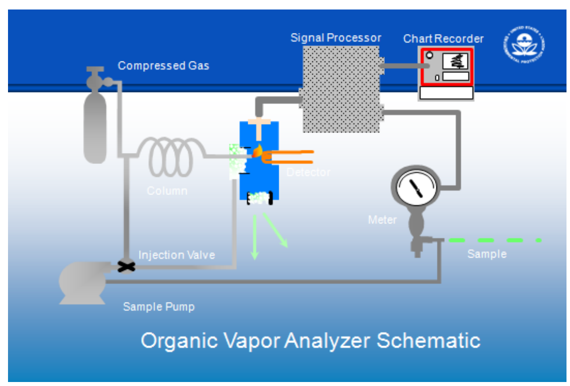
Although the MSA Passport was originally designed as a passive personal dosimeter, it has a pump attachment that allows it to be used as an active survey meter. The unit only has three buttons so it is easy to use. It also has preset alarms and data logging capabilities.

FLAME IONIZATION DETECTOR(FID) THEORY OF OPERATION



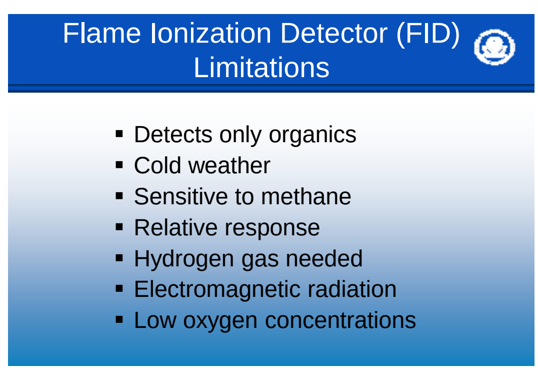
The Flame Ionization Detector responds to any molecule with a carbon-hydrogen bond, but its response is either poor or nonexistent to compounds such as hydrogen sulfide, ammonia, or carbon tetrachloride. Since the FID is "mass" sensitive, not concentration sensitive, changes in carrier-gas-flow rate have little effect on the detector response. It is useful for general hydrocarbon analysis, with a detection range from 0.1ppm to almost 100%. The FID's response is stable from day to day, and is not susceptible to contamination from dirty samples or column bleed. It is generally robust and easy to operate, but because it uses a hydrogen diffusion flame to ionize compounds for analysis, it destroys the sample in the process.

ORGANIC VAPOR ANALYZER SCHEMATIC



The sample of air is drawn into the probe by the sample pump, where an injection valve mixes it with hydrogen (H_2) gas at the pump outlet. The sample/H_2 blend is then introduced into the explosion-proof sample chamber, where the pilot light ignites the atmosphere. The mixture's burning creates ion pairs, which are collected by the electrodes. The current generated at the input electrode passes through a preamplifier, whose output signal is proportional to the ionization current. A signal-conducting amplifier is used to amplify this signal and to condition it for subsequent display on either the meter or on an external recorder.

FLAME IONIZATION LIMITATIONS



Lighting the FID and maintaining the flame in cold weather can be a problem. Because methane is used as a calibration gas for the OVA, naturally occurring methane from landfills or decaying organic matter may cause interference. As with all instruments, FIDs respond differently to different chemicals.

The hydrogen fuel, which must be at least 99.999% pure, can be a problem to ship. However, a new unit from Sentex uses water as its hydrogen source. As with many solid state instruments, electromagnetic (RF) radiation can cause interference. In addition, oxygen concentrations of less than 14% can cause “flameout.”

FID METHANE CALIBRATION

When a FID is calibrated to methane, it detects benzene at higher than actual concentrations and detects acetone at lower than actual concentrations.

Relative Response for FID Calibrated to Methane

Chemical	Response
Methane	1.00
Propane	0.64
Benzene	1.50
Toluene	1.20
Acetone	0.60
Vinyl chloride	0.35

APPLICATION SUMMARY

Both of these instruments are field-screening devices that are used to determine whether there are detectable gases or vapors present either in the atmosphere or at a specific source, such as a leaking drum or contaminated soil. They are not designed to provide quantitative results.

FIDs have a more generalized response in detecting organic vapors than PIDs. Therefore, large sensitivity shifts between different substances are not seen when using a FID, as opposed to a PID.

Summary of Applications

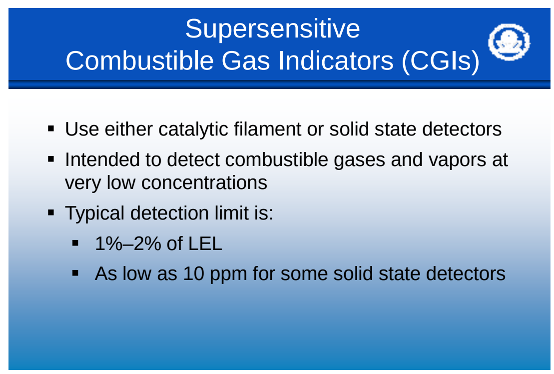
	PID	FID
Detects	Many organics, some inorganics	Organics only
Measures	Total concentration of detectable gases or vapors	
Cal. Gas	Isobutylene	Methane
Ease of Operation	Fairly easy	Requires experience
Detection Limit	0.1 ppm benzene	0.1 ppm methane
Atmosphere Limitations	Dust or humidity	Cold <40\F or low oxygen

TVA-1000 TOXIC VAPOR ANALYZER

The TVA-1000B Toxic Vapor Analyzer is a portable, organic/inorganic vapor monitor. This analyzer uses either a flame ionization detector (FID), or a photoionization detector (PID), or both types of detectors to sample and measure concentration of gases.

The vapor concentration may be read immediately on either of two displays — one mounted directly on the hand-held sample probe and the other on the instrument "sidepack" itself. Vapor concentration can be displayed on both displays in parts per million (ppm), parts per billion (ppb), or percent concentration (%). The data displayed may also be collected and saved in analyzer memory and downloaded to a personal computer for analysis.

SUPERSENSITIVE CGI

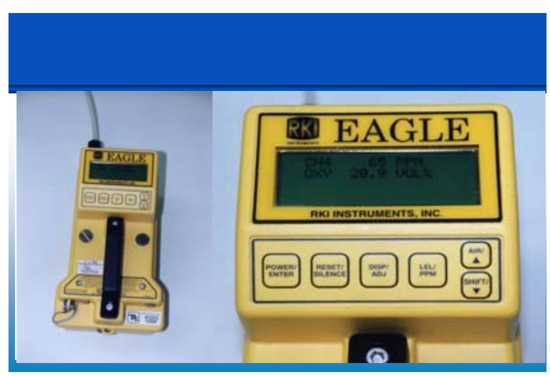


There are toxic monitors that use the same detection system as CGIs but are more sensitive. These are *Supersensitive* CGIs with *readouts in ppm instead of % LEL*. Supersensitive CGIs detect the same gases and vapors that are detected by an FID. This allows early detection of leaks while they are still well below the flammable range. These instruments can also be used to help control worker exposures to organic gases and vapors.

BACHARACH TLV SNIFFER

This instrument only reads in ppm. It is calibrated to hexane and ranges up to 10,000 ppm. The hexane LEL equals 1.1% or 11,000 ppm.

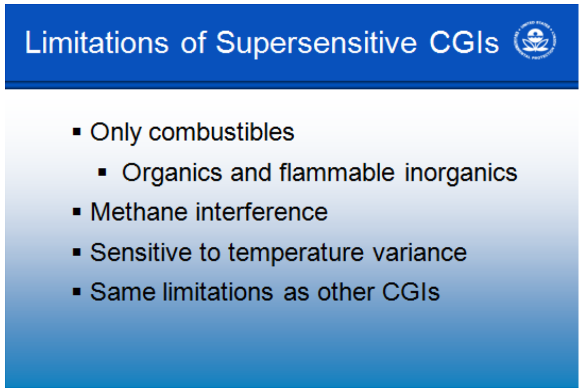
RKI EAGLE

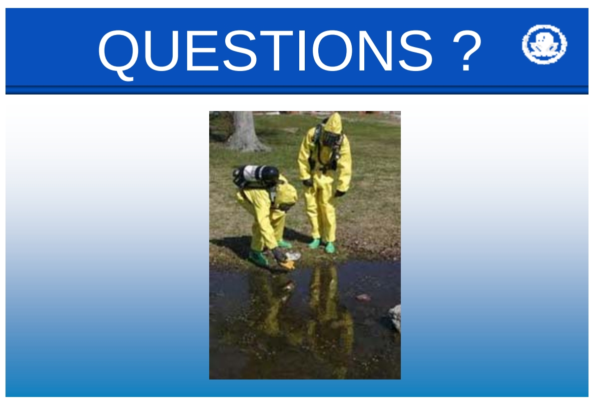


Simultaneous detection of up to six different gases, with a wide range of toxic gases. The instrument displays either ppm or LEL hydrocarbon detection. Infrared sensors are employed for carbon dioxide detection; methane elimination switch.

May be used as a survey instrument or as a personnel dosimeter when properly employed; has programmable alarm set point; and measures organics and some flammable inorganic chemicals.

SUPERSENSITIVE CGI LIMITATIONS





REFERENCES

HNU. Trace Gas Analyzer, HNU Model PI 101: Instruction Manual. HNU Systems, Inc. Newton Highlands, MA, 1985. (Used with permission of HNU Systems, Inc.)

THIS PAGE INTENTIONALLY BLANK

TOXICOLOGY AND EXPOSURE GUIDELINES

Student Performance Objectives

1. Explain the “dose-response relationship” as it relates to toxicity.
2. Discuss the following as they relate to toxicity:
    a. Local effect
    b. Systemic effect
    c. Asphyxiation
    d. Sensitization
    e. Teratogen
    f. Mutagen
    g. Carcinogen
3. List the routes of exposure.
4. Describe the following chemical interaction terminology:
    a. Addition
    b. Synergism
    c. Potentiation
    d. Antagonism
5. Name the organizations identified under 29 CFR 1910.120 that develop exposure limits.
6. Identify the types of exposure limits applied to airborne contaminants at hazardous waste sites.
7. List three uses for exposure limits as specified in 29 CFR 1910.120.

THIS PAGE INTENTIONALLY BLANK.

TOXICOLOGY

Toxicology is an ancient science. The term literally means the “study of poisons.” Toxicology was used to determine how to incapacitate or kill organisms, including humans, using poison.

A modern approach to toxicology is the study of the interaction between chemical agents and biological systems. It is known that a given amount of a substance can produce certain harmful effects. While the subject of toxicology is quite complex, it is necessary to understand the basic concepts in order to make logical decisions concerning the protection of personnel from toxic-substance injuries.

Paracelsus **(1493-1541),** more properly Theophrastus Phillippus Aureolus Bombastus von Hohenheim,

As Paracelsus suggests, the quantity or dose of a substance determines whether its effects are toxic, nontoxic, or beneficial. In addition to dose, other factors may also influence the toxicity of a compound, such as the route of entry, the duration and frequency of exposure, variations between different species (interspecies), and variations among members of the same species (intraspecies).

Toxicity

The ability of a substance to cause adverse effects in living organisms

Toxicology

Classic definition: "Study of Poisons"

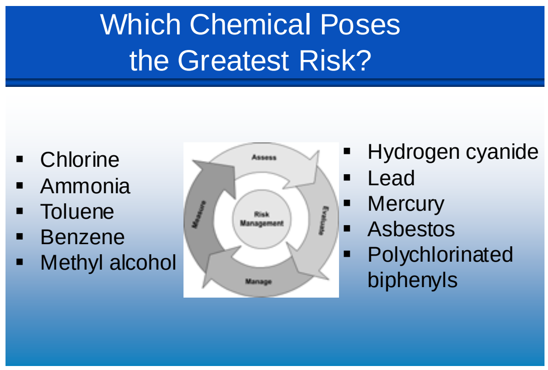
Modern concept: "Limits of Safety"

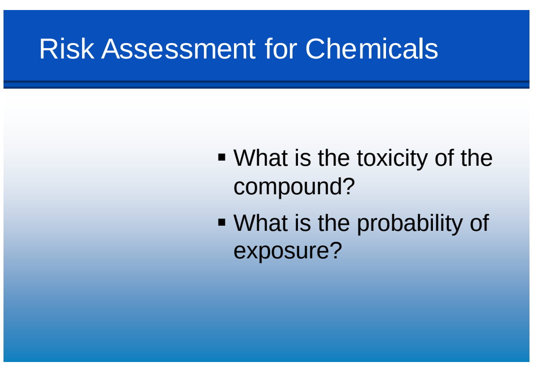
Paracelsus(1493–1541)

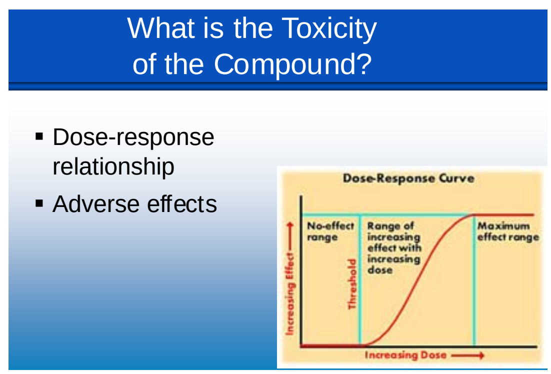
“All substances are poisonous; there is none which is not a poison. The right dose differentiates a poison from a remedy.”

TOXICITY INFORMATION

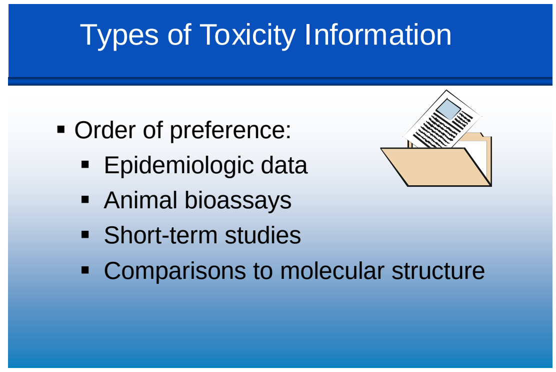
When assessing toxicity information, it is important to understand two different concepts: *dose-response relationship* and *adverse effects*. In general, these indicate how much of a toxic agent is necessary to elicit a predetermined type and intensity of a response in an experimental population. The dose-response relationship is a fundamental concept in toxicology and the basis for measuring the relative harmfulness of a chemical.







TYPES OF TOXICITY



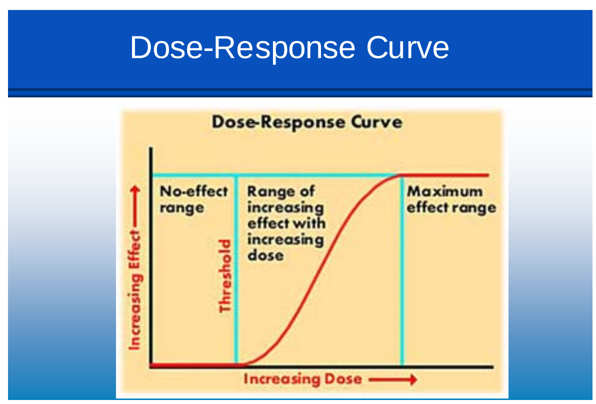
There are several sources of toxicological information. The following sources, in the order of decreasing confidence, provide information on the toxic properties and dose-response relationships of chemical compounds:

(1) Epidemiological investigations of exposed human populations (2) Animal studies used to test human organ systems. However, these may indicate different responses due to the differences in metabolic processes between humans and the subject animals

(3) Clinical short-term studies of humans or animals on acute exposures and immediate effects. This does not provide information on chronic exposures or long-term effects

(4) Comparisons of similar molecular structures. This kind of information can be misleading, even dangerous, due to the way organisms metabolize chemicals with similar, but not identical, molecular structures. For example, humans can metabolize ethyl alcohol fairly easily, but methyl alcohol will cause serious physiological problems, even death.

DOSE-RESPONSE CURVE



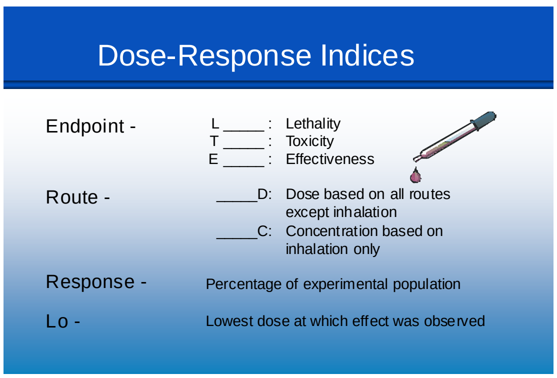
A *dose* is the relative strength of an administered substance (whether it was administered deliberately or accidentally). To ensure consistency of information, the dose is normally represented by the amount of substance per unit of body weight. A dose-response curve represents the dose of the chemical versus the percentage of the experimental population affected.

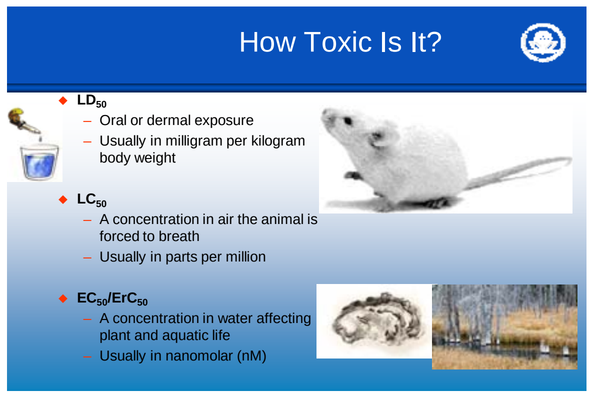
The stochastic effect is a direct function of the dose, whose probability of occurrence in an exposed population has no threshold. These include cancer and birth defects. Non-stochastic effects are those whose severity are a function of dose and usually have a threshold dose. These include alcohol intoxication, liver damage from chlorinated organic compounds, and kidney damage from heavy metals.

The threshold dose is that dose below which no observable effect occurs in the average individual.

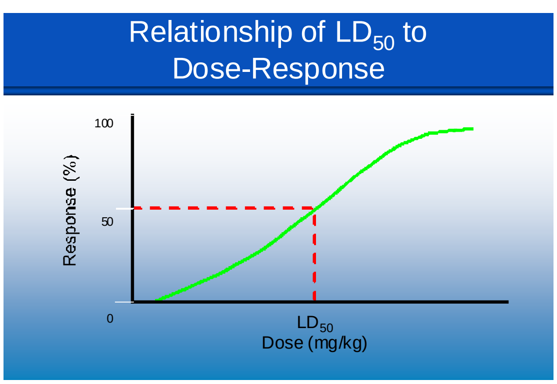
LETHALITY

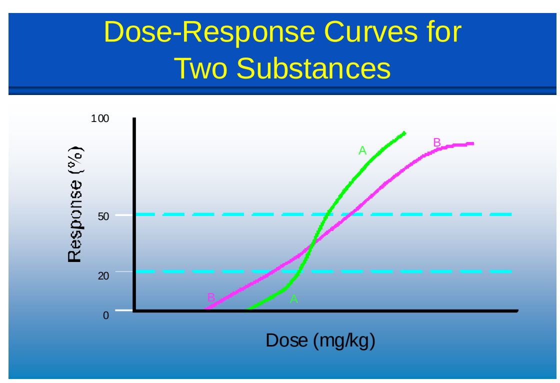
Lethality is the endpoint and is the easiest to observe. LD_{50} (Lethal Dose 50) is the dose that will kill 50% of the population. This is an attempt to identify the average toxicity of a substance for organisms of a particular species.



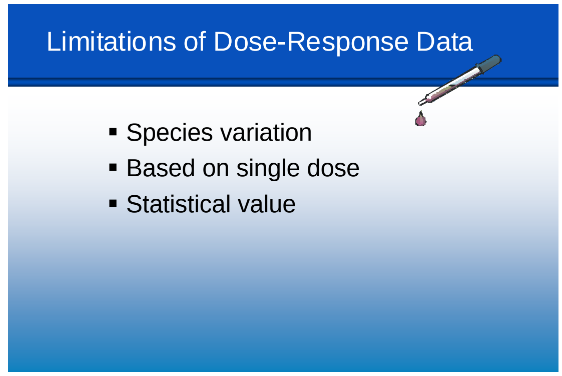


LD_{50} can be illustrated graphically on the dose-response curve by moving horizontally from the 50% point to the curve, then moving vertically downward to get the dose that corresponds to that point. When determining worker protection for operating in a multiple chemical environment, it is more appropriate to compare the lowest observable doses of all chemicals involved as opposed to the LD_{50} for each substance.





TOXICITY DATA LIMITATIONS

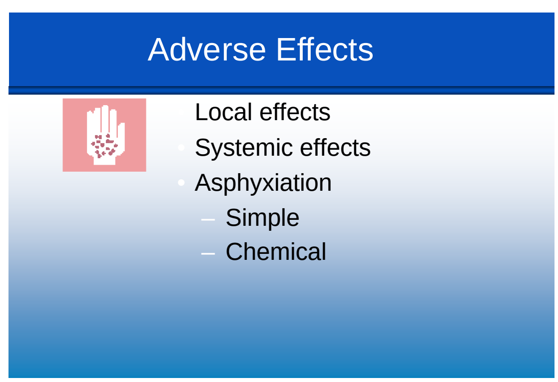


There can be significant limitations in dose-response data that should be considered when assessing exposures. First, it is difficult to select a test species that will closely duplicate the human response to a specific chemical. Although animal testing is used to represent human reaction to exposures, humans may react much differently to a specific agent where multiple systems are involved. For example, human data indicate that arsenic is a carcinogen, while animal studies do not demonstrate these results. Specific metabolic functions can significantly change the outcome. No single animal will provide sufficient information to make overall toxicological determinations. Pigs are used for testing effects on the human digestive tract, while rabbits are used for testing the effects on human skin.

Second, most dose-response data gathered is based on a single dose, whereas most occupational exposures occur incrementally, at varying levels, over a period of time. This data may not accurately reflect the effects produced from long-term or chronic exposures in an occupational environment.

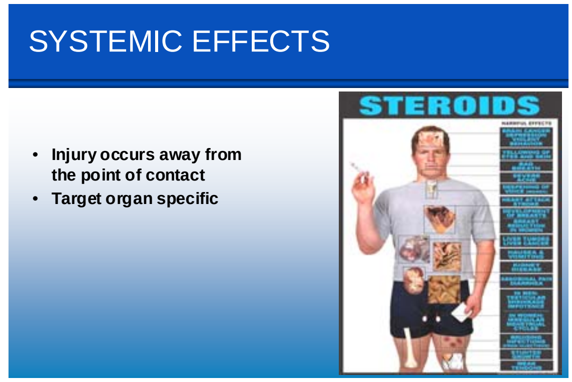
Finally, statistical data can be skewed because of homogenic test populations. Human test subjects may be largely socio-economically disadvantaged, given to undernourishment, sleep deprivation, and substance abuse. Also, different statistical values may be used incorrectly or inappropriately in some circumstances.

ADVERSE EFFECTS



Adverse health effects can range from local to systemic, from mild reactions to cancers, or they may be passed on genetically. Local effects occur on contact, such as skin burns or irritated lungs. Systemic effects occur in a particular organ or system and usually require some type of transport into the body in order to produce the effect. For example, if lead dust is inhaled it can cause damage to the central nervous system.

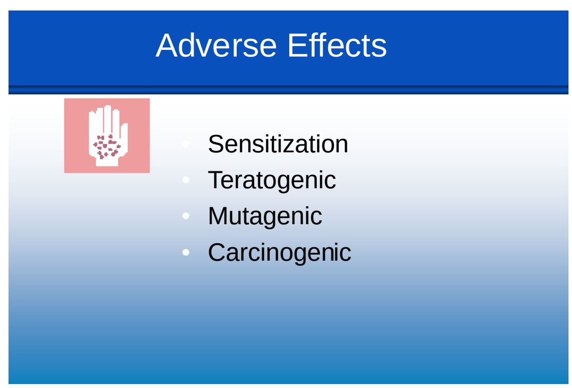
With simple asphyxiation, “inert” gases or vapors in high concentrations displace oxygen leading to suffocation. Examples: nitrogen, helium, neon, methane, and argon.



Chemical asphyxiation is caused when an agent inhibits or prevents the body's tissues from getting enough oxygen even when there is a sufficient amount available. Examples: carbon monoxide and cyanide.

Biological results can be different for the same dose, depending on whether the chemical is inhaled, ingested, applied to the skin, or injected. Local effects occur at the point of contact between the toxicant and the body. This site is usually the skin or eyes, but can include the lungs if irritants are inhaled, or the gastrointestinal tract if corrosives are ingested. Systemic effects occur when the toxicant has been absorbed into the body from its initial contact point, then transported to the susceptible organs. Many chemicals can cause both local and systemic effects.

OTHER EFFECTS



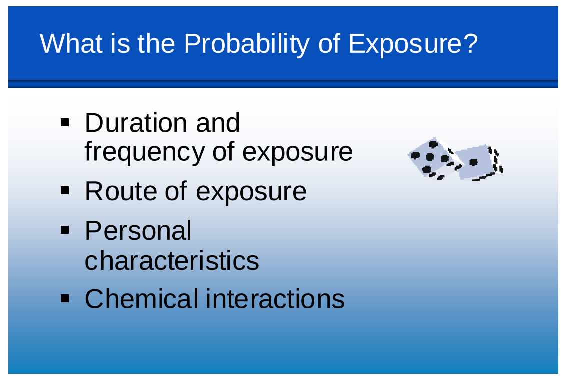
Sensitization is caused by exposure to a toxic agent that makes the individual more susceptible to its effects after future exposures or to a lesser dose when combined with other physical agents (e.g., poison ivy).

Teratogenic effects are caused by exposure to agents that produce birth defects. These can be related to heredity, maternal diseases (e.g., German measles and viral infections), malnutrition, physical injury, radiation, or exposure to chemicals during pregnancy. The greatest concern is during the first trimester of a pregnancy. Teratogenic effects can also occur if a male is exposed to a teratogen prior to conception. Examples of teratogenic agents include thalidomide, organic mercury compounds, and ionizing radiation.

Mutagenic effects are caused by agents that change (mutate) the genetic code, or alter DNA, which, in turn, are passed on to future generations. Examples include hydrogen peroxide (a bleaching agent), benzene (a chemical intermediary), and hydrazine (used in rocket fuel).

Carcinogenic effects produce tumors or cancer. There are several problems encountered when evaluating the carcinogenic potential of various agents in the environment. Human health can be affected by a wide range of factors including the environment, occupation, genetic predisposition, and lifestyle (e.g., cigarette smoking and diet). Therefore, it is often difficult to determine the relationship between any one exposure and the onset of cancer. Chemicals associated with lung cancer include cigarette smoke, coke oven emissions, asbestos, and arsenic.

PROBABILITY OF EXPOSURE

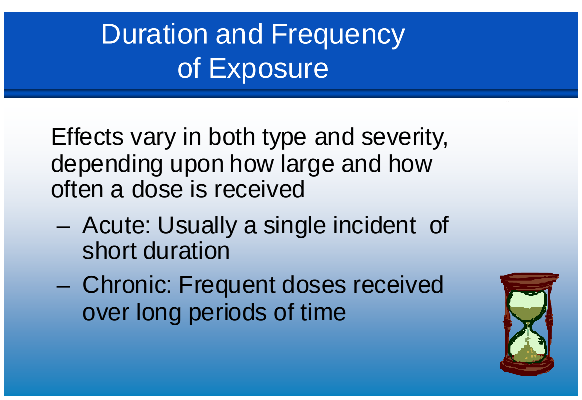


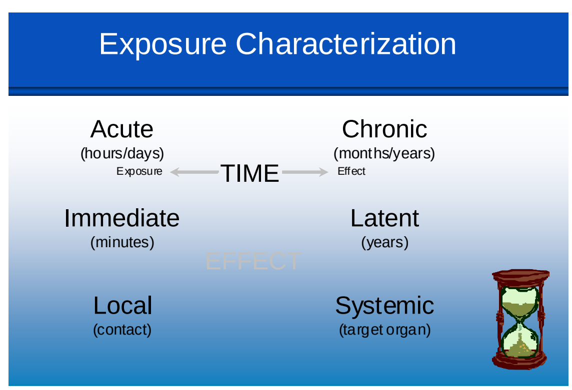
There are many factors that affect the reaction of an organism to a toxic chemical. These factors include the duration and frequency of exposure, the route of exposure, personal characteristics, and chemical interactions.

Exposure durations are typically classified as *acute* or *chronic*. An acute exposure occurs over a short period of time (minutes to days). Exposure guidelines typically restrict acute exposures to 10- to 15-minute exposure periods. Chronic or long-term exposures occur over periods ranging from months to years. Exposure guidelines for chronic effects from exposures are typically based on a 40-hour workweek and a 2000-hour work year.

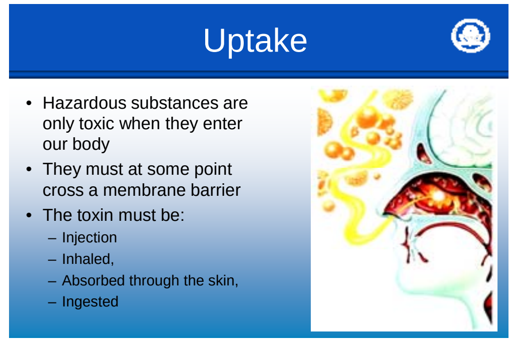
EXPOSURE

Effects can be significantly different between exposures to a high concentrations for a short period (acute) and exposures to low concentrations over a long time period (chronic).



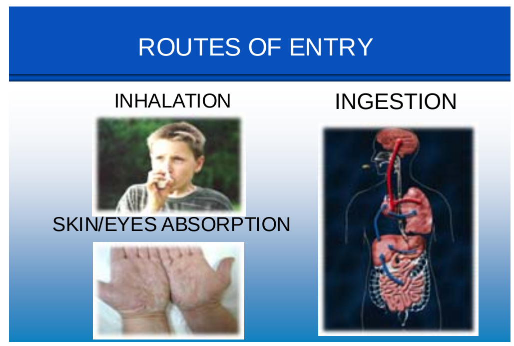


ROUTES OF EXPOSURE



- Inhalation of chemicals can damage the respiratory system through direct contact with lung tissue, or, if the chemical diffuses into the blood through the lung-blood interface, it can affect many organs in the body.

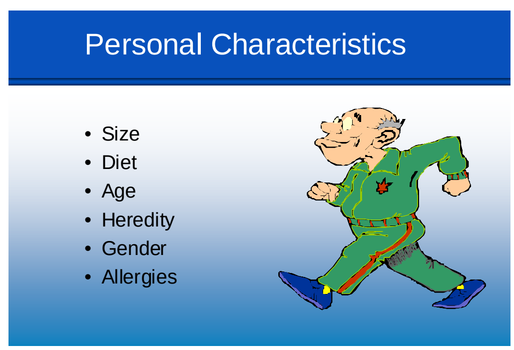
- External contact may occur by absorption of the agent through damaged skin tissue or sensitive eye tissue, resulting in the substance being transported to other parts of the body.



- While injection is rare, it could occur in an occupational setting as a result of a puncture, cut, or tear.

- Ingestion into the gastrointestinal tract is primarily the result of poor work habits or inadequate decontamination techniques resulting from hand-to-mouth transfer of the contaminant by eating, drinking, or smoking.

PERSONAL CHARACTERISTICS



Because of variations in personal characteristics between individuals, not all members of the population respond identically to the same dose of a substance. Some people will be more sensitive to a chemical and will be affected by lower doses than those people who are more resistant to it and would require larger doses to elicit the same response.

- Males and females have different organs and chemical levels. These differences in the way their organs and systems operate result in differing sensitivities and tolerances to various exposures between men and women.

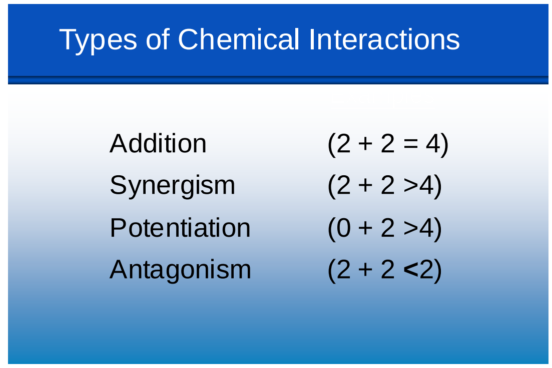
- Genetic factors also influence individual responses to toxic substances. Some people are genetically predisposed to chemical sensitivity. Such factors should be identified during the work function medical certification process.

- People in poor health are generally more susceptible to toxic damage than those in good health because poor health decreases the body's ability to deal with chemical insult.

- Infants, children, and the elderly are often more sensitive to toxic effects than young adults.

TYPES OF CHEMICAL INTERACTIONS

Some combinations of chemicals produce effects that are different from those attributed to each chemical individually.



- *Additive* effects of two chemicals: Each chemical, taken independently, has a certain toxic effect on the same organ or system that, when combined, must be evaluated additively when assessing the exposure.

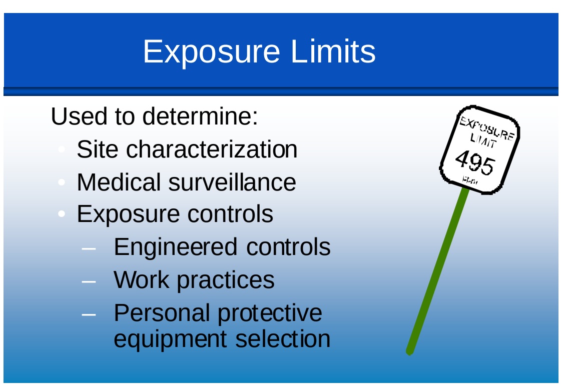
- *Synergistic* effects of two chemicals: When combined, the two (or more) chemicals produce an effect that is greater than an additive effect.

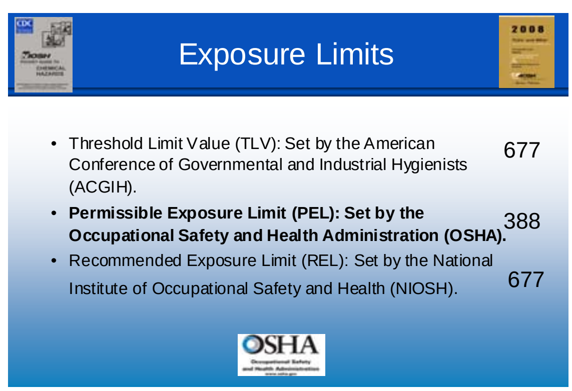
- *Potentiated* effects of two chemicals: An individual chemical may not be toxic to a particular organ or system, but has the ability to increase the toxicity of other chemicals.

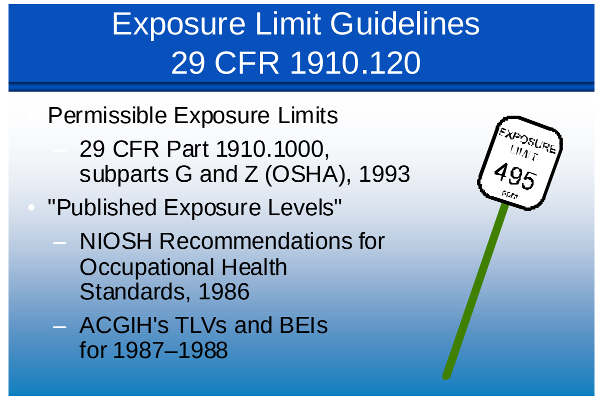
- *Antagonistic* effects of two chemicals: When combined, the effect is less than the expected effects if the exposure to the two chemicals occurred independently. This effect is commonly seen when using antidotes and chelating agents.

EXPOSURE LIMITS

Exposure limits are used in site characterization to identify both the contaminant(s) and its concentration(s) onsite. They are also used to determine both the type and extent of the medical monitoring and control needed on the site.







Although there are many sources for general exposure guidelines, only a few provide more specific information about what is considered a safe exposure limit. The following are three sources of general exposure guidelines:

- OSHA is a regulatory agency whose PELs are legally enforceable standards that apply to all private industries and federal agencies. They may also apply to state and local employees, depending upon state laws.

- NIOSH is charged, in part, with making recommendations for new standards, as well as for revising old ones, as more information is accumulated. The exposure levels researched by NIOSH are used to develop new OSHA standards.

- American Conference of Governmental Industrial Hygienists (ACGIH). ACGIH developed Maximum Allowable Concentrations (MACs) for use by industry in 1946. In the early 1960s, ACGIH revised those recommendations and renamed them Threshold Limit Values (TLVs).

It also publishes Biological Exposure Indices (BEIs) for use as guides to evaluate exposures where inhalation *is not* the only possible route of exposure. Since the *TLVs are for inhalation only*, they may not be applicable if the chemical is ingested or absorbed through the skin. Biological monitoring (e.g., urine samples, breath analysis) can be used to assess the overall exposure.

29 CFR 1910.120

Although RELs and TLVs were established as recommendations, if no PEL is available for a substance, an OSHA inspector can legally enforce the published exposure levels. If the inspector(s) decides to use a published exposure level (as identified in 29 CFR 1910.120), the 1986 version of the REL and the 1987-88 version of the TLVs *must* be used.

The TLVs are reviewed yearly and are published in their booklet, *Threshold Limit Values and Biological Exposure Indices*.

GENERAL GUIDELINES

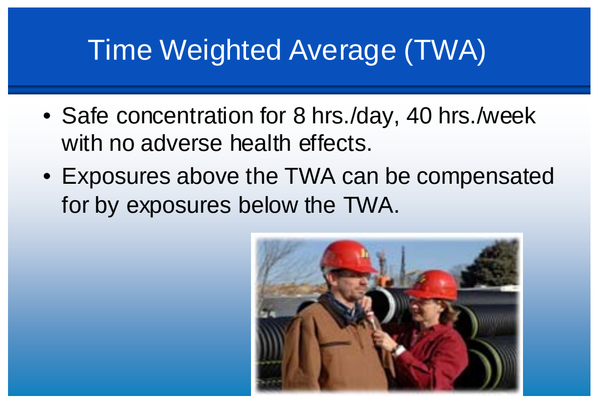
The effects of chemical exposure with the route and dosage required can be found in NIOSH's *Registry of Toxic Effects of Chemical Substances* (1983). However, because most of the data is for animal exposures, there may be problems in trying to use the data for human exposure guidelines.

Two sources of information go a little further and use a ranking system for exposure to chemicals. Irving Sax, in *Dangerous Properties of Industrial Materials*, gives a Toxic Hazard Rating (THR) for certain chemicals.

In the book, *Fire Protection Guide to Hazardous Materials*, the National Fire Protection Association (NFPA) also uses a ranking system to identify the toxic hazards of a chemical. These numbers are part of the NFPA 704 M identification system.

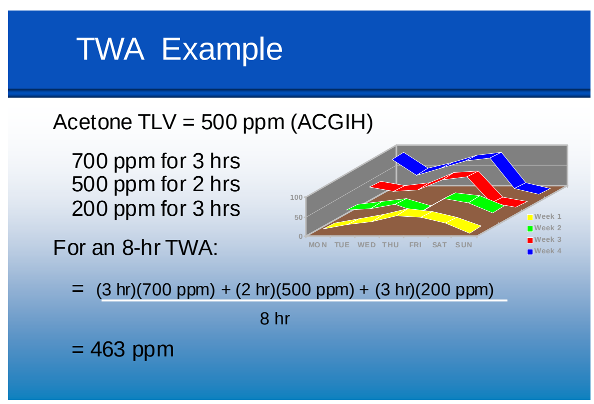
The Sax and NFPA sources provide information about the routes of exposures and some effects, along with a rating system that indicates which chemicals require extra precaution and special protective equipment.

TOXICITY DATA: TYPES OF EXPOSURE GUIDELINES



TIME-WEIGHTED AVERAGE (TWA)

TWAs are used to determine the average concentration of a contaminant over a specific period of time. The most common averaging period used is based on an 8-hour workday. When using a NIOSH REL, a 10-hour TWA (still based on a 40-hour week) can be calculated for comparison with an REL.



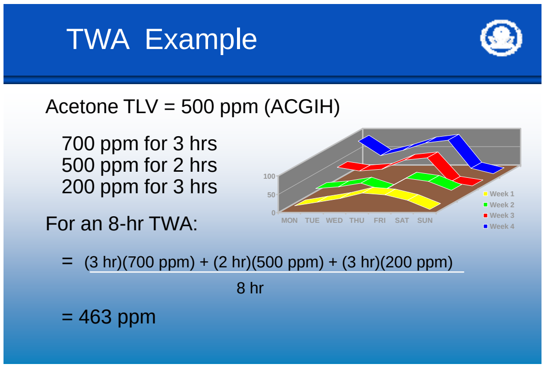
To meet the requirements for flow rate and volume when performing air sampling, an industrial hygienist may have to take several air samples over an 8-hour workday. These will be taken in the breathing zone of the individual.

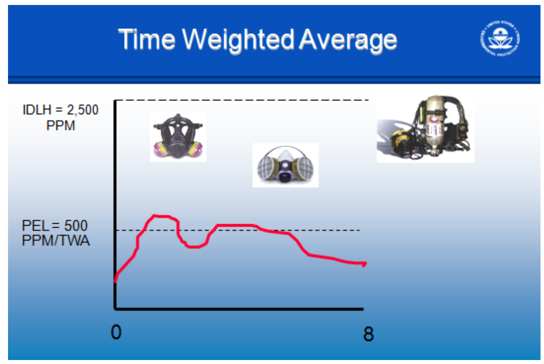
To determine an 8-hour TWA with:

Time = T   Concentration = C   Sample Number = Subscript

$$(T_1C_1+T_2C_2+\ldots T_NC_N) \div 8 = \textbf{TWA (8 Hours)}$$

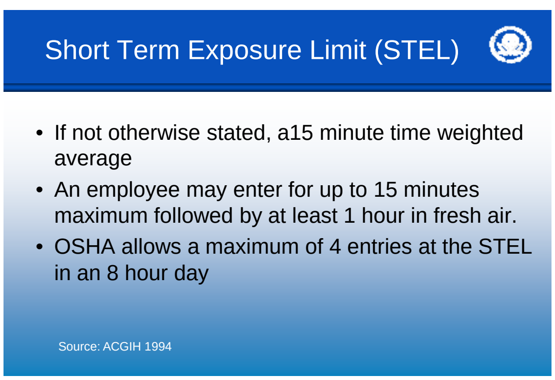
Graphically, over a workday, an individual exposed to acetic acid may show exposure levels above the limit at times; however, if the overall average does not violate the 8-hour TWA, there is no significant health risk.

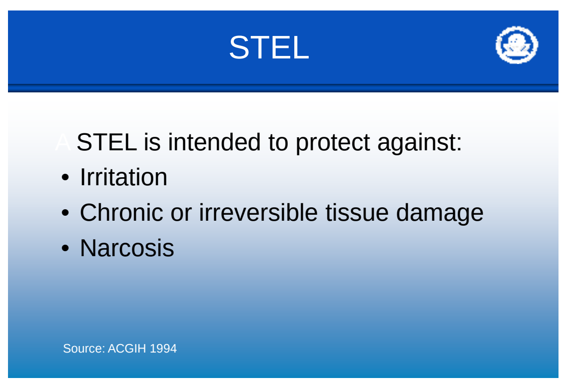




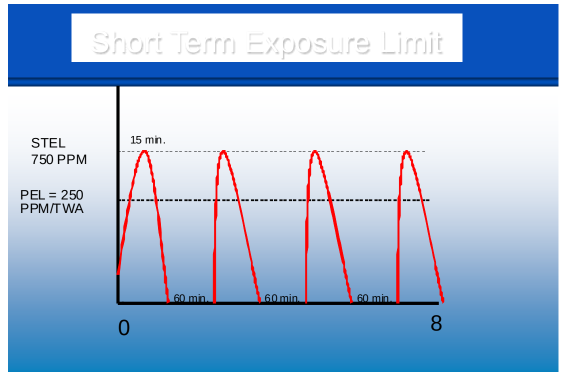
SHORT-TERM EXPOSURE LIMIT (STEL)

The STEL supplements the TWA. Although an individual may meet the occupational exposure limits for an 8-hour TWA, short duration increases in concentration could cause adverse health effects. The STEL concentrations (known as an excursion to the TWA) reflect an exposure limit that protects against acute effects from a substance that primarily exhibits chronic toxic effects.





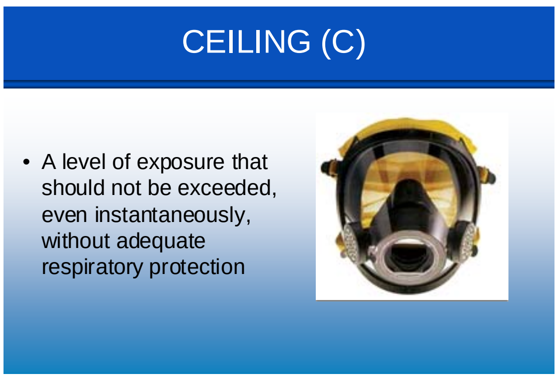
STEL

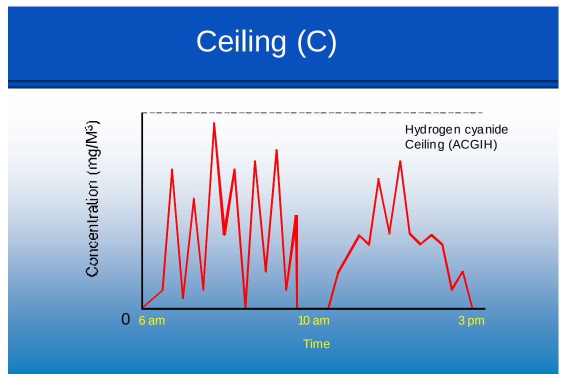


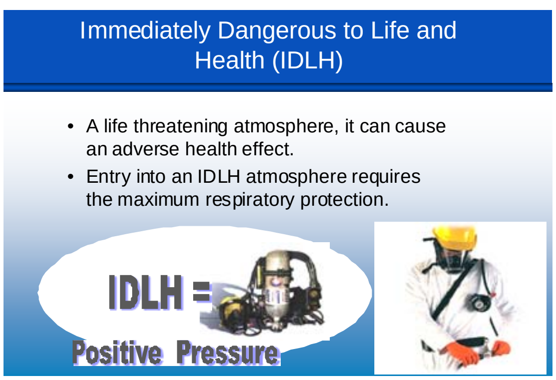
As with the 8-hour TWA, the STEL concentration can be exceeded at any point during a 15-minute period as long as the 15-minute TWA does not exceed the STEL.

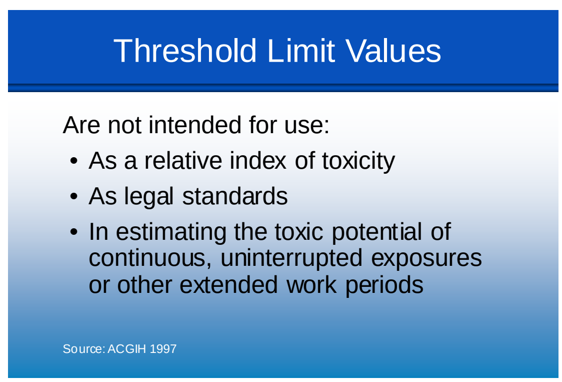
CEILING

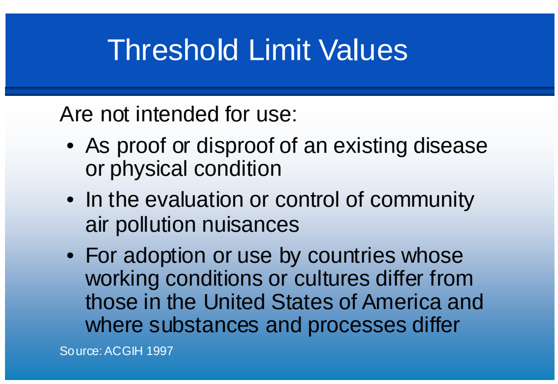
The ceiling limit is an instantaneous value that *can never be exceeded at any time*. Ceiling values exist for substances where exposure results in a rapid and particular type of response. It is *not* a TWA with its allowable excursions.











REFERENCES

ACGIH. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. American Conference of Governmental Industrial Hygienists. Cincinnati, OH.1994. (Used with permission of ACGIH.)

Klaassen, C.D., M.O. Amdur and J. Doull. Casarett and Doull's Toxicology: The Basic Science of Poisons. 3rd Ed. McGraw-Hill, Inc. New York, NY. 1986. (Used with permission of McGraw-Hill, Inc.)

Lewis, Richard J. *Sax's Dangerous Properties of Industrial Materials*, 8th Ed. Van Nostrand Reinhold. New York, NY. 1992

NFPA. Fire Protection Guide to Hazardous Materials, 11th Ed. [NFPA No. HAZ-91, ISBN 0-87765-366-6.] National Fire Protection Association. Quincy MA. 1994.

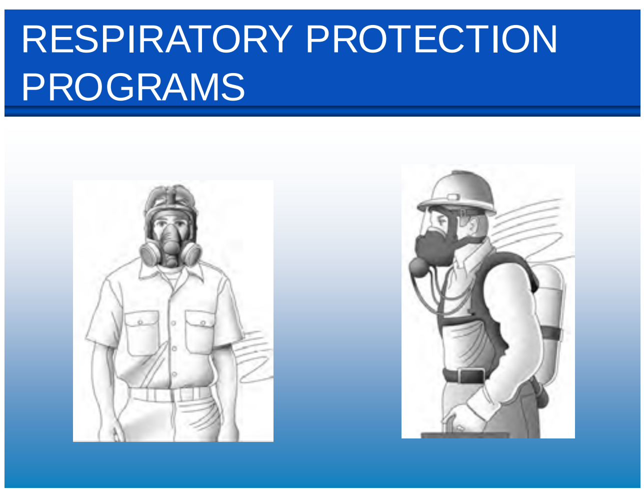
U.S. DHHS. Publication No. 81-116. Registry of Toxic Effects of Chemical Substances. 1980 Edition. - Vol. 1. Richard J. Lewis, Sr., and Rodger L. Tatken, Editors. U.S. Department of Health and Human Services, Public Health Service, National Institute for Occupational Safety and Health. Washington, DC. 1982.

U.S. DHHS. NIOSH Publication 85-115. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. Prepared by National Institute of Occupational Safety and Health, Occupational Safety and Health Administration, and U.S. Environmental Protection Agency.

RESPIRATORY PROTECTION PROGRAMS

Student Performance Objectives

1. Identify elements required for the establishment of a respiratory protection program.
2. State the regulation that establishes respirator testing and approval criteria.
3. Define an Immediately Dangerous to Life or Health (IDLH) atmosphere and its relevance to respirator selection.
4. State the regulatory requirements for cleaning and inspecting a respirator.
5. State the requirements for breathing air under the Respiratory Protection Standard.
6. Identify employee training requirements under the Respiratory Protection Standard.



THIS PAGE INTENTIONALLY BLANK.

INTRODUCTION

The Occupational Safety and Health Administration (OSHA) issued the new respiratory protection standard with an effective enforcement date of October 8, 1998. The primary changes in the program requirements affect some basic principles of employee protection. The first is that wearing a respirator, in itself, poses a risk to the worker. The second is the need to eliminate subjective decision-making in respirator selection. The third is to offer guidance on respirator use that provides equal protection to all employees wearing respirators with adequate margins of safety. The requirements of the new respiratory protection standard have been incorporated into five different areas of industry: (1) General Industry, 29 CFR 1910; (2) Construction Industry, 29 CFR 1926; (3) Shipyards, 29 CFR 1915; (4) Marine Terminals, 29 CFR 1917; and (5) Longshoring, 29 CFR 1918. Under General Industry, a separate respiratory protection standard for workers exposed to tuberculosis is being developed and is designated 29 CFR 1910.139. Until the new standard is completely developed, the “old” requirements under 29 CFR 1910.134 are to be used under 29 CFR 1910.139.

Applicability of Respiratory Protection Standards

1. Requirements have been adopted into:
2. General Industry – Part 1910
3. Construction Industry – Part 1926
4. Shipyards – Part 1915
5. Marine Terminals – Part 1917
6. Longshoring – Part 1918

EMPLOYERS’ RESPONSIBILITIES

The employer must appoint a program administrator to implement and oversee the program. That individual must have adequate knowledge and understanding of the respiratory protection standard to implement those portions of the program that apply to his/her specific workplace. The program must be written and contain all of the documentation required by the respiratory protection standard. The employer must provide, at no cost to the employee, NIOSH-certified respirators appropriate for the type of hazardous atmosphere and work to be performed. Records must be kept and made available to employees or OSHA upon request that include the written program, employee training, medical fitness report verifying the employee’s ability to wear respiratory protection, gas and vapor filter change-out schedules, employee fit-test results, evaluations of hazardous atmospheres, and program evaluations.

Employers' Responsibilities

- Appoint program administrator
- Establish and implement program
- Provide appropriate respirators when necessary
- Keep accurate records

PROGRAM ELEMENTS

The written program must be site-specific, because environmental conditions and atmospheric hazards play a role in decisions about respirator selection and use. For example, temperature, humidity, and contaminant concentration at a site affect the replacement schedule for gas and vapor filters.

The written program *must* contain procedures on how to select the correct respirator for each task. But before any employee wears a respirator for the first time, a medical examination must verify his/her fitness to withstand the inherent risks of respirator use.

Procedures and methods for fit-testing all employees wearing tight-fitting face pieces are identified in Appendix A of 29 CFR 1910.134. These include: 1) Procedures for respirator use during routine operations and during foreseeable emergencies; 2) Procedures and schedules for the cleaning, maintenance, and inspection of respirators used; 3) Procedures to ensure that the supply of breathing air used for atmosphere-supplying respirators is of adequate quality and quantity to protect the respirator wearer; 4) Training in the respiratory hazards to which employees will be exposed during routine and emergency situations; in the use of respirators, including donning, doffing, care and maintenance; in the limitations of each respirator.

There must also be a program in place for evaluating the effectiveness of the respiratory protection program.

Respiratory Protection Program Elements

- Written, site-specific program that includes:

1. Procedures for respirator selection
2. Medical evaluation of employees
3. Fit-testing procedures for tight-fitting respirators
4. Procedures for respirator use (routine and foreseeable emergency)

Respiratory Protection Program Elements

5. Procedures and schedules for maintaining respirators
6. Procedures to ensure adequate breathing air for atmosphere-supplying respirators (ASRs)
7. Training in respiratory hazards during routine and emergency situations

Respiratory Protection Program Elements

8. Training in the use of respirators, including donning, doffing, limitations, care, and maintenance
9. Procedures for evaluating program effectiveness

APPROVED RESPIRATORS

All new respirators worn by employees covered by the respiratory protection standard must be certified by NIOSH under the requirements of 42 CFR 84. Older respirators certified under the requirements of 30 CFR 11 may continue to be used until supplies have been exhausted, provided that their performance meets the requirements of 29 CFR 1910.134. This primarily affects the use of air-purifying respirators certified under 30 CFR 11. All respiratory protection devices certified under 42 CFR 84 will have a certification label that begins with "TC." Currently, NIOSH certifies all new respirator designs. However, NIOSH is looking into the possibility of "privatizing" the certification testing so it can dedicate its efforts to establishing testing standards and conducting oversight of the certification testing facilities.

Approved Respirators

NIOSH-approved respirators must be worn

42 CFR Part 84

- Establishes testing criteria
- Provides protocols for approval testing

Respiratory program requirements vary with the type of "sealing surface" the respirator uses. Filtering face pieces, commonly called dust masks, have no true sealing surface area. Likewise, hooded respirators have no true sealing surface area. However, there is a category of respirators known as *tight-fitting* respirators. These respirators may be air-purifying or atmosphere-supplying. They may be a quarter-face, half-face, or full-face design. Each type of the tight-fitting respirator provides an air-tight seal wherever the respirator contacts the wearer. All employees wearing tight-fitting respirators must have a fit-test performed to verify that the seal is adequate.

Tight-fitting Mask Types

Full-face respirator

RESPIRATOR SELECTION

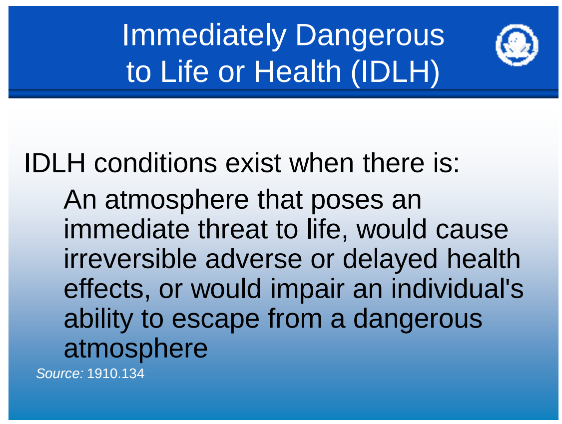
Employers have a responsibility to properly evaluate the respiratory hazards to which the employees will be exposed. Respirator selection must be based on *objective* data. Although there is not a specific requirement to perform air monitoring in order to select the type of respirator to be worn, there is a specific requirement that the decision be made based on objective data that must be documented.

Respirator Selection

- Employers must:
  Evaluate and identify respiratory hazards
  - Estimate employee exposure
  - Identify chemical state and physical form
- Consider IDLH, in situations where hazards cannot be evaluated
- Evaluate respirator fit and user acceptability

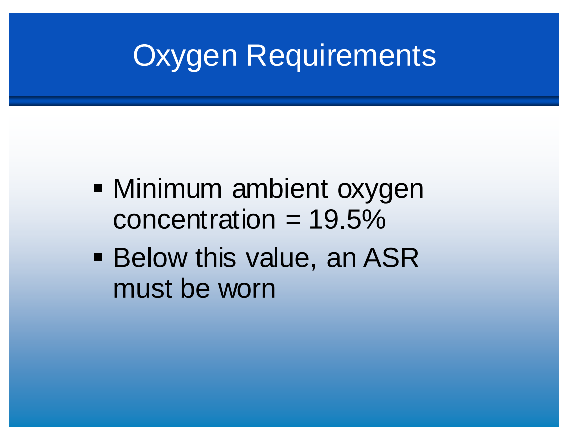
Estimation of the expected exposure levels and the physical and chemical state of the contaminant will be major factors in respirator selection. In situations where no objective data exists that allows the employer to estimate expected worker exposure levels, the atmosphere must be assumed to be Immediately Dangerous to Life and Health (IDLH). Additionally, the respirator selected must provide an adequate fit for the worker and allow him/her to perform the work assigned without unnecessary discomfort.

IDLH ATMOSPHERE

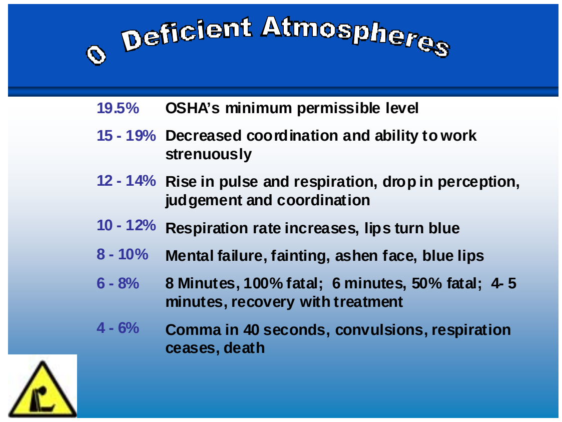


The principle that certain hazardous atmospheres may pose an immediate health threat to workers has been around for many years. However, with the publication of 42 CFR 84 and the revised 29 CFR 1910.134, the term "Immediately Dangerous to Life and Health" (IDLH) has been codified in these standards. The IDLH concentration for a contaminant is established by NIOSH and enforced by OSHA. Those IDLH concentrations that are enforceable are found in the *NIOSH Pocket Guide to Chemical Hazards*, Publication Number 90-117. Chemicals that have an IDLH concentration established are those chemicals from which a short duration exposure could cause irreversible health effects, death, or escape-impairing narcosis or irritation. Therefore, chemicals like asbestos will not have an IDLH exposure limit, because asbestos does not have any of the above-listed characteristics. However, because toluene does have escape-impairing narcotic effects, it will have an IDLH exposure limit assigned.

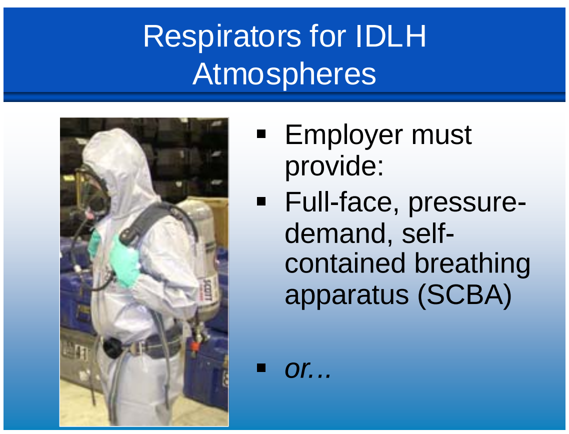
RESPIRATORS FOR IDLH ATMOSPHERES



In the new respiratory protection standard, OSHA has identified the difference between oxygen- deficient environments and IDLH levels of oxygen concentration. An oxygen-deficient atmosphere is one where the oxygen concentration is less than 19.5%. However, an IDLH level of oxygen is an oxygen concentration that falls below the levels established in Table II of the respiratory protection standard, which corresponds to 100 mmHg partial pressure. This would correspond to an oxygen concentration of 16% at sea level. Although there is a legal difference between oxygen deficiency and IDLH oxygen levels, OSHA does not expect many employers to try to take advantage of this difference because the burden of proof needed to demonstrate compliance would outweigh the benefits.

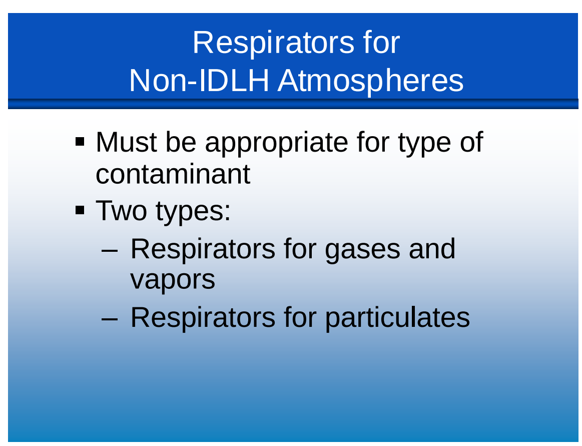


Respirators to be used in IDLH atmospheres have been limited to only two choices. One choice is a self-contained breathing apparatus (SCBA) with a full face piece that operates in the pressure-demand (PD) mode. The other choice is a supplied-air respirator (SAR) with full face piece that operates in the PD mode with an auxiliary SCBA bottle attached. If the employer cannot determine the level of atmospheric hazard using objective data, then the atmosphere must be assumed to be IDLH.

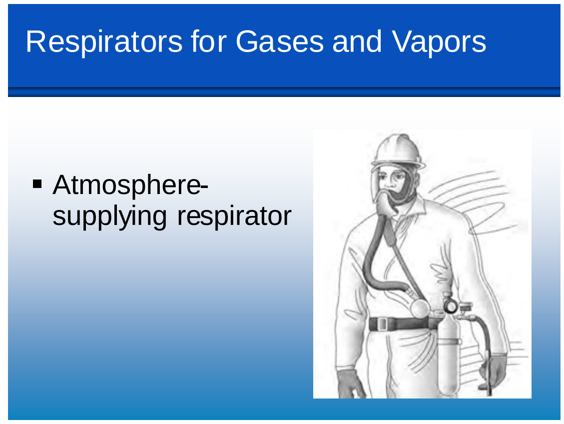


RESPIRATORS FOR NON-IDLH ATMOSPHERES

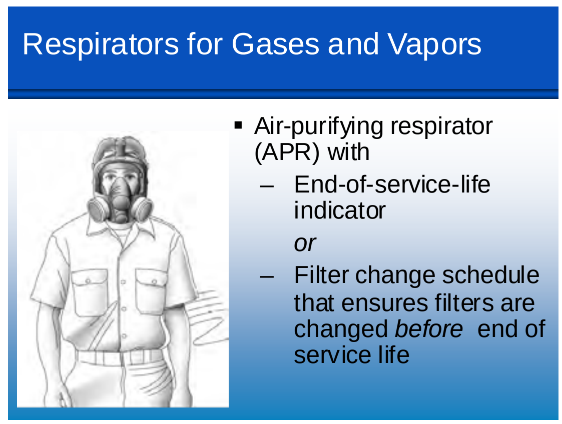
Under the respiratory protection standard, there is a much greater range of respirators available for use in non-IDLH atmospheres. However, the levels of protection as defined in the U.S. EPA Standard Operating Safety Guides require that only tight-fitting, full-faced respirators are to be used when performing hazardous waste site work. This greatly limits the selection of available respirators to be worn. Respirators selected for use in non-IDLH atmospheres must be appropriate for the type of contaminant present. Contaminants



are separated into two classifications: gases and vapors, and particulates. These terms will be defined in the *Respirator Selection and Use* lecture.

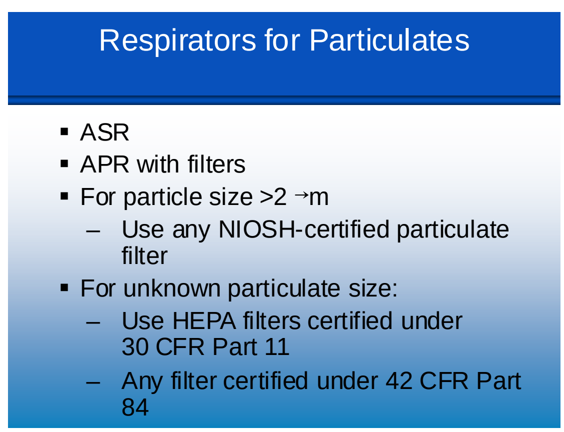


Choices of respirators for non-IDLH atmospheres with a gas or vapor contaminant can be any atmosphere-supplying respirator (ASR), or an air-purifying respirator (APR) with a filter canister that either has an end-of-service-life indicator (ESLI) or for which a filter change schedule has been developed that will let the worker change the filter prior to contaminant breakthrough. It is expected that the filter will be changed when it has reached 90% capacity. This will allow the worker adequate time to exit the work area and change filters prior to any exposure occurring due to filter breakthrough. If no ESLI is available for the contaminant, then a filter change schedule *must* be established and documented in the Respiratory Protection Program. This change schedule must take into account all of the environmental factors that affect filter use. These factors include, but are not limited to temperature, humidity, user breathing rate, and contaminant concentration.



The previous practice of relying on the warning properties of chemicals (smell, taste, etc.) to determine filter changes is no longer allowed.

Respirators for use in particulate environments can be either ASRs or APRs with particulate filters. If the particulate filter is one that has been certified under 42 CFR 84, or one certified as a high efficiency particulate air (HEPA) filter under 30 CFR 11, then it is not necessary to know the size of the particulate contaminant. If the employer wishes to use a filter certified under 30 CFR 11 that is not a HEPA filter, then the employer must conduct a particle sizing analysis to determine whether the mass median aerodynamic diameter (MMAD) is at least 2 micrometers in size for the filters to provide adequate protection against the contaminant.



MEDICAL EVALUATION

The medical evaluation requirements under the new standard are very different from what was previously required. Today an actual medical physical is no longer required, nor is a physician required to perform the evaluation. However, the medical evaluation, including fit-testing and training, must be performed before the first time a person wears a respirator. OSHA adopted this position since wearing a respirator, in itself, poses a risk to the worker. Additionally, since OSHA was concerned about the possibility of the employer improperly using the results of the medical evaluation, the employer is not allowed to have access to the medical records resulting from the medical evaluations.

The physician or licensed health care professional (PLHCP) instead will provide the employer and employee with a written statement that verifies the worker's ability to wear the respiratory protection that the employer has determined must be worn under the stated conditions of use.

Medical Evaluation

- Determines employee's ability to wear a respirator
- Cost borne by employer
- Includes medical history and physical examination by physician or licensed health-care professional (PLHCP)

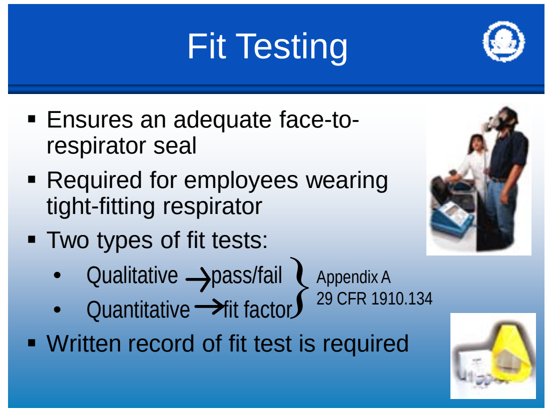
Medical Evaluation

- Written documentation of ability to wear a respirator
- Additional medical evaluations are required when there are changes in:
  - Workplace
  - PPE
  - Health status of employee

The medical evaluation must include those items listed in Appendix C of 29 CFR 1910.134, with the cost of that medical evaluation being borne by the employer and provided during working hours, or at a time convenient to the employee. A medical evaluation must be performed whenever there are changes in the workplace environment, including temperature and humidity extremes; in the work load; in the type of personal protective equipment worn; or in the employee's health status.

FIT-TESTING REQUIREMENTS

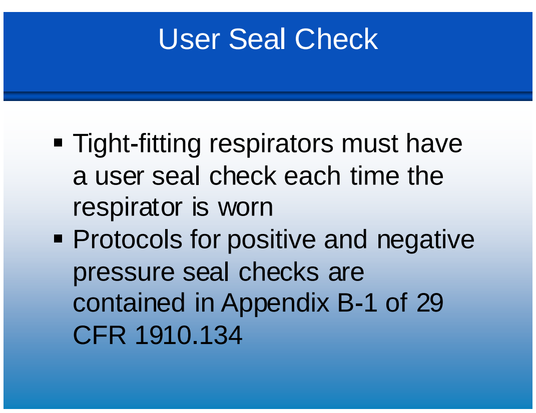
The fit-testing protocols are more formal with additional guidance on the limitations of respirator use associated with the fit-testing. The purpose of fit-testing is to demonstrate that the respirator the employee will wear will provide adequate protection under the expected conditions of use. Fit-tests are only required for tight-fitting respirators. All fit-testing must be performed with the respirator in the "negative" pressure mode, regardless of the pressure mode that will actually be used during work. The fit-testing protocols are found in Appendix A of 29 CFR 1910.134.

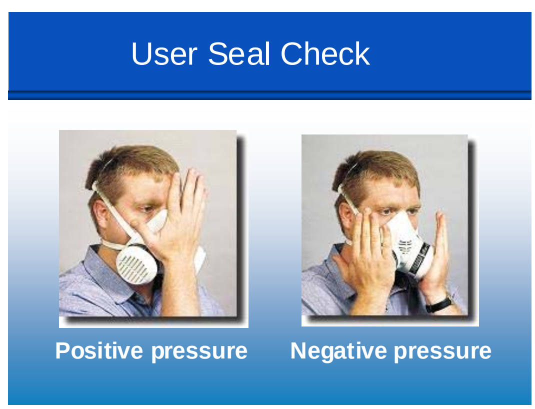


Qualitative (QLFT) or Quantitative (QNFT) fit-tests can be used for ASRs. For APRs requiring a fit-factor of 100 or less, a qualitative fit-test may be performed. However, if a QLFT is performed, that respirator may only be worn up to 10 times (10×) the exposure limit, regardless of the assigned protection factor (APF) of the respirator. If a QNFT is performed, then the respirator must provide a fit factor that is at least 10 times (10×) the APF. APFs are currently provided by NIOSH and adopted by OSHA until further evaluation has been made by OSHA. Whether QLFTs or QNFTs are used, a formal record of each employee's fit-test results will be kept on file. Fit tests should be performed at least annually and any time that there is a change in the employee's physical characteristics that could affect respirator fit (e.g., dentures, facial scars.).

USER SEAL CHECK

The practice of checking the respirator sealing surface each time a respirator is worn has now been formalized as the User Seal Check. The User Seal Check protocol can be found in 29 CFR 1910.134 Appendix B-1. Either the positive pressure check or the negative pressure check can be used to test the respirator seal. The method used is primarily based on the design of the specific respirator. The ideal would be to perform both, since that would also verify the proper operation of the check valves in the respirator.





RESPIRATOR CLEANING AND DISINFECTING

The protocols for cleaning respirators have been added to the standard and can be found in Appendix B-2 of 29 CFR 1910.134. These protocols require that each respirator be disassembled each time it is cleaned. If a respirator is assigned to a specific person, that respirator only needs to be cleaned as often as necessary for personal hygiene reasons. However, if the respirator is to be "shared," it must be cleaned after each use prior to another person wearing it. This requirement also extends to the regulators used on mask-mounted regulator (MMR) SCBAs.

Cleaning and Disinfecting

- Respirators will be cleaned and disinfected according to:
  - Protocol in Appendix B-2 of 29 CFR 1910.134

  or

  - Manufacturer's procedure with equivalent effectiveness

Respirator Cleaning Requirements

Respirator	Cleaning Schedule
Issued to employee	As necessary
Shared	Before use by another worker
Emergency use	After each use
Fit-test	After each use
Training	After each use

RESPIRATOR INSPECTIONS

Respirator Inspection

Respirator Use	Inspection Requirement
Routine	• Before each use • During cleaning
Emergency	• Monthly • Before and after each use
Escape-only	• Before bringing into workplace

The inspection of respirators has been formalized, both in frequency and in the items to be inspected. Each respirator must be inspected prior to someone wearing it, whether for routine operations or emergency use. Additionally, respirators used for emergency use should be inspected monthly; this requirement also includes SCBAs. "Escape only" respirators are inspected prior to being brought into the workplace, because it is not known when they will be needed. It is the responsibility of the employer to ensure that each employee knows how to properly check the function and operation of each respirator component. It is the responsibility of the employee to perform that check each time the respirator is worn.

Disassembled APR

Inspection Procedures

At a minimum, check function, tightness, and condition of the following:

- Facepiece
- Head straps
- Valves
- Connecting tubes
- Filters
- Elastomeric pliability
- Signs of deterioration
- Cylinders charged to 90%

BREATHING AIR QUALITY

For atmosphere-supplying respirators (ASRs) used for terrestrial work, the quality of breathing air must be at least Grade D as defined in the American National Standards Institute (ANSI) Compressed Gas Association (CGA) standard ANSI/CGA G-7.1, 1989. If underwater work is involved, then Grade E breathing air is the minimum for “shallow” water work.

Grade D Breathing Air

- Compressed breathing air must meet the following specifications for Grade D air:
  - Oxygen volume within 19.5-23.5%
  - Hydrocarbon (condensed): no more than 5 milligrams per cubic meter of air
  - Carbon **monoxide** (CO): no more than 10 parts per million (ppm)
  - Carbon **dioxide** (CO_2): no more than 1,000 ppm
  - No noticeable odor

Compressed-gas cylinders are classified as shipping containers by the U.S. Department of Transportation (DOT) and, as such, must be tested and maintained in accordance with 49 CFR parts 173–178. Cylinders of steel or aluminum design with package specifications contained in 49 CFR must be hydrostatically tested every 5 years, with no limitations on service life other than successfully passing the hydrostatic test. Cylinders operating under a DOT exemption, such as the fiberglass, Kevlar, or composite graphite cylinders, must be hydrostatically tested every 3 years and have a maximum service life of 15 years.

Breathing Air Cylinder Requirements

Employer shall ensure:

- Cylinders are tested and maintained as prescribed in 49 CFR Parts 173–178
- Purchased cylinders of breathing air have certificates of analysis
- Moisture content does not exceed dew point of -50\F

Purchased cylinders of breathing air must have a certificate of analysis documenting that the compressed air meets the ANSI/CGA G-7.1 requirements for Grade D breathing air.

The moisture content of the breathing air must not exceed a dew point of –50ºF to prevent freezing of the regulator components during use.

If compressors are used to generate the compressed air for filling cylinders, or as the air source for supplied-air respirators, then there are requirements that must be met regarding their construction and placement.

Breathing Air Compressor Requirements

Compressors constructed and situated to:

- Prevent entry of contaminants into system
  - CO <10 ppm
  - Inline filter
  - Oil (temp)
  - Low moisture
- Ensure breathing air fittings are *incompatible* with other gas fittings

The compressor must be situated so that no airborne contaminants are drawn into the intake of the compressor. If the compressor is oil-lubricated, then it must have an inline, high-temperature alarm or carbon monoxide alarm with the system. If only a high temperature alarm is used, then the employer will periodically test the air to ensure that carbon monoxide content does not exceed 10 ppm. Inline filters should be used to ensure adequate air purity. These filters should be maintained periodically with a tag indicating who performed the maintenance and when. The moisture content will be kept below a dew point of 10ºF. All breathing air fittings must be *incompatible* with all other gas fittings.

TRAINING REQUIREMENTS

Training Requirements

- Must occur prior to wearing a respirator
- Retraining annually or when:
  - Changes occur in workplace or type of respirator
  - Employee demonstrates inadequate knowledge
  - Any situation arises that warrants retraining

The respiratory protection standard requires that each employee be trained annually prior to using a respirator and whenever changes in the respiratory protection program occur. The standard also states that retraining is warranted if an employee shows inadequate knowledge of any aspect of the program. The training requirements are significant in technical content; however, OSHA only requires the employees to have knowledge in the requirements of the employer's program. In other words, if only SCBAs are used onsite, there is no requirement to know the limitations of an APR filter since it will never be used.

Training Requirements

Employee shall demonstrate knowledge of:

1. Why respirator is needed and the consequences of improper operation
2. Limitations and capabilities of respirator
3. How to use in emergency situations
4. How to inspect and use

Training Requirements

- Employee shall demonstrate knowledge of:
- Procedures for maintenance and storage
- How to recognize medical signs and symptoms that prevent or limit use of respirators
- General requirements of the standard (29 CFR 1910.134)

PROGRAM EVALUATION

The employer is required to periodically evaluate the effectiveness of the respiratory program through all available means, including direct observation, document reviews, and interviews with employees. These interviews should include the following: the ability to comfortably use the respirator under actual workplace conditions; that the appropriate respirators are selected to perform the assigned task; that the respirators are properly used when performing work (many workers have been exposed to hazardous atmospheres when wearing a respirator because they did not use them properly); and that proper respirator maintenance and inspections are performed.

Program Evaluation

Employer will ensure written program effectiveness and consult employees on topics such as:

1. Respirator fit (ability to use without interfering with work)
2. Appropriate respirator selection
3. Proper use under workplace conditions
4. Proper maintenance

APPENDICES

The appendices provided with the respiratory protection standard give the employer guidance on how to conduct those portions of the program addressed in the appendices. Appendices A, B, and C provide employers with guidance on how to perform various functions such as proper respirator fit, cleaning, and employee medical evaluation. For each function the employer may use the manufacturer's method provided that it is at least as protective as OSHA's recommendation.

Appendices

- A – Fit-Testing Procedures
- B-1 – User Seal Check Procedures
- B-2 – Respirator Cleaning Procedures
- C – OSHA Respirator Medical Evaluation Questionnaire
- D – Information for Employees Using Respirators When Not Required Under the Standard

Appendix D is for employers who allow employees to wear tight-fitting respirators when there is no airborne hazard that requires wearing a respirator. For example, an employee works with organic compounds. The airborne concentrations are below all occupational exposure limits. However, the employee finds the smell of those organic vapors to be very unpleasant and wishes to wear an APR with organic vapor cartridges to alleviate the unpleasant aroma. If an employer is going to allow employees to wear tight-fitting respirators voluntarily, then the employer must ensure that the employee is provided with those aspects of the respiratory protection standard that apply to the wearing of the respirator. Those aspects would include the medical evaluation, proper care, and sanitation of the respirator. A copy of Appendix D should be provided to the employee.


Questions?

THIS PAGE INTENTIONALLY BLANK.

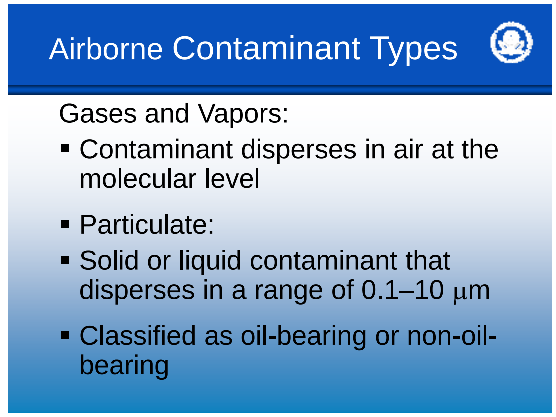
RESPIRATOR SELECTION AND USE

Student Performance Objectives

1. Identify the types of airborne contaminants that require respiratory protection.
2. State the tight-fitting face piece pressure modes.
3. Differentiate atmosphere-supplying from air-purifying respirators.
4. Explain the classification method for particulate filters and the criteria for filter change.
5. Describe five factors to consider when selecting a gas/vapor filter.
6. Define warning properties and hazard ratio.
7. Explain the advantages and disadvantages of air-purifying respirators, supplied-air respirators, closed-circuit SCBAs, and open-circuit SCBAs.
8. Given an atmospheric scenario and the Respirator Decision Logic flowchart, select the required respiratory protection.

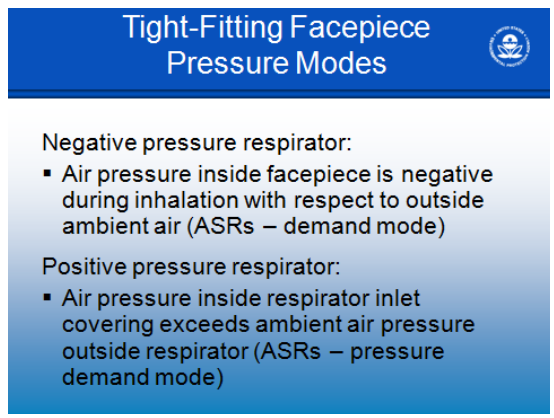
THIS PAGE INTENTIONALLY BLANK.

AIRBORNE CONTAMINANT TYPES



Airborne contaminants are segregated into two general types, gases/vapors and particulates. Gases and vapors disperse on the molecular level when released into the atmosphere. This characteristic prevents them from being removed by a simple mechanical filter. The filtering mechanism must be chemically adsorbent in order to remove the contaminant from the air. Particulates do not disperse on the molecular level when released into atmosphere and are usually present in the form of mists, fogs, aerosols, fumes, or dust. Because the larger physical size of the particulate contaminants, they can be removed from the air by mechanical filtration. This distinction between gases/vapors and particulates is an important consideration when selecting air-purifying respirator filters.

TIGHT-FITTING RESPIRATOR

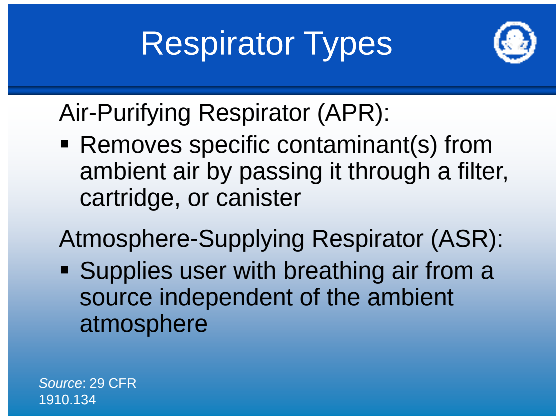


A tight-fitting respirator is one that forms an air-tight seal around the user's face when worn. These types of respirators are classified as being "negative pressure" or "positive pressure." This term refers to the relative pressure differential between the pressure inside the face piece and the outside air pressure. If the pressure mode is negative, the air pressure inside the face piece is less than the outside pressure when the user is inhaling. If there is a leak in the mask's sealing surface, the contaminant can leak into the face piece and expose the user. All air-purifying respirators (APR) are negative pressure.

Atmosphere-supplying respirators (ASR) that are negative pressure are called "demand" types. Only ASRs can be of the positive pressure type. With positive pressure respirators the pressure inside the face piece is always higher than the outside air pressure. Thus, if there is a leak in the sealing surface of the face piece, the leakage will be in the outward direction and should not expose the user to the contaminant. ASRs that operate in the positive pressure mode are referred to as "pressure-demand" types.

RESPIRATOR TYPES

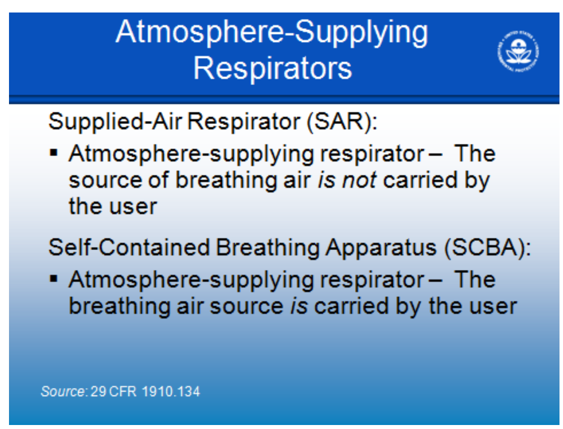
There are two basic types of respirators: the *air-purifying respirator* (APR) and the *atmosphere-supplying respirator* (ASR). The APR filters airborne contaminants from the ambient air using a cartridge or canister type filter. APR filters for gases and vapors use an adsorbent media that chemically bonds the contaminant to the filtering media. Particulate contaminants are removed from the air by mechanical filtration. The ASR, on the other hand, provides breathing air from a source other than the ambient air. The air source for ASRs can be either self-contained or can be from a remotely located air manifold system.



Air-purifying respirators are further divided into “non-powered” and “powered” APRs. Non-powered APRs use the partial vacuum created when the user inhales to draw ambient air through the filter to remove the contaminant. As the filter becomes “loaded” with contaminant, the resistance to breathing increases. A powered APR (PAPR) uses a motor-driven fan to draw ambient air through the filtering mechanism before it goes to the user. Although not considered to be a positive pressure respirator, the pressure inside the face piece from a PAPR is usually higher than outside air pressure.

The most important consideration for choosing either a powered or non-powered APR is the fact that when using a non-powered APR, respiratory stress is created because the user has to forcefully inhale against the filter’s resistance. For people who might be prohibited from wearing a non-powered APR because of a cardiopulmonary condition, the powered APR may be an acceptable alternative, provided a proper medical evaluation has been conducted. Regardless of medical status, the PAPR is more comfortable to wear than the non-powered counterpart.

Atmosphere-supplying respirators (ASR) are subdivided according to the source of the breathing air. If the breathing air is provided from a source that is not worn by the user, it is referred to as a *supplied-air respirator* (SAR). If the breathing air source is worn by the user, it is referred to as a *self-contained breathing apparatus* (SCBA).



SARs come in three types: continuous flow (CF), demand (D), or pressure-demand (PD). CF type SARs may have a tight-fitting face piece or a hood with breathing air supplied at a constant flow rate without regard to the pressure inside the face piece. They provide better comfort to the wearer; however, like demand type ASRs, they do not qualify for atmospheres where positive pressure *is required* for respiratory protection. All PD type SARs use a tight-fitting face piece in conjunction with a positive pressure breathing regulator to maintain a positive pressure inside the face piece. This is the only type of SAR that can be used in an environment where positive pressure is required to protect the wearer.

SCBAs can either be *closed circuit* (commonly called a “rebreather”) or *open circuit*. The most common type is the open circuit. The closed-circuit SCBA takes the exhaled breath of the user and conditions it to be breathed again. Carbon dioxide is “scrubbed” from the exhaled breath using a filter cartridge. Older models used chemicals such as potassium superoxide (KO_3) to generate oxygen as it removed the CO_2 to maintain the oxygen level in the breathing air. These units are highly exothermic and generate characteristic waste in the form of lithium hydroxide (LiOH) or potassium hydroxide (KOH). Newer models, however, use a filtering mechanism that simply removes the CO_2 from the air while oxygen is replaced from a pressurized gas cylinder containing air with an elevated oxygen level (ranging from 38% to100% oxygen depending on the specific unit). This compressed gas cylinder charged with enriched oxygen also maintains the positive pressure inside the respirator. The greatest advantage of using closed circuit SCBAs is the long duration of use that can be achieved; some can be worn as long as 4 hours. However, this benefit could be easily negated by the environmental heat stress they create when worn for extended periods of time in conjunction with personal protective clothing.

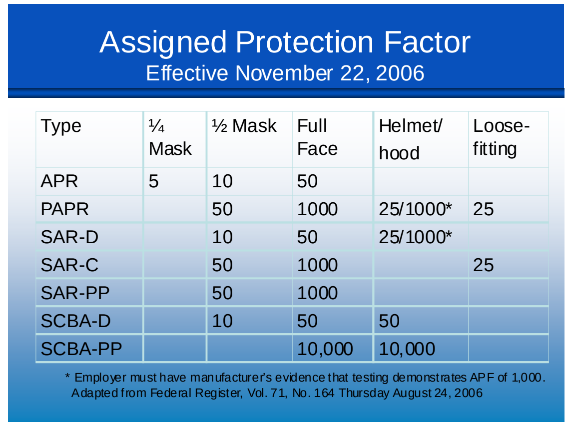
Respirator Types

- Air-Purifying Respirator (APR)
  - ✓ Non-powered
  - ✓ Powered
- Supplied-Air Respirator (SAR)
  - ✓ Continuous flow
  - ✓ Tight-fitting pressure demand
- Self-Contained Breathing Apparatus (SCBA)
  - ✓ Closed circuit
  - ✓ Open circuit

Open circuit SCBAs use normal compressed air as their source of breathing air. In order to qualify as a respirator for performing site entries, an open circuit SCBA must have duration of at least 30 minutes. Once the air has been breathed by the user, it is exhaled through an exhaust valve into the ambient air. Although duration is limited by the weight of the cylinder, some models have a 60-minute duration.

ASSIGNED PROTECTION FACTORS

An *assigned protection factor* (APF) is a numerical value that represents the relative risk of exposure to a contaminant due to the failure of a respirator component or sealing surface. The regulatory definition has not yet been promulgated in the Respiratory Protection Standard 29 CFR 1910.134, since the definition is still under consideration by OSHA. The numerical values to be used are those currently provided by NIOSH (until OSHA adopts values to be incorporated into the standard). For tight-fitting respirators, the APF increases as a higher percentage of the user's face is used to form the sealing surface. Pressure-demand, tight-fitting respirators have a greater APF than demand, tight-fitting respirators. SCBAs have higher APFs than SARs.

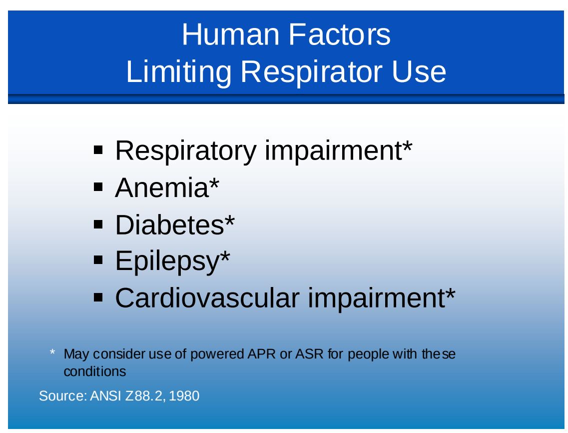


Type	¼ Mask	½ Mask	Full Face	Helmet/ hood	Loose-fitting
APR	5	10	50		
PAPR		50	1000	25/1000*	25
SAR-D		10	50	25/1000*	
SAR-C		50	1000		25
SAR-PP		50	1000		
SCBA-D		10	50	50	
SCBA-PP			10,000	10,000	

HUMAN FACTORS LIMITING RESPIRATOR USE

There are several human factors that could limit or restrict a person from using a respirator. Examples include medical conditions that result in the impairment of the body's ability to move air through the respiratory system, transfer oxygen to the blood stream, or reduce its ability to transport oxygenated blood to all necessary parts of the body. Some examples of respiratory impairments are asthma, bronchial tube restrictions, and insufficient lung capacity.

Anemia is a condition of reduced blood-oxygen level that a demand-type respirator could further reduce.



Diabetes has a complicating factor in that it reduces the blood flow to the extremities, which results in reduced oxygen delivery to those parts of the body. The use of a demand-type respirator could further exacerbate this condition.

Epilepsy is a medical condition that causes seizures in affected individuals. These seizures can be initiated by physiological stress like labored breathing caused by wearing a respirator.

Cardiovascular impairment comes in many forms, some of which cause reduced blood flow to various parts of the body, while others can be aggravated by physiological stress. The above listed medical conditions should be very carefully considered by a physician or licensed health care professional (PLHCP) prior to approving an individual to wear respiratory protection. Certain conditions could allow the use of a PAPR or CF-SAR in lieu of a non-powered APR, or a demand or pressure-demand ASR. However, this decision must be made by a PLHCP.

Human Factors Limiting Respirator Use

- Facial hair
- Comfort
- Vision
- Claustrophobia
- Punctured eardrum

Source: ANSI Z88.2, 1980

Facial hair that interferes with the sealing surface or operation of respirator components is prohibited. Hair growth in the sealing surface area *must be no more than one-day's growth*. Facial hair, such as mustaches, cannot interfere with the operation of inhalation or exhaust valves.

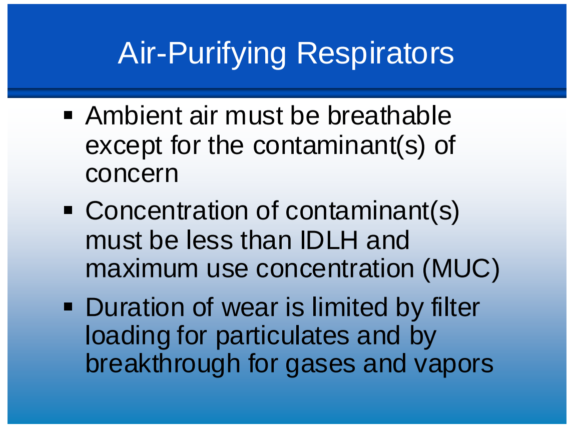
The *comfort* of the wearer is also a consideration for several reasons because when it comes to safety, the more comfortable the users are, the more likely they are to don and wear their respiratory protection properly, even when no oversight is being conducted.

For personnel with *impaired vision*, there are options to be considered. If a person requires corrective lenses to see well enough to perform his/her job, then consideration should be given to acquiring a spectacle kit, with appropriate prescription lenses installed, for the style of respirator to be worn. Another possibility is to use contact lenses; however, using contact lenses in hazardous atmospheres should be carefully considered.

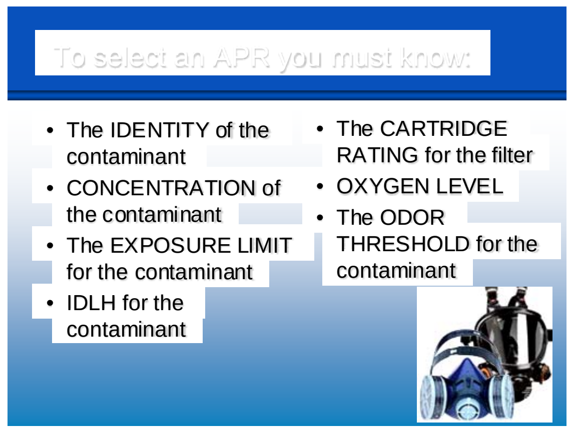
Claustrophobia is also a condition that could prevent an individual from wearing a respirator. Since degrees of this condition vary significantly, some people with minor claustrophobia can still function while wearing a respirator. However, with more severe cases, serious injury or death could occur.

A punctured eardrum is normally a temporary medical condition during which a person should probably not wear a respirator. Although this condition could allow a contaminant to enter through the auditory canal, the dose received would not likely be clinically significant. However, the pressure differential caused by wearing a positive- or negative-pressure respirator could aggravate the condition.

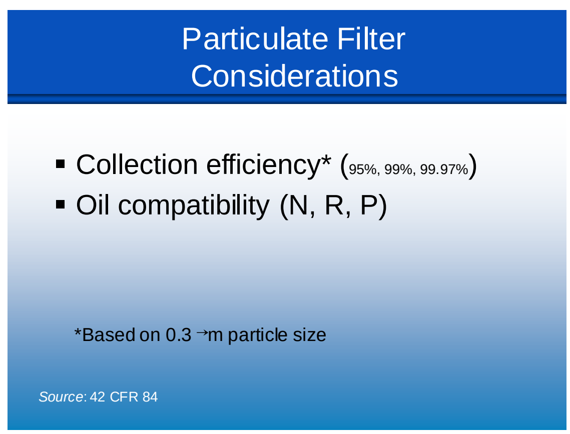
AIR-PURIFYING RESPIRATORS



Since APRs provide only the minimum respiratory protection, there are many restrictions associated with their use for performing work in hazardous atmospheres. Some of these restrictions are that: 1) the ambient air must be breathable, with the exception of the contaminant present. In other words, there must be the normal levels of oxygen, nitrogen, and the other components of air that are normally found in the atmosphere; 2) *all* airborne contaminants must be identified and monitored to ensure that their concentrations are below the IDLH value established by NIOSH, and below the *maximum use concentration* (MUC) for the type of respirator being worn; 3) the amount of time that a person can wear a respirator without changing the filter is a function of filter loading if the contaminant is a particulate, or by breakthrough if the contaminant is a gas or vapor.



PARTICULATE FILTER CLASSIFICATIONS



Since particulates are contaminants that disperse in air on a non-molecular level, they can be removed from the air by mechanical filtration. The standard particle size for filter evaluation and testing is 0.3 µm. The NIOSH standard, 42 CFR 84, is the standard by which all respirators used for personal protection when performing hazardous waste site work are tested and certified. Filters are classified by both their collection efficiency, as well as their compatibility with oil-bearing particulates.

Therefore, to select the correct respirator filter, it must first be known if oil-bearing particulates are present, and second, the filter efficiency must be chosen. For particulates that have an exposure limit of less than 0.05 mg/m^3, only filters with a collection efficiency of 99.97% should be used.

If oil-bearing particulates are present, then a respirator filter with an “R” designation can be worn for a maximum of *one shift only*. Respirator filters with a “P” designation can be worn for as long a time as determined by the manufacturer.

Particulate Filter Classifications

- "N" series filters cannot be used in oil-bearing particulate environment
- "R" series filters may be used in oil-bearing environment for one shift only
- "P" series filters may be used in any particulate environment with service time limit determined by the manufacturer

Source: 42 CFR 84

Summary of Particulate Filter Classifications

Not Oil-Resistant	Oil-Resistant	Oil-Proof	% Efficiency
N95	R95	P95	95%
N99	R99	P99	99%
N100	R100	P100	99.97%

CHANGING OF PARTICULATE FILTERS

Particulate filters have criteria that establish when the filter should be replaced. The first is based on worker hygiene concerns. This is a very subjective criterion since workers' opinions of personal hygiene vary greatly. The second criterion is damage to the filter. This damage could be physical damage to the filter as a result of kinetic impact, or could result from a splash or other contact with a degrading material, such as water. The third criterion is a filter loading of 200 mg of total particulates. If the airborne contaminant is the only particulate, the filter loading limit is rarely the controlling criterion; however, in very dusty environments the filter loading limit may be the limiting factor.

Changing of Particulate Filters

Limited by:

- Personal hygiene
- Damage to filter
- Breathing resistance (total filter loading of 200 mg)

GAS/VAPOR FILTER CONSIDERATIONS

When selecting filters for gases or vapors, the factors to consider are different than with particulates. Since the chemical to be removed from the air must chemically react with the filter media, specific filters must be selected for specific contaminants. There are limitations for the maximum concentrations a specific filter can handle (*maximum use concentration* will be discussed in detail later). The time period for which the filter can be used before it reaches saturation limits is called its *service life* and is a function of the length of time it takes for the chemical to *break through* the filter.

Warning properties of a chemical are those characteristics (smell, touch, taste, etc.) that cause a sensory response in people to warn them of the chemical's presence.

Unlike a particulate filter, once a gas or vapor cartridge reaches saturation, the contaminant will no longer be filtered out of the air. Therefore, either a cartridge-change schedule must be developed, or an *end-of-service-life indicator* (ESLI) must be employed to prevent worker exposures resulting from saturated respirator filters.

Gas/Vapor Filter Considerations

- Contaminant of concern
- Maximum use concentration
- Breakthrough time
- Warning properties
- End-of-service-life indicators

GAS VAPOR ELEMENT CLASSIFICATIONS

Under 42 CFR 84, NIOSH has separated gas/vapor cartridges into three types (listed in order of increasing capacity): cartridges, chin canisters, and front/back canisters. Each respirator submitted for approval is tested against the chemical contaminants for which the manufacturer is requesting certification. Each filter type has distinct advantages and disadvantages of use; for example, cartridges have the shortest duration but are most comfortable, while canisters are more cumbersome but provide a longer service life.

Gas/Vapor Element Classifications

Contaminant	Cartridge	Chin Canister	Front/Back Canister
Organic vapor	x	x	x
Acid gas	x	x	x
Ammonia	x	x	x
Carbon monoxide			x
Other gases/vapors	x	x	x
Combination	x	x	x

MAXIMUM USE CONCENTRATION (MUC)

Maximum Use Concentration (MUC) is a term whose definition is currently reserved in the respiratory protection standard. However, based on historical and current guidance from several manufacturers, NIOSH, and OSHA, the following is how this term is to be used until a formal definition is codified. In 42 CFR 84, specific MUCs have been assigned to certain respirator cartridges as part of the respirator's certification process. A formula for calculating the MUC is provided and is based on the occupational exposure limit for a particular chemical and the NIOSH assigned protection factor for a particular respirator type. The NIOSH defined Immediately Dangerous to

Maximum Use Concentration (MUC)

- Specified for some contaminants in 42 CFR 84
- Formula for calculation:
  - ✓ MUC = Assigned Protection Factor (APF) X Exposure Limit (EL)
- Cannot exceed IDLH
- Cannot exceed manufacturer's limitation
- Cannot exceed 10 X E.L. for APR with qualitative fit test

Life or Health (IDLH) concentration *must never be exceeded* when using an APR. An additional limitation from the Respiratory Protection Standard is that if a qualitative fit test is used to verify adequate sealing of the respirator, then the MUC is ten times (10×) the occupational exposure limit. This requirement takes individual differences in senses of smell into account.

DETERMINING MUC

Answer:

Reason:

Determining MUC

Contaminant:	Toluene
Exposure limit:	50 ppm (TLV)
IDLH:	500 ppm
Manufacturer limit:	None specified
Qualitative fit test used?	Yes
Full face APR:	NIOSH APF-50
NIOSH MUC:	1000 (42 CFR 84)

SERVICE LIFE

Service life is a term that refers to how long a filter can be worn until it reaches 90% of its capacity. This property is highly variable and depends on factors such as humidity, temperature, chemical concentration, and workers' breathing rate. This is why filter change schedules must be site-specific. Below are examples of a particular manufacturer's cartridge's breakthrough time for various chemicals for which it is certified. Recognize that altering any one of the environmental factors could drastically change the breakthrough time. For example, increasing the relative humidity from 50% to 90% could reduce service life by as much as four times (4×).

Gas/Vapor Filter Limitations

Breakthrough:

The penetration of challenge materials through a gas or vapor air-purifying element

Service life:

Length of time required for an air-purifying element to reach 90% capacity

Service Life Examples

Solvent	*Service Life (minutes)
Benzene	73.00
Chloroform	33.00
Ethanol	28.00
Methanol	0.20
Methyl chloride	0.05
Vinyl chloride	3.80
Carbon tetrachloride	77.00

*Challenge atmosphere: 1000 ppm

WARNING PROPERTIES

Warning properties, as stated earlier, are the properties of a chemical that provides some sensory indication of its presence to a worker. This sensory input could be a smell, taste, or irritating effect. Ideally, sensory input would occur at or below the exposure limit so the worker could know that the respirator has failed prior to exceeding the exposure limit. Warning properties are no longer permitted to be used as a method for determining when a respirator filter needs to be changed. However, each respirator wearer should know the warning properties for the contaminant they are working with so that respirator-failure can be identified immediately by the user. Filter change schedules have replaced warning properties for determining when to change respirator filters.

Warning Properties

Properties of a substance that provide detectable and persistent sensory input (odor, taste, irritation) to alert the individual of the contaminant's presence

Ideally, properties trigger awareness of the presence of a contaminant while its concentration is "at or below" the permissible exposure limit

Example Warning Properties

Chemical	Warning Conc. (ppm)	PEL (ppm)
Acetone	0.10–699	1000
Butylamine	0.1–5	C5
Carbon monoxide	odorless	50
Hydrogen sulfide	0.00001–1.4 (fatigue)	C20
Sulfur dioxide	0.3–5 (taste)	5
Butyl mercaptan	0.0008–0.038	10

END-OF-SERVICE-LIFE INDICATOR (ESLI)

An end-of-service-life indicator (ESLI) is a device that indicates when the respirator filter has reached 90% of its capacity. ESLIs are usually passive devices that change color when the cartridge's service life is over. The value of ESLIs is that they allow the user to get the maximum use from the respirator filter without exposing the worker. In contrast, filter change schedules must have a significant margin of safety due to changing environmental factors and interpersonal differences. This results in disposing filters that have significant service life remaining. Currently there are only a few contaminants for which there is an approved ESLI. With the new Respiratory Protection Standard's requirements to base filter changing on objective data, there will be a greater focus by respirator manufacturers to develop ESLIs for a wider range of contaminants.

End-of-Service-Life Indicator (ESLI)

A device, usually passive, that indicates to the wearer that the gas/vapor filter has reached 90% of its filtering capacity and will soon be expended

HAZARD RATIO

The term Hazard Ratio (HR) is a unit-less number representing the ratio of the actual airborne concentration of a contaminant with respect to the occupational exposure limit for that contaminant. The HR is used for determining the minimum protection that the selected respirator should provide. The assigned protection factor of the selected respirator must be at least equal to or greater than the HR in order to ensure adequate protection from the contaminant.

Hazard Ratio

Definition: Numeric ratio of the actual airborne concentration of the contaminant with respect to the exposure limit

$$HR = \frac{\text{Airborne Concentration}}{\text{Exposure Limit}}$$

Air-Purifying Respirator

Cartridge Type

RESPIRATION SELECTION FACTORS

When selecting a respirator, many factors must be considered, some of which have little to do with the contaminant, and more to do with the cost and the job to be performed. For example, the job requires an ASR, but the person must work for extended periods of time primarily in a stationary location. Using an SCBA would require stopping work every 20 minutes to change cylinders, producing a subsequent loss in productivity. Therefore, it would be better to select an SAR that would provide adequate protection and allow for maximum worker productivity. However, if the job requires that the worker be mobile, or if the distances to be covered exceed 300 ft, then an SCBA would be the respirator of choice.

TIGHT-FITTING RESPIRATOR

Air-Purifying Respirator

Canister Type

Air-Purifying Respirator

Powered

APRs

Advantages	Disadvantages
- Low cost	- Maximum use concentration
- Less maintenance	- IDLH conditions
- Long duration	- Unknown contaminants

Supplied-Air Respirators (SARs)

- Types
  - Tight-fitting
    - ✓ Pressure demand
    - ✓ Continuous flow
  - Hooded continuous flow

SAR Specifications

Maximum hose length	300 ft
Minimum air flow rate	115 L/min Pressure demand 170 L/min Continuous flow
Maximum flow rate	435 L/min

Air-Line Respirator

with Escape Bottle

Supplied-Air Respirator

Mobile

Supplied-Air Respirator

for Heavy Equipment Operation

Continuous-Flow Hood

SARs

Advantages	Disadvantages
▪ Longest duration	▪ 300 ft maximum length
▪ Least physiological stress	▪ Greatest logistical support
▪ Most comfortable	▪ Protection of air line

Self-Contained Breathing Apparatus (SCBA)

- Types
  - Closed circuit
  - Open circuit

Closed-Circuit SCBA Theory of Operation

Uses moisture in exhaled breath with a solid oxidizer of potassium superoxide (KO_2) to produce oxygen and remove CO_2 or uses a CO_2 scrubber

Closed-Circuit SCBAs

<u>Advantages</u>

- Long duration
- Safer storage

<u>Disadvantages</u>

- Extremely exothermic
- Characteristic waste
- Duration of use is harder to determine

Open-Circuit SCBAs

- Compressed air cylinder worn by worker
- Cylinders tested and inspected in accordance with 49 CFR 173-178
- Duration approximately 30–60 min (45 SCF/30 min)
- Escape SCBA's duration fixed at 5, 10, and 15 min

SCBA Cylinders

Scott Carbon Fiber Cylinder

Scott SCBA. Uses Mask Mounted Regulator

Open-Circuit SCBAs

Advantages

- Greatest mobility for level of protection
- No waste generated

Disadvantages

- Require air source for filling cylinders
- Hydrostatic testing
- High-pressure cylinder storage
- Shortest duration of respirators

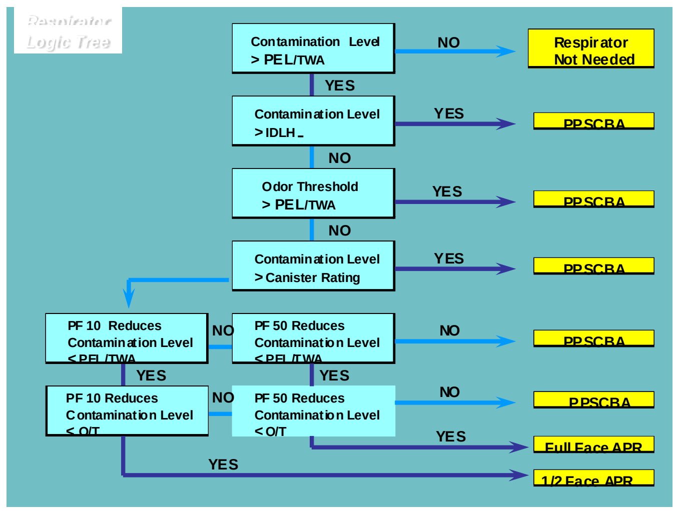
Respirator Selection

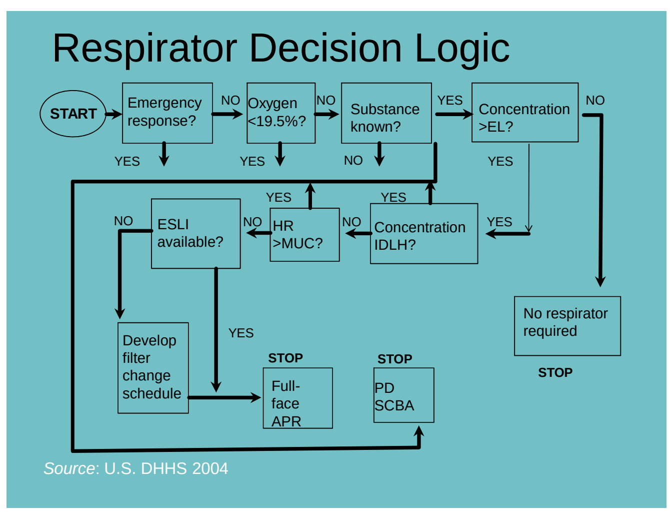
- Identify contaminant and nature of hazards
- Characteristics of operation and worker activity
- Location of hazardous area
- Duration of use
- Respirator capabilities and limitations

Source: ANSI Z88.2, 1980

RESPIRATOR DECISION LOGIC

The respirator selection flowchart (shown below) is a compilation of the NIOSH Respirator Decision Logic (U.S. DHHS 1987) and the changes put forth in the new Respiratory Protection Standard. For the sake of simplification, the respirator choices were limited to SCBAs and full-face APRs, since those are the respirators most likely to be worn by personnel who do hazardous waste site cleanup. Additionally, this flowchart addresses neither the selection of a particulate filter that would include whether the contaminant was oil-bearing or not, nor the collection efficiency needed. (Note the block that identifies developing a filter-change schedule.) Developing a filter change schedule requires the use of a separate multipage flowchart to address the site-specific environmental issues, contaminant breakthrough, and work load factors. A copy of the filter change schedule flowchart is available on OSHA's internet website at: **www.osha.gov**.





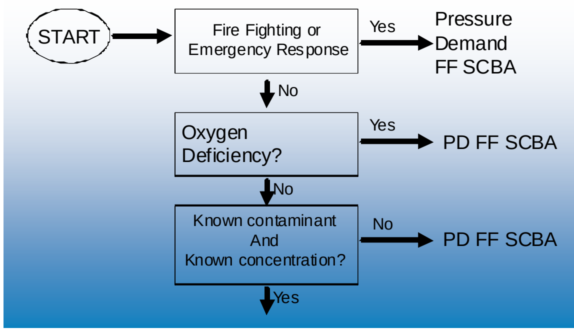
Procedures for respirator selection

NIOSH-approved respirators must be worn

42 CFR Part 84

- Establishes testing criteria
- Provides protocols for approval testing

Respirator Selection



Questions ?

THIS PAGE INTENTIONALLY BLANK.

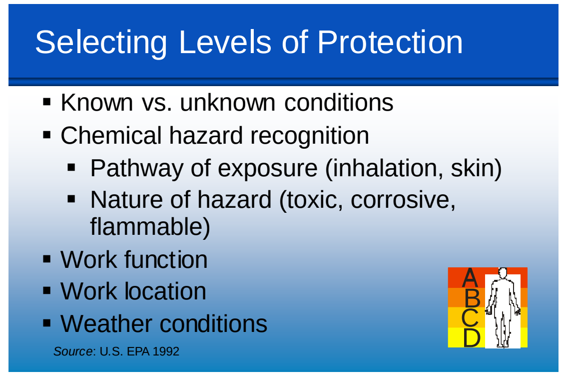
LEVELS OF PROTECTION AND CHEMICAL PROTECTIVE CLOTHING

Student Performance Objectives

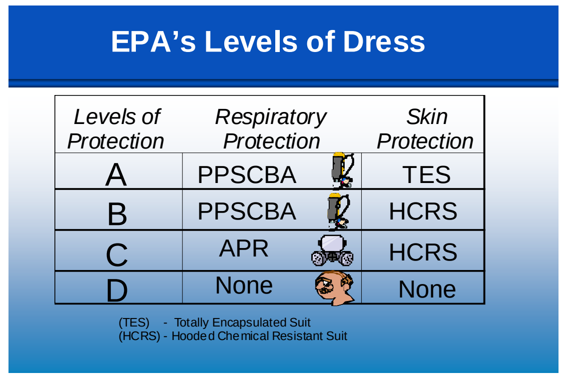
1. List the factors to consider when selecting a level of protection.
2. Identify the criteria for selecting Level A, Level B, Level C and Level D.
3. List the U.S. EPA's equipment requirements for Levels A, B, C, and D personal protective equipment (PPE).
4. Explain the performance qualities to consider when selecting protective clothing.
5. Explain the chemical resistance properties attributed to protective clothing.
6. Describe how to inspect suit integrity.
7. List the agencies or organizations that regulate or provide technical guidance on chemical protective clothing.
8. Describe the types of suit configurations.
9. List the suit components.

THIS PAGE INTENTIONALLY BLANK.

SELECTING LEVELS OF PROTECTION



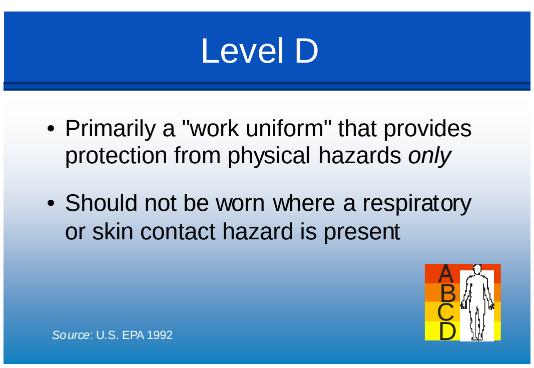
The proper level of protection depends on the toxicological hazard posed by the substance and the pathways for exposure. Protection for the head, eyes, face, and feet will provide additional barriers against hazards. Selected clothing used with respiratory protection can minimize the risk of exposure to chemicals, impact, and noise, but may not protect against such things as fires, radiation, and electrical hazards.

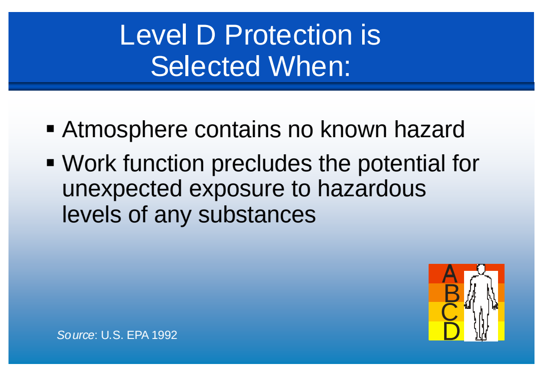


Are there risks of physical injury? What are the toxic effects? What are the exposure pathways and airborne concentrations? Different levels of protection may be required for different work functions or locations. Sampling and container handling need more protection than conducting an inspection. An open-air location with low levels of contamination requires less protection than working in an area with highly contaminated soil piles. Temperature and humidity affect both the PPE performance characteristics as well as the stresses on workers.

LEVEL OF PROTECTION SELECTION CRITERIA

Level D protects from physical hazards only, not respiratory or skin protection from chemicals.





Level D Equipment

- Coveralls
- Gloves
- Safety boots/shoes (leather or chemical resistant)
- Disposable boot covers*

* Optional

Source: U.S. EPA 1992

Level D Equipment

- Safety glasses (chemical splash goggles*)
- Hard hat (face shield*)
- Escape mask*

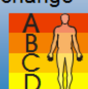
* Optional

Source: U.S. EPA 1992

Levels C and B have a splash suit that gives minimal skin protection from chemicals. Level C gives minimal respiratory protection with an APR. Level B has an ASR for maximum respiratory protection.

Level C Protection is Selected When:

- Airborne contaminants are identified
- Concentrations are measured
- Criteria for wearing APR are met
- Atmospheric concentrations are moderate to low and easily controlled
- Atmospheric conditions are not likely to change rapidly
- Low degree of splash hazards present



Source: U.S. EPA 1992

Level C Equipment

- Air-purifying respirator (full-face, canister)
- Hooded, chemical-resistant clothing
- Inner clothing
- Chemical-resistant gloves (inner and outer)

Source: U.S. EPA 1992

Level C Equipment

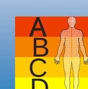
- Chemical-resistant safety boots
- Disposable boot covers*
- Hard hat (face shield*)
- Escape mask*
- Two-way radio

* Optional

Source: U.S. EPA 1992

Level B Protection is Selected When*:

- Initial entry may expose worker to unknown atmospheric hazards
- Highest degree of respiratory protection is needed
- Some degree of skin protection is needed
- Air contaminants are unknown
- Air contaminants have been identified and the criteria for using APRs are not met
- Direct contact does not pose a severe skin hazard



* Level B is the minimum protection for initial entry recommended by both the EPA and OSHA

Source: U.S. EPA 1992

Level B Equipment

- Atmosphere-supplying respirator (pressure-demand)
- Hooded chemical-resistant clothing
- Inner clothing
- Chemical-resistant gloves (inner and outer)

Source: U.S. EPA 1992

Level B Equipment

- Chemical-resistant safety boots
- Disposable boot covers*
- Hard hat (face shield*)
- Two-way radio

* Optional

Source: U.S. EPA 1992

Level A has a fully encapsulating suit (FES) for maximum protection from skin hazards, and an ASR for maximum respiratory protection. Fully encapsulating, chemical protective clothing is a one-piece garment that completely encloses the wearer. Boots, gloves, and face-piece are an integral part of the suit, but may be removed. If removable, they are connected to the suit by devices that provide a vapor- or gas-proof seal. These are gas-tight suits and must be periodically pressure tested to ensure integrity.

Level A Protection is Selected When:

- The highest level of protection is needed for:
  - Respiratory system
  - Skin
  - Eyes
- Working conditions and contaminants are unknown
- Substance has been identified and requires highest level of protection
  - Pesticides and nerve agents
  - Anhydrous acids and bases

Source: U.S. EPA 1992

Level A Protection is Selected When:

- Operations are conducted in small, poorly ventilated areas
- Work involves a high potential for splash or skin exposure hazards
  - Patching chlorine cylinders
  - Plugging leaks in bulk storage tanks

Source: U.S. EPA 1992

Level A Equipment

- Atmosphere-supplying respirator (pressure-demand)
- Fully encapsulating, chemical-resistant suit
- Inner clothing
- Chemical-resistant gloves (inner and outer)

Source: U.S. EPA 1992

Level A Equipment

- Chemical-resistant safety boots
- Outer clothing (disposable protective suit, gloves, and boot covers)*
- Hard hat* (under suit)
- Cooling unit*
- Two-way radio

* Optional
Source: U.S. EPA 1992

Levels of Protection

	Chemical Protective Clothing	Respiratory Protection
Level A	FES	ASR
Level B	Splash Suit	ASR
Level C	Splash Suit	APR
Level D	None	None

PERFORMANCE QUALITIES

The ability of a material to impede chemical and physical change when exposed to a challenge chemical is chemical resistance. This is the most important performance requirement. If a material has the ability to maintain its chemical resistance and physical integrity during temperature extremes, then hot temperatures will not reduce its strength or increase permeability, and cold will not reduce

Performance Qualities

Chemical resistance	Design
Temperature resistance	Aging resistance
Flexibility	Cleanability
Durability	Comfort

its flexibility making it rigid. Flexibility is extremely important both for glove and full-body suit materials because it directly impacts the worker's mobility, agility, and range of motion; however, it is a tradeoff with durability.

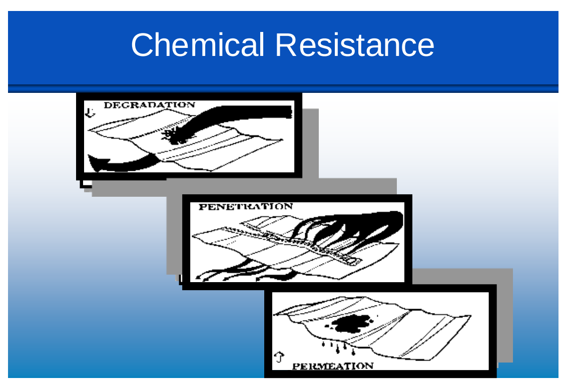
Durability is the ability of a material to resist damage due to punctures, abrasions, and tears during normal wear. This is provided by both the thickness of the material and the supporting substrates of the suit. The more durable the material and design, the less flexible it is. If a material resists degradation over time in storage it is *age resistant*. The factors which may affect aging are extreme temperature, moisture, ultraviolet light, oxidizing agents, and others. Storage and care *MUST* follow the recommendations of the manufacturer.

The relative ease of effectively decontaminating protective materials is important to age resistance. Some materials are nearly impossible to decontaminate, so it may be important to cover those materials with disposable garments to prevent gross contamination. Consider the following factors that affect decontamination:

- Textured or treaded surfaces on gloves and boots;
- Closure types, such as snaps or hook-and-pile (Velcro®);
- Creases, folds, and inaccessible component parts.

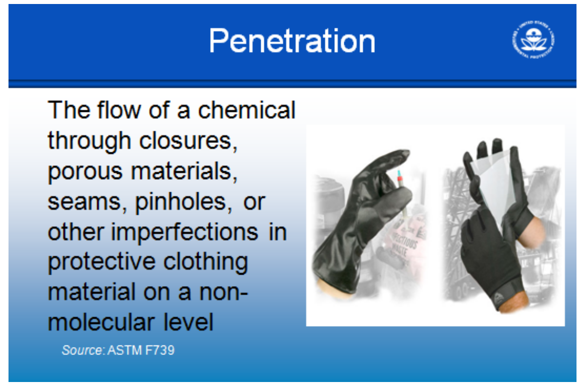
Size is directly related to comfort and influences the number of unnecessary physical accidents. Ill-fitting clothing limits a worker's mobility, dexterity, and concentration. Manufacturers offer standard sizes in boots and gloves; however, there are no standardized sizes as in the textile industry.

CHEMICAL RESISTANCE



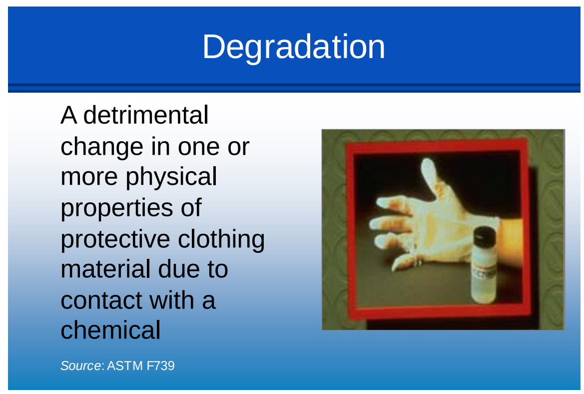
No single material is resistant to all chemicals, and every chemical will eventually permeate through every material. The Site Safety Officer should select the material that will provide adequate protection for the chemical hazards present. For removal and remedial work, a wear-period of four (4) hours should be the target duration of wear. For emergency response, the duration of a single entry would be the minimum wear-period.

PENETRATION



Penetration is a direct function of the suit's physical construction more than the material itself. Stitched seams, buttonholes, pinholes, zippers, and woven fabrics can provide an avenue for the chemical to penetrate the garment. A well-designed and constructed garment prevents this by using self-sealing zippers, seams overlaid with tape, flap closures, and nonwoven fabrics.

DEGRADATION

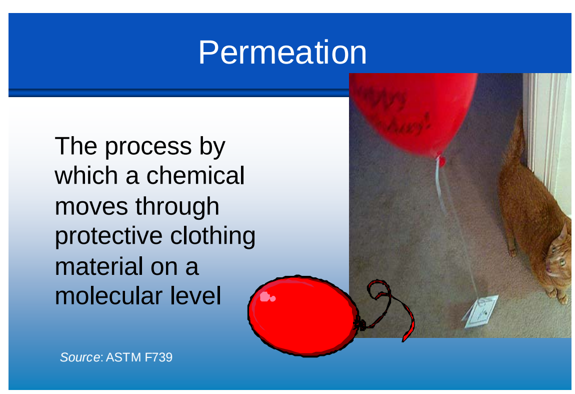


Degradation may cause the material to shrink or swell, become brittle or soft, or completely change its chemical properties. Other changes may be a slight discoloration, rough or gummy surface, or cracks in the material. Such changes may enhance permeation or allow penetration by the contaminant.

Certain suit materials are not compatible with certain chemicals and will not maintain their protective qualities when exposed to these chemicals. For example, methyl ethyl ketone (MEK) will dissolve a polyvinyl chloride (PVC) suit. For certain contaminants and chemical mixtures, there are no materials available that will protect for more than an hour after initial contact.

Degradation data can help in assessing the protective capability of a material but should not replace permeation test data. The reason for this is that a material with excellent degradation resistance can have poor permeation properties. Degradation and permeation are not directly related and cannot be used interchangeably. The manufacturer should be consulted by the user to determine the degradation changes upon which the rating is based.

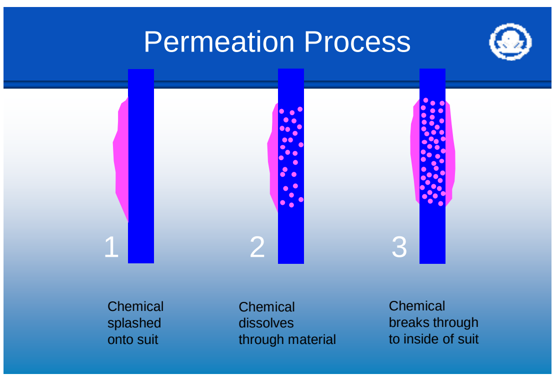
PERMEATION

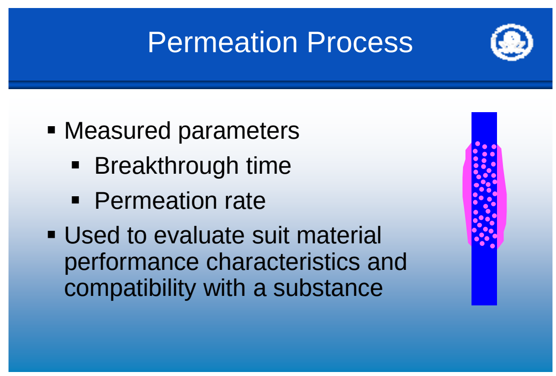


Since *all chemicals* will permeate through *all suit material,* the objective is to select a suit material that has permeation characteristics to meet the expected duration of wear. Highly toxic chemicals leach back out at a later time and the potential for future use with a noncompatible chemical is possible. These are the driving forces behind the move by the industry toward disposable suits.

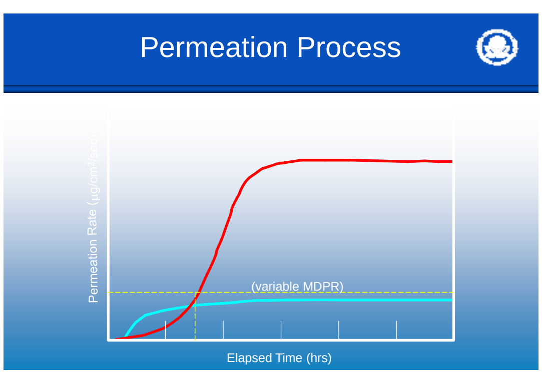
PERMEATION PROCESS

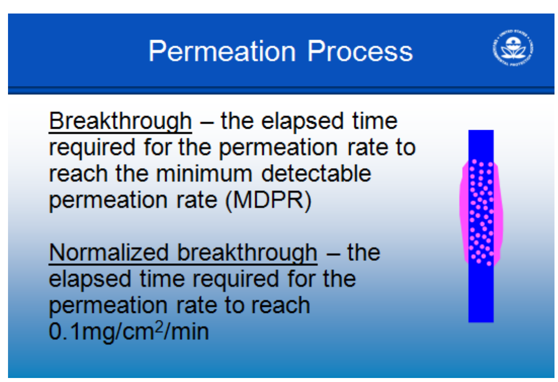
Breakthrough time is a measure of elapsed time, and the permeation rate is a measure of how much of the chemical is passing through the suit over a given period of time. Like permeation rate, breakthrough time is chemical specific for a particular material and is influenced by the same factors. A rule of thumb concerning breakthrough time is that it is directly proportional to the square of the thickness (2× thickness = 4× breakthrough time). A long breakthrough time does not always correlate with a low permeation rate or vice versa. A long breakthrough time is usually desired. These measures are used to evaluate suit material performance and chemical compatibilities and are manufacturer-specific and can vary with both the thickness of the material and the temperature.





The MDPR line shows the Minimum Detectable Permeation Rate (MDPR). This value varies depending on the analytical process used. It is possible that the rate of permeation could be below the detectable limits of the analytical process, even though all chemicals will eventually permeate through all suit materials.
Normalized breakthrough is a value that allows the comparison of different makes and/or models of suits.





Permeation Process

Steady state permeation rate – the point at which the permeation rate levels off during the testing

CAUTION

Permeation rate can increase by as much as 350% with a 10\F increase in temperature

Permeation/Degradation Resistance Guide

	Nitrile NBR			Polyvinyl Alcohol			Polyvinyl Chloride		
	PR	*PBT*	*DR*	*PR*	*PBT*	*DR*	*PR*	*PBT*	*DR*
Acetone	–	–	NR	–	–	P	–	–	NR
Carbon Tetrachloride	G	2.5 hr	G	E	ND	E	F	25 min	F
Ethyl Alcohol	VG	4 hr	E	–	–	NR	VG	1 hr	G
Hydrochloric Acid	–	ND	E	–	–	NR	–	>5 hr	E
1,1,1-Trichloroethane	P	1.5 hr	F	E	ND	G	–	–	NR

DR = Degradation rating *PR* = Permeation rate E = Excellent VG = Very good G = Good F = Fair
PBT = Permeation breakthrough time *NR* = Not recommended P = Poor ND = Not detected

Source: Ansell Edmont 1990

MATERIAL TESTING NOTES

The literature on material testing notes that permeation rates and breakthrough times are not tested for those materials that receive a poor degradation rating; only breakthrough time is measured for those chemicals (especially corrosives) that are known to be direct skin hazards. The data also reflect the testing of pure substances and not mixtures.

Blends and Layers

- Optimize compatibility with a wide range of chemicals
- Examples:
  - Neoprene/latex rubber
  - Viton/Neoprene
  - Viton/butyl rubber

Considerations for Selection and Use

1. *All* chemicals permeate *all* protective clothing
   a. Evaluate each chemical or mixture for compatibility
   b. Target is 4 hours use
2. Inspect clothing before and after use
   a. Inflate gloves
   b. Light leak-check splash suits
   c. Pressure test vapor-tight suits

Considerations for Selection and Use

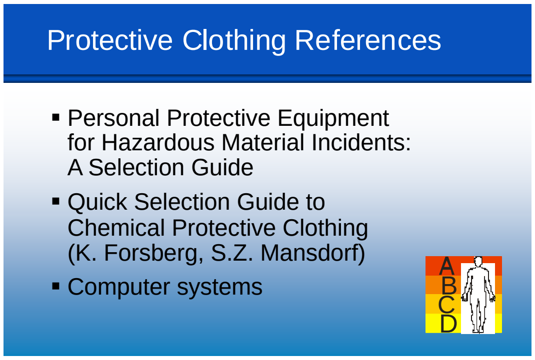
3. Evaluate suits for actual weather conditions
4. Generally, thicker is better except where dexterity is hindered
5. Do not base selection on color or appearance, as many materials look alike
6. Recognize differences between manufacturers and product lots (performance varies widely)
7. Know the shelf life and storage requirements

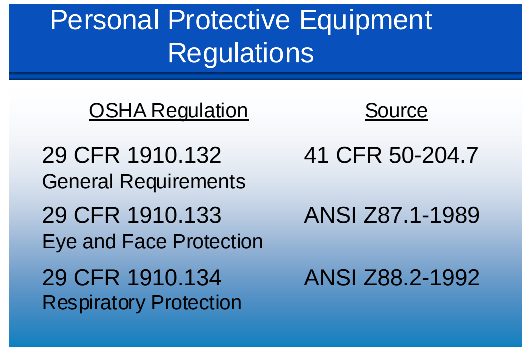
Protective Clothing References

- Manufacturers' data
- Published studies
- Guidelines for the Selection of Chemical Protective Clothing (Arthur D. Little, Inc.)
- Field test kits

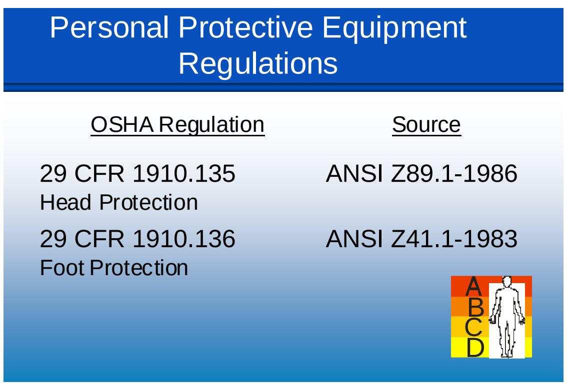
TEST DATA RECOMMENDATIONS

The available test data and recommendations for all chemical protective clothing are extremely limited, both in scope and use. The user must consider these restrictions when selecting CPC and use the guidelines in the way they were intended.





Concomitantly, they protect against splashes of liquids. The protection they provide against a specific chemical depends upon the material from which they are constructed.



REFERENCES

A.D. Little, Inc. Guidelines for the Selection of Chemical Protective Clothing. Second Edition. Prepared by Arthur D. Little, Inc. Cambridge, MA. Under contract to Los Alamos National Laboratory, for the U.S. Environmental Protection Agency. Washington, DC. 1985.

A.D. Little, Inc. Guidelines for the Selection of Chemical Protective Clothing. Third Edition. Prepared by Arthur D. Little, Inc. Cambridge, MA. Under contract to Los Alamos National Laboratory, for the U.S. Environmental Protection Agency. Washington, DC. 1987.

Ansell, Edmont. Chemical Resistance Guide, 5th Edition. Ansell, Edmont Industrial. Coshocton, OH. Used with permission. 1990.

ASTM. ASTM Standard Test Method F739-81. American Society for Testing and Materials. Philadelphia, PA. 1981.

U.S. DOT. Survey of Personal Protective Clothing and Respiratory Apparatus. U.S. Department of Transportation, Office of Research and Development. Washington, DC. 1974.

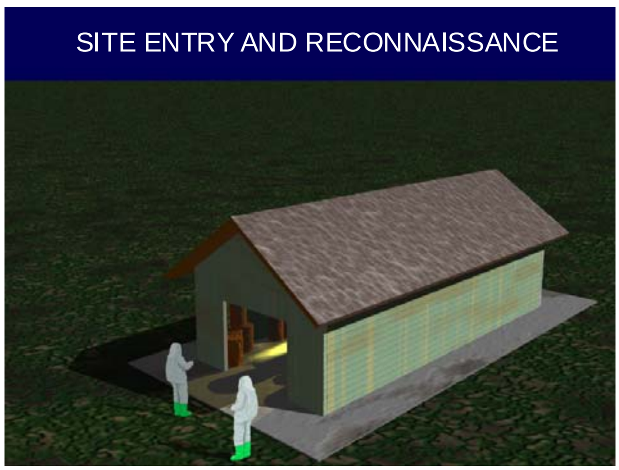
U.S. EPA. Standard Operating Safety Guides. Office of Emergency and Remedial Response, Emergency Response Division, Environmental Response Team, U.S. Environmental Protection Agency. Washington, DC. 1992.

THIS PAGE INTENTIONALLY BLANK.

SITE ENTRY AND RECONNAISSANCE

Student Performance Objectives

1. Explain the purpose of a Health and Safety Plan.
2. Identify the components of a Health and Safety Plan.
3. Describe Preliminary Site Evaluation and five examples of the types of information obtained in the process.
4. Describe what is accomplished during an initial site entry.



THIS PAGE INTENTIONALLY BLANK.

HEALTH AND SAFETY PLAN (HASP)

The purpose of the HASP is to organize general safety practices for the site and to provide worker protection guidelines when conducting site activities.

Health and Safety Plan (HASP)

- Definition: a written program to identify, evaluate, and control health and safety hazards at any site, and to provide for emergency response
- Site-specific HASP required under 29 CFR 1910.120(b)

HASP REQUIREMENTS

The HASP must be provided to OSHA inspectors when requested. If work objectives change on site, the HASP must be changed to reflect the new site activities. If additional hazards are encountered or if the job functions change, the plan must be updated. All personnel should be aware of the details of the HASP as it relates to their job functions on the site. Daily meetings should be held before the work begins to discuss health and safety concerns about the work to be conducted.

HASP Requirements

1. Keep onsite for reference
2. Address health and safety issues for each work phase
3. Read, understood, and signed by workers
4. Safety meetings

HASP COMPONENTS

Key personnel within the organizational structure should be identified and listed by name in the HASP. Although not specifically required, key personnel *should* be different people. Two mandatory positions are the On-Scene Coordinator (OSC) or Incident Commander (IC), and the Health and Safety Officer (H/SO). Qualified alternates should be named for the key personnel. They should be familiar with the site so they can make decisions in the absence of the primary person.

Questions to ask are: “What are the risks associated with performing this task?” and “What are the chemical hazards associated with this task?”

The advantages of site control are that it will minimize employee and public exposure to hazardous substances by preventing contact with contamination through unauthorized site entry, it will reduce the possibility of spreading contaminants by either personnel or equipment leaving the site, work zones are established, and the “buddy system” is used to protect employees. This delineation of work zones is a basic way of establishing site control.

General site workers require 40 hours of OSHA-approved health and safety training, 3 days onsite and an 8-hour annual refresher course. Occasional site workers require 24 hours of OSHA-approved health and safety training for employees, 1 day on site, and an 8-hour annual refresher course. Additional training is required for managers and supervisors by 29 CFR 1910.120, and may be needed for others depending on the function of an employee. At least one person must be trained in first-aid and CPR.

The purpose of medical surveillance is to verify that workers are physically capable of performing all of the activities that their job descriptions require. For example, work requiring the wearing of respiratory and other personal protective equipment (PPE) requires that the worker have 1) no particular sensitivities to chemical exposures, and 2) full-color sight. Also the physicals can determine if any effects of exposures have occurred.

Once the site hazards have been identified and evaluated, the required levels of protection (LOP) and PPE can be selected. For initial site entry, the minimum LOP is Level B. Once the site has been characterized, lower levels can be selected if conditions permit.

Components of a HASP

1. Organizational structure: identify key personnel and alternates
2. Health and safety risk analysis
3. Site control measures
4. Site training requirements
5. Medical surveillance requirements
6. Personal protective equipment …

Components of a HASP

7. Air and employee monitoring needs
8. Spill containment program
9. Confined space procedures
10. Decontamination procedures
11. Emergency response plan

Initial site investigation requires monitoring for any Immediately Dangerous to Life or Health (IDLH) condition, such as exposure over occupational exposure limits, the presence of radiation exposure hazards, and flammable or oxygen-deficient environments. The monitoring needs of high-risk workers, and the required frequency of monitoring based on work activities, should be determined.

To contain spills, the plan should consider both the site and the tasks to be performed, under 29 CFR 1910.120. Equipment for cleanup should be determined based on both "reasonable and likely" as well as "worst" cases. For example, use sorbent pads when drum sampling. Use containment wherever possible to limit the spread of contaminants.

The HASP should address specific procedures for confined space work based on 29 CFR 1910.146 and should identify the hazards, risks, and training requirements. Confined space work has the following characteristics: (1) limited entry and exit openings; (2) ability to physically enter and work; (3) not designed for continuous worker occupancy. For example: storage tanks, sewers, concrete vaults, and caves.

Decontamination is based on both site contaminants and levels of protection used. The procedures *must* include both routine and emergency decontamination for personnel and equipment.

Contingencies for site emergencies *must* include plans, procedures, and medical facilities. Each person must know how to identify and report an emergency as well as what their duties and responsibilities are. From the standpoint of the organization, a decision must be made whether to adopt an emergency response plan or an emergency action plan. Emergency action plans may be developed in lieu of an emergency response plan *only* if employees are evacuated from the site when an emergency occurs and not permitted to assist in the response.

Emergency phone numbers for police, fire department, and EMS must be conspicuously posted identifying specific individuals to make the notification. Determine which medical facility can handle contaminated workers on an emergency basis, preferably the nearest one. A route to the medical facility should be established and posted. The map should be made only after the route is driven.

THREE WORK ZONES

The Contamination Reduction Zone (CRZ) requires the same level of PPE, or one below the level of protection worn by the entry team in the Exclusion or “hot” Zone.

Three Work Zones

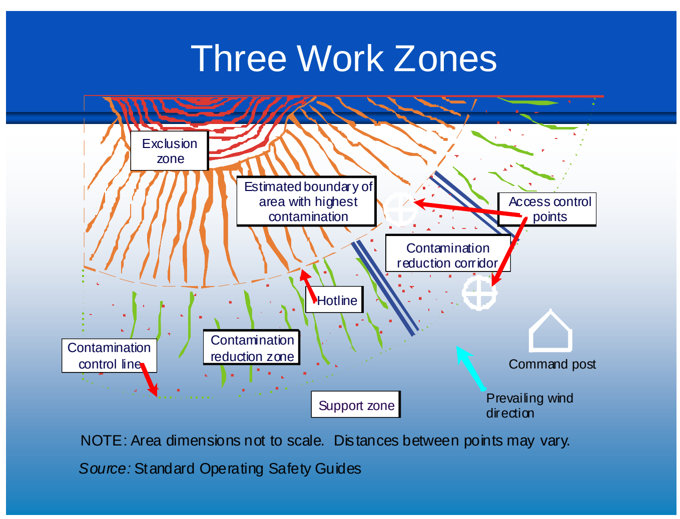
- Purpose: to reduce the spread of contamination and confine work activities
- Support zone
  - Command post
  - No contamination
  - Level D work clothing

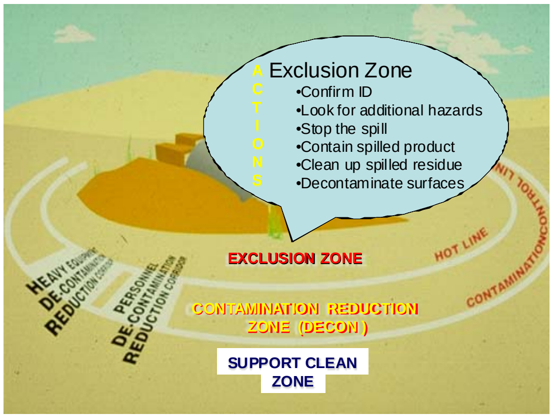
Three Work Zones

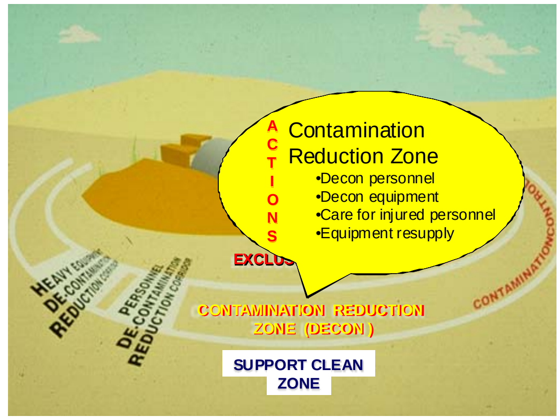
- Contamination reduction zone (CRZ)
  - Buffer zone for contamination
  - Location of decon line
  - PPE required
- Exclusion zone
  - Contaminated work zone
  - PPE required

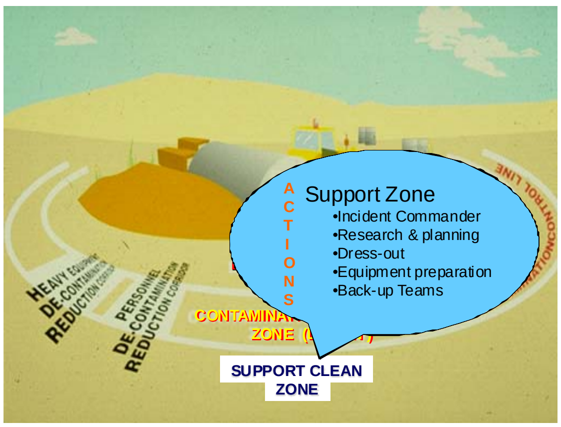
CONSIDERATIONS FOR WORK ZONE DESIGN

The size of each work zone is site-specific and may have such physical and topographical features as pits, trenches, low areas, and water bodies. Stage the support zone upwind of the hot zone, if possible.

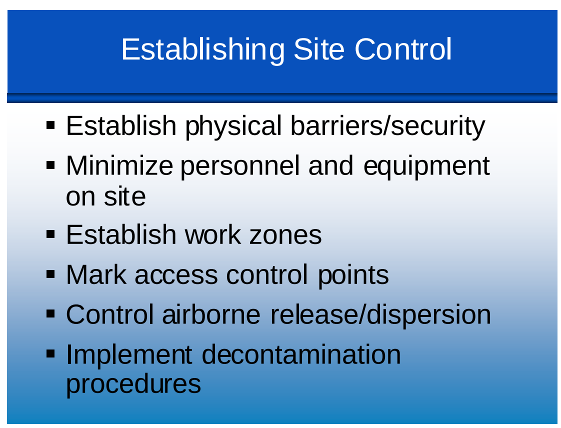








ESTABLISHING SITE CONTROL

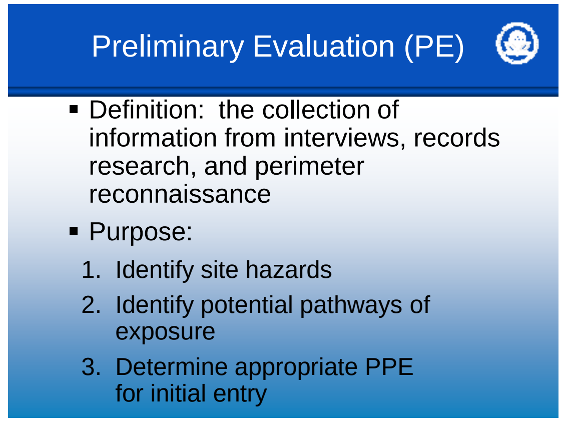


One way to establish the hot line location is to use air monitoring results. Generally this is done by first establishing background conditions then monitoring the air while walking toward the suspected area of contamination. When air monitor readings on an instrument reach 5 meter units above background, move back a non-specified distance to provide a buffer zone, and then establish a hot line. Look for visual clues such as stained soil, stressed vegetation, pools of unknown liquid, etc. Use previous investigation data in conjunction with air monitoring readings to establish work zones.

Set up a barrier or structure to delineate the hot line. The warm zone should be 75 feet in length or more, if possible, to allow adequate space for the decon line. There should be one access control point for entry into the hot zone and one for exit from the hot zone into the contamination reduction zone. Airborne dispersion can be controlled with tarps, water, or some other dust suppression method.

PRELIMINARY EVALUATION (PE)

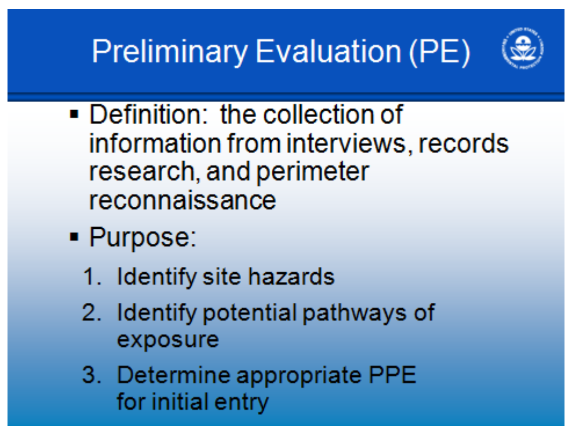
The PE, including the perimeter reconnaissance, must take place off site to protect the health and safety of site workers. Obtain information from site files, tax assessor's office, topographic maps, aerial photographs, facility owner/manager, and neighbors. Site boundaries may go beyond fence lines. A site is defined by the extent of the contamination spread.



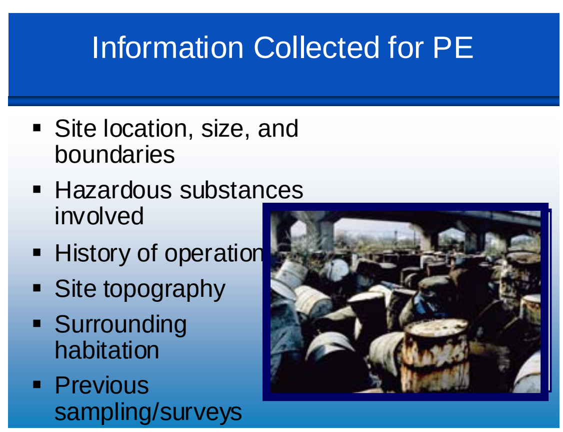
Determine the substances used on or off the site, and the types of contaminates used or stored on site. This will help to determine the necessary air monitoring equipment, PPE, and SOPs to use.

INFORMATION COLLECTED FOR PE

Gather information on previous site operations, products used, disposal methods, or disposal areas. Evaluate the information source because different sources may provide conflicting information.

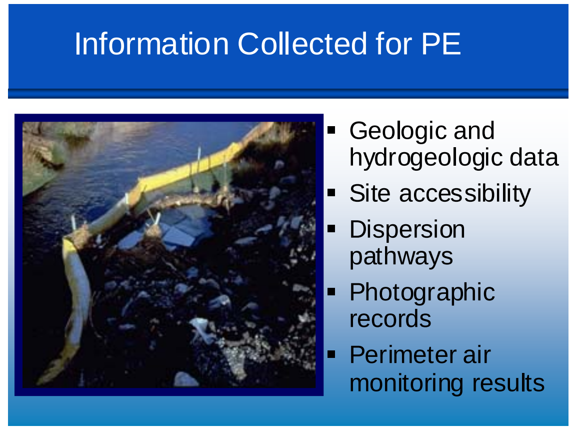


Is the population in the area urban or rural? Determine the potential dangers to the population and the extent of site control needed. Urban areas will have emergency services more readily available.



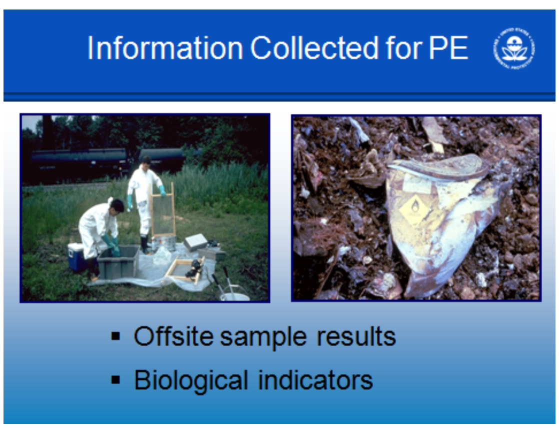
Local or state environmental and health agencies may have information on any site activities or entries. Check their findings, lab results, and any records kept on the facility being investigated.

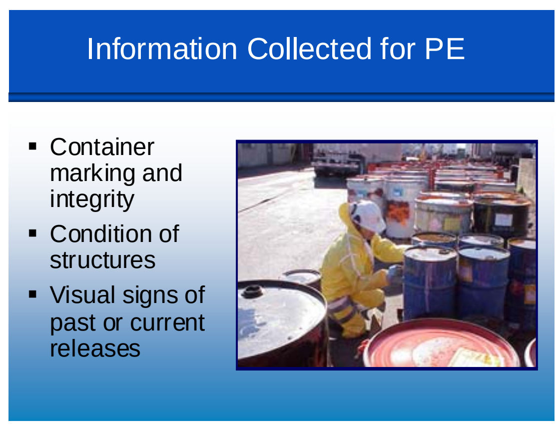
The data provided could include groundwater levels and flow direction, and monitoring well placement. Sources of this information are the U.S. Geological Survey,



state geologic surveys, drilling companies, local colleges and universities, and reference materials. Meteorological information can determine the best times for site operations. Weather may determine how to adjust work zones.

The terrain and population will affect accessibility and may determine work progress. If inaccessible, consider aerial photos or air reconnaissance. The primary contaminant migration pathways should be determined and an estimate of the time period when contamination may have occurred. Migration pathways also may have changed since that time due to the removal of structures or placement of concrete or asphalt pads. Aerial photographs taken over a period of time may show site progression and can be used to look for ponds, lagoons, above ground storage tanks, and areas of stressed vegetation. Sources for these photographs are the U.S. Geological Survey, state geological surveys, and local planning boards. Background readings of the perimeter air should be determined by monitoring during reconnaissance.

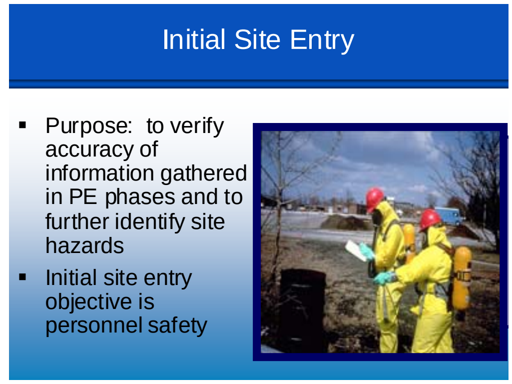




Collect samples from soil, drinking water, groundwater, surface water, and sediment. Use the results to establish background levels. Determine if structures are safe to enter and if there are any other physical hazards. Look for vapor clouds, mist, dust, pooled liquid, stained soil, and stressed vegetation.

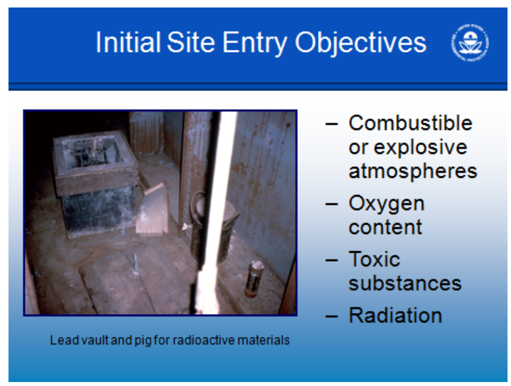
INITIAL SITE ENTRY

At a minimum, site entry should consist of air monitoring and a visual survey of hazards. Typically, sampling is *not* performed during initial site entry.



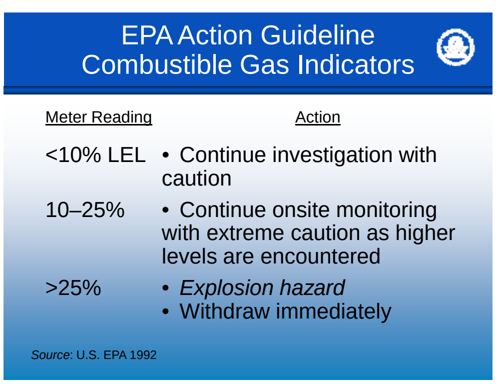
SITE ENTRY OBJECTIVES

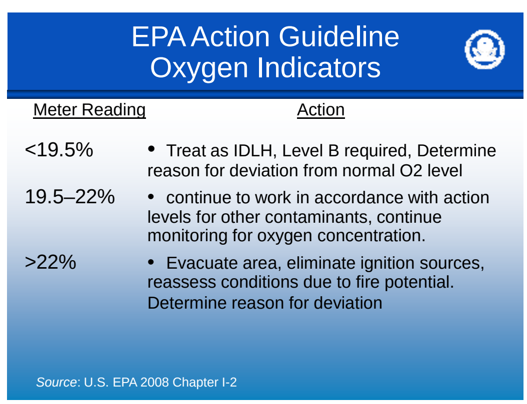
The capabilities and limitations of your monitoring instruments must be understood. It is critical to know if other vapors or gases are present that cannot be detected by the instrument. The risk to personnel must be weighed against the need for entry. It must be known that there are no carcinogens or extremely toxic substances. Employee activity must be evaluated in order to use lower levels of protection.



MONITORING CONDITIONS

Monitor at high, middle, and low levels with about a 4-foot separation between levels. Look for IDLH conditions such as confined spaces, source of vapor clouds, and biological indicators.





EPA Action Guideline
Radiation Indicators

Meter Reading	Action
<1 mR/hr	• If levels are above background, continue investigation with caution • Perform thorough monitoring • Consult health physicist
>1 mR/hr	• Potential radiation hazard • Suspend site activities • Continue monitoring only upon advice of a health physicist

Source: U.S. EPA 1992

EPA Action Guideline
Total Gas/Vapor Meters

Meter Reading	Action
Unknowns:	
Background-5ppm	Level C
5–500 ppm	Level B
500–1000 ppm	Level A
Known's:	Compare to Exposure Guides

Source: U.S. EPA 2009 Chapter I-3 ER H&S Manaual

DECONTAMINATION

There is a need to consider decontamination of workers and equipment and, in some cases, a two-line setup, one for dirty workers and one for clean workers.

***CAUTION**: Containers **should not** be opened unless materials inside are identified except, possibly, with a remote opening device.*

Initial Site Entry Objectives

- Visually survey for physical hazards
  - Structural integrity
  - Slip/trip/fall hazards
  - Confined spaces
  - Lighting
  - Ventilation

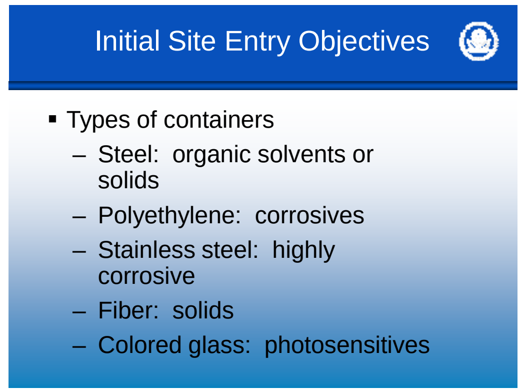
The primary objective when responding to a hazardous material incident is the prevention, or reduction, of detrimental effects to public health or the environment. To accomplish this it is necessary to:

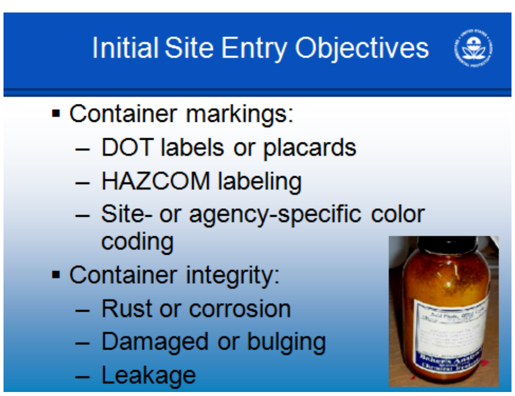
- Identify the substance involved;
- Evaluate its behavior when released and its effects on public health and the environment;
- Initiate actions to prevent or modify its effects.

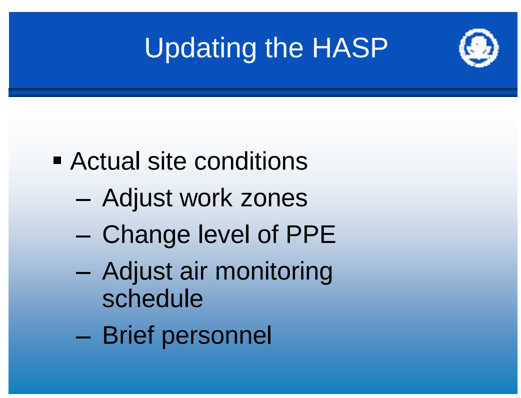
A high priority, from start to finish of an incident, is obtaining the necessary information to evaluate its impact. This is called incident characterization and is the process of identifying the substance involved and evaluating its actual or potential impact on public health or the environment.

Characterization is relatively straightforward in incidents where the substance involved is known or easily identified, the pathways of dispersion are clearly defined, and the effect or potential impact is demonstrated. For example, the effects of a large discharge of vinyl chloride on fish in a small stream are relatively easy to evaluate. However, an incident such as an abandoned waste site containing 60,000 55-gallon drums is more complex because generally there is not enough initial information to determine the hazards and to evaluate their impact.

Evaluating a hazardous substance incident is generally a two-phase process: (1) an initial characterization and (2) a more comprehensive characterization.







PRELIMINARY ASSESSMENT

At site responses where the hazards are largely unknown and where there is no need to go on site immediately, conduct an offsite reconnaissance by (1) making visual observations, (2) monitoring atmospheric hazards near the site, and (3) collecting offsite samples that may indicate onsite conditions or migration from the incident.

Any offsite reconnaissance and information gathering should also include:

- Collections of information not available or needed to verify or supplement the preliminary assessment.
- General layout and map of the site.
- Monitoring ambient air with direct-reading instruments for oxygen deficiency; combustible gases; radiation; organic vapors, gases, and particulates; inorganic vapors, gases, and particulates; and specific materials, if known.
- Placards, labels, markings on containers or transportation vehicles.
- Configuration of containers, tank cars, and trailers.
- Types and number of containers, buildings, and impoundments.
- Biological indicators – dead vegetation, animals, insects, and fish.
- Unusual odors or conditions.
- Visual observation of vapors, clouds, or suspicious substances.
- Offsite samples (surface water, drinking water, site runoff, groundwater, soil, air).
- Interviews with inhabitants, observers, or witnesses.

INITIAL CHARACTERIZATION

The initial characterization is based on information that is readily available or that can be quickly obtained. This information is used to determine (1) what hazards exist and (2) whether immediate protective measures are necessary. During this initial phase, the following key decisions must be made:

1. Is there an imminent or potential risk to public health and to the environment?
2. Is there an immediate need for protective actions to prevent or reduce the impact?
3. What will provide the best protection of the health and safety of response personnel?

Once immediate control measures are implemented, actions can start to restore the area to environmentally acceptable conditions. If no emergency exists, time can be spent: (1) evaluating hazards, (2) designing cleanup plans, and (3) establishing safety requirements for response personnel. Also, information to characterize the hazards can be obtained from intelligence (records, placards, eye witnesses, etc.), direct-reading instruments, and sampling. Various combinations of these information gathering techniques can be used depending on the nature of the incident and the time available.

The outline that follows lists the types of data necessary to evaluate the impact of a hazardous materials incident. Although not every incident requires obtaining all items on the list, the list does provide a guide that can be adapted to meet site-specific conditions.

DATA GATHERING AND PRELIMINARY ASSESSMENT

Upon notification or discovery of an incident, obtain the following information:

- Brief description
- Exact location
- Date and time of occurrence
- Hazardous materials involved and their physical/chemical properties
- Present status of the incident
- Potential pathways of dispersion
- Habitation: population at risk
- Environmentally sensitive areas: endangered species, delicate ecosystems
- Economically sensitive areas: industrial, agricultural
- Accessibility by air and roads
- Waterways
- Current weather and forecast
- Terrain: include topographic map
- Geology and hydrology: include appropriate maps
- Aerial photographs
- Communications
- Any other related background information

Information about an incident, especially abandoned waste sites, may also be available from:

- Other federal agencies
- State and local health or environmental agencies
- Company records

- Court records
- Water departments, sewage districts
- State and local authorities

ONSITE SURVEY

A more thorough evaluation of hazards generally requires personnel to enter the defined site. Before going onsite, an entry plan is developed: (1) to address what will be initially accomplished, and (2) to give the procedures to protect the health and safety of response personnel. Onsite inspection and information gathering includes:

- Monitoring ambient air with direct-reading instruments for oxygen deficiency; combustible gases; radiation; organic vapors, gases, and particulates; inorganic vapors, gases, and particulates; and specific materials, if known.
- Utilize pH paper, oxidizer paper, and water finding paper.
- Types of containers, impoundments, and their storage systems, including numbers, types, and quantities of material.
- Condition of storage systems (state of repair or deterioration, visible damage, etc.).
- Leaks or discharges from containers, tanks, ponds, vehicles, etc.
- Potential pathways of dispersion: air, surface water, groundwater, land surface, and/or biological routes.
- Placards, labels, markings, identification tags, or indicators of material.
- Container configuration, shape of tank cars or trailers.
- Location of standing water or liquids.
- Condition of soil.
- Location of wells, storage containers, drainage ditches, or streams and ponds.

COMPREHENSIVE CHARACTERIZATION

The second phase, comprehensive characterization (which may not be needed in all responses), is a more methodical investigation to enhance, refine, and enlarge the information base obtained during the preliminary inspection. This phase provides more complete information to characterize the hazards associated with an incident. As a continuously operating program, the second phase also reflects environmental changes resulting from response activities.

Available information and information obtained through initial site entries may be sufficient to thoroughly identify and assess the human and environmental effects of an incident. If not, an environmental surveillance program needs to be implemented. Much of the same type of information as collected during the preliminary inspection is needed. However, it may be much more extensive. Instead of one or two groundwater samples being collected, an extensive groundwater survey may be needed over a long period of time. Results from the preliminary inspection provide a screening mechanism for a more complete environmental surveillance program to determine the extent of contamination. Also, since mitigation and remedial measures may cause changes in the original conditions, a continual surveillance program must be maintained to identify any changes.

Evaluating the hazards associated with an incident involves various degrees of complexity. The release of a single, known chemical compound may represent a relatively simple problem. It becomes progressively more difficult to determine harmful effects as the number of compounds increases. Evaluation of the imminent or potential hazards associated with an abandoned waste site, storage tanks, or lagoons holding vast amounts of known or unknown chemical substances is far more complex than evaluating a single release of an identifiable substance.

The major responsibility of response personnel is the protection of public health and the environment. The effective accomplishment of this goal is dependent upon a thorough characterization of the chemical compounds involved, their dispersion pathways, concentrations in the environment, and deleterious effects. A base of information is developed over the lifetime of the incident to assess the harmful effects and ensure that effective actions are taken to mitigate the release.

REFERENCES

U.S. EPA. *Standard Operating Safety Guides*. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Emergency Response Division, Environmental Response Team. Washington, D.C. 1992.

DECONTAMINATION

Student Performance Objectives

1. List at least five factors used to determine the level of decontamination.
2. Identify the six plan provisions for conducting decontamination.
3. Describe at least two prevention methods used during decontamination to minimize contact with hazardous substances.
4. List the decontamination steps for:

    a. Maximum Level A Decontamination

    b. Maximum Level B Decontamination

    c. Maximum Level C Decontamination.

THIS PAGE INTENTIONALLY BLANK.

DECONTAMINATION

To prevent the mixing or contact of incompatible materials and the spread of contamination from the Exclusion Zone, a decontamination plan is developed using standard operating procedures (SOPs) that provide a safe and effective process for removing and containing contaminants. It also prevents the spread of contamination to decontamination workers, personnel in the Support Zone, and the offsite community.

Decontamination

OSHA 29 CFR 1910.120 (k) establishes a legal requirement:

"...procedures for all phases of decontamination shall be developed..."

Decontamination

The process of removing potentially harmful contaminants from exposed individuals and equipment in order to:

- Prevent the spread of contamination from the work area
- Minimize contact with contaminated materials

DECONTAMINATION EVALUATION AND PLAN DEVELOPMENT

The type of decontamination method selected depends on the types of contaminants. These methods may include:

- Solid powders that can be brushed off
- Liquids that can be rinsed or scrubbed away
- Dry decontamination for water-reactive materials
- Mechanical methods for sludge

Decon Evaluation

- Personnel or equipment contaminated by:
  - Contact with vapors, gases, mists, or particulates
  - Being splashed by Materials while sampling
  - Contact with liquids or soil
  - Using instruments or equipment

Decontamination Plan Development

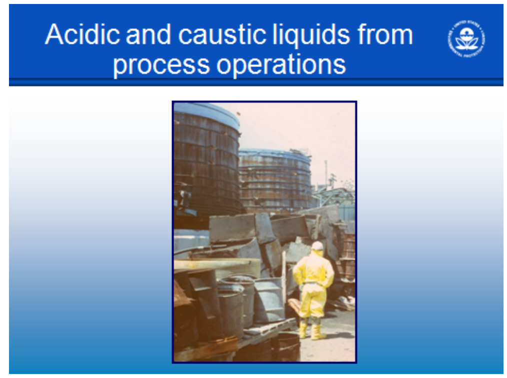
- Initial plan based on:
  - Worst-case scenario
  - No site information available
- After site entry, plan is modified to eliminate steps or adapt to site conditions, considering several factors

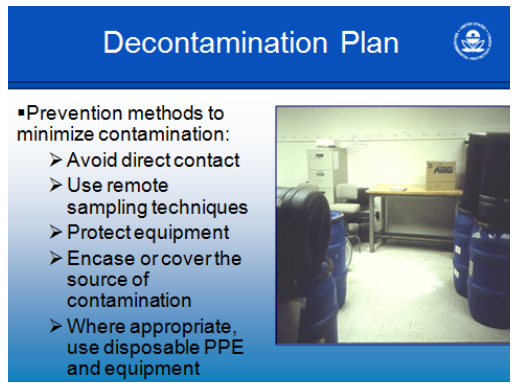
Care must be taken to identify the hazard class and chemical name(s) to determine potential combinations, toxic, corrosive or reactive characteristics, and its affinity to personal protective clothing (PPC) and equipment. With chemical mixtures, the contaminant that poses the greatest risk may be in low concentration.

Personal protective equipment (PPE) that is reusable, as opposed to disposable, will require more complete decontamination. Personnel who decontaminate heavy equipment or tanks will be decontaminated differently than personnel performing air monitoring for health and safety compliance.

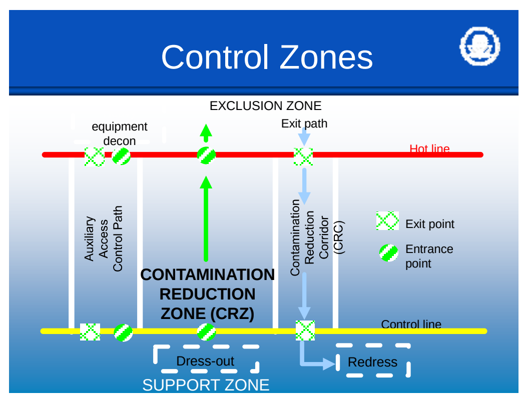
DECONTAMINATION PLAN

The best way to simplify decontamination is to minimize contact with contaminants. Do not walk through contaminated areas. Do not work in puddles or splashed material or set equipment down in obvious contamination. Use remote techniques to handle or open containers. Use a Colawasa or "drum thief" to collect samples. Wrap equipment with disposable plastic and make openings in the bags for sample ports, probes, sensors, etc. Cover equipment and tools with a strippable coating that can be removed during decontamination. Put a disposable tarpaulin over contaminated soil. The plan must also include steps to decontaminate decontamination workers.





THE EXCLUSION ZONE



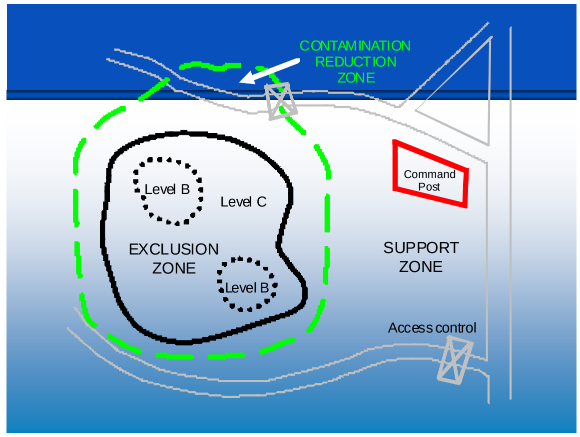
The Exclusion or “hot” zone is a specifically delineated area, within which contamination is either known or suspected to exist. The extent of the “hot” zone is determined by the air monitoring documentation; the wind direction; physical boundaries like roads, buildings, and fences; and control of the zone’s access both into and out of the site.

The Contamination Reduction or “warm” zone (CRZ) contains the Contamination Reduction Corridor (CRC) which controls access into and out of the Exclusion Zone and confines personnel decontamination activities to a limited area.

The Support Zone is the “cold” zone.

CONTAMINATION REDUCTION CORRIDOR

Decontamination workers are decontaminated in the Contamination Reduction Corridor (CRC) upon exiting the Exclusion Zone and before they enter the Support Zone.



DECONTAMINATION PLAN PROVISIONS

Generally, decontamination workers will either don the same level of protection that is worn by workers in the Exclusion Zone or downgrade one level of protection. In any case, the level of protection for decontamination workers is relative to the site in question and the worker's position in the decontamination line. The selected dermal and respiratory protection for the Decontamination Team should be *no more than one level below the Entry Team's level of protection*.

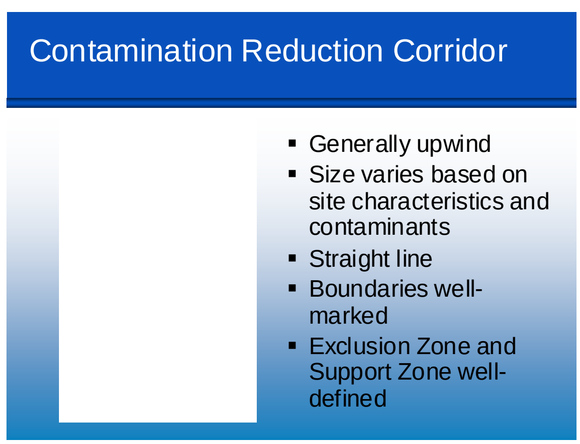
Evaluation by self-auditing and waste stream monitoring procedures should be established. Investigation derived waste (IDW) is regulated under the Resource Conservation and Recovery Act (RCRA). RCRA requires offsite disposal of waste that has a generator ID number, and is manifested and transported by a licensed carrier to a current treatment, storage, and disposal (TSD) facility.

CONTAMINATION REDUCTION CORRIDOR

Zone Layout

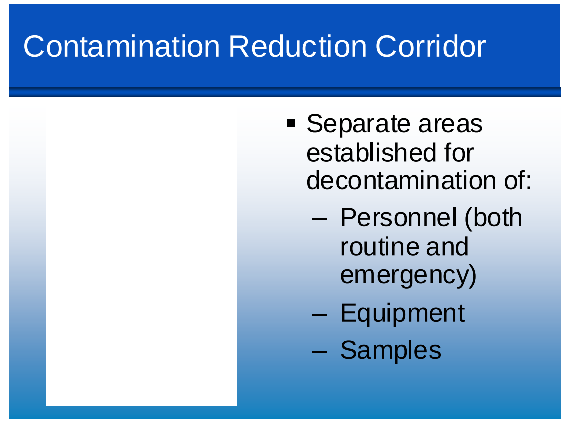
The size of the CRC depends on the number of stations in the decontamination procedure, the overall dimensions of work control zones, and the amount of space available. A 75'×15' corridor should be adequate for full decontamination.

The CRC should have restricted entry and exit points. At the far end of the CRC is the



hotline, the boundary between the Exclusion Zone and the Contamination Reduction Zone. Personnel exiting the Exclusion Zone must go through the CRC. Everyone in the CRC should be wearing the level of protection designated for the decontamination crew. Another corridor may be required for the entrance and exit of heavy equipment needing decontamination.

CRC



Within the CRC, specific areas are set aside for the decontamination of personnel, portable field equipment, removed clothing, etc. These areas should be well marked and restricted to those personnel wearing the appropriate level of protection. All activities within the corridor are confined to decontamination.

Protective clothing, respirators, monitoring equipment, sampling supplies, and other equipment are all maintained outside of the CRC. Personnel don their protective equipment away from the CRC and enter the Exclusion Zone through a separate access control point at the hotline.

DECONTAMINATION TECHNIQUES

Decontamination Solutions

Protective equipment, sampling tools, and other equipment are usually decontaminated by scrubbing with detergent water using a soft-bristle brush, followed by rinsing with copious amounts of water. Water is the universal solvent, but other chemicals may be needed.

<u>NOTE:</u> Special care must be taken not to compromise the protective qualities of the PPE.

While using water may not be fully effective in removing some contaminants (because of their reactivity with water), it is a relatively safe option compared to using other decontamination solutions.

BASIC CONTAINMENTS AND METHODS

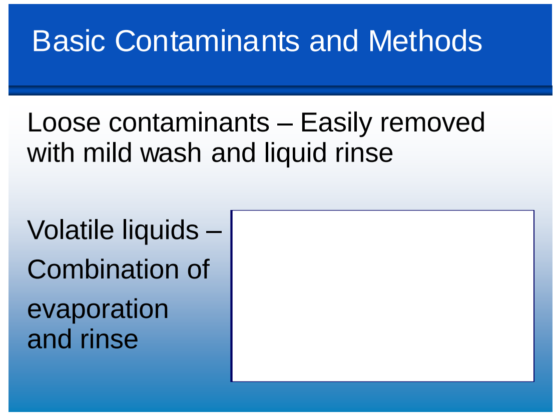
Solvents should be used only at the direction of the site Safety and Health Officer. These include:

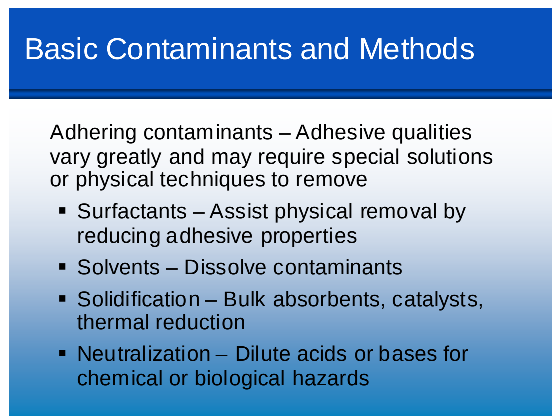
(1) Water for low-chain hydrocarbons, inorganic compounds, salts, some organic acids, and other polar compounds.

(2) Dilute acids for basic or caustic compounds, amines, and hydrazines.

(3) Dilute bases (detergent, soap, etc.) for acidic compounds, phenols, thiols, and some nitro and sulfonic compounds.

(4) Organic solvents and petroleum products (fuel oil, kerosene) for non-polar organic compounds.





WARNING: Extreme caution should be exercised when using solutions other than detergent and water on personnel, because of the potential risk of exposure to a hazard from the decontamination solution.

Solidification is used to enhance physical removal. It is useful for viscous contaminants, but does not change the contaminants. Solidification techniques include:

(1) Bulk absorbents (soil, sand, limestone, clay, vermiculite, or Speedy Dry™) for moisture removal.

(2) Chemical reactions: polymerization catalysts (resinous materials), and chemical reagents (precipitates).

(3) Freezing (ice or ice water) for materials with high freezing temperatures.

To neutralize chemicals or biological agents, use dilute acids or bases, such as bleach, for killing infectious agents.

Routine Personnel Decon

- Visually inspect prior to decon for:
  - Gross contamination
  - Rips or tears in PPE
  - Material degradation
- Thoroughly wash and rinse each item, as applicable, before removal
- Remove items that are most contaminated first

Routine Personnel Decon

- Prevent cross-contamination between entry and decon personnel
- Only one person at each station at a time
- Look for signs and symptoms of chemical exposure or heat and cold stress

Emergency Decon

- Quickly assess medical hazard
  - Physical injury
  - Chemical exposure
  - Life-threatening
- Perform rapid gross decon, if possible, prior to suit removal
- Minimize potential exposure to medical and decon personnel

Dry Decontamination Methods

- May be performed by:
  - Brushing contamination off of surface
  - Pulling contamination off of protective clothing with tape
  - Chemical absorbent/adsorbent wipes/pads
  - Carefully rolling contaminated PPE downwards upon itself and discarding it in a proper container for disposal

Dry Decontamination

This method may also be known as aseptic or isolation and disposal decontamination. Dry decontamination is the most readily available method to quickly reduce contamination and exposure. Under extreme circumstances when proper resources are not available, consideration for use of natural resources such as sand, dirt, grass, and leaves may be considered. The removal of chemical protective outer garments will remove most of the contamination and minimize cross-contamination. This may be the preferred method when working in outdoor temperatures <18˚ C (<65˚ F), especially for Emergency Decontamination.
Some methods may employ a suitable vacuum cleaner. Provide a dry brush and a containment capture method for materials falling off contaminated personnel.

If material is suspected to be radioactive, workers suspected of being contaminated will be scanned carefully with a radiation monitor suitable for detecting surface contamination (instruments that may be used are covered in the Radiation Exposure Chapter). All parts of their protective clothing and personal equipment will be scanned, including the soles of the feet. If no readings are found, personnel that have been checked can leave the decontamination reduction zone.

ROUTINE AND EMERGENCY DECONTAMINATION

Effectiveness of Decontamination

There is no immediate method for determining how effective decontamination is in removing contaminants. Discolorations, stains, corrosion, and residues on objects may indicate that contaminants have not been removed. However, observable effects only indicate surface contamination and not permeation (absorption) into clothing. Many contaminants are not easily observed.

Equipment Decon

- More aggressive techniques can be used
  - Chemical methods
    - Strong acids or bases
    - Organic solvents

Equipment Decon

- Mechanical methods
  - Steam cleaning
  - Water lancing
  - Abrasive blasting
  - Ultrasonic cleaning

Sample Decon

- Preservation of sample integrity is paramount
  - Detergent and tap water wash, deionized water rinse
  - Dilute acids or bases before using
  - Contaminant compatible with container

Program Evaluation

One way to document the effectiveness of the Decon process and to provide documentation for the disposal of IDW solids is swipe testing on decontaminated PPE. Cloth or paper patches (swipes) are wiped over predetermined inner and outer surfaces of the suspected contaminated clothing and later analyzed in a laboratory. Positive results for both sets of swipes would indicate that surface contamination has not been removed and that

Program Evaluation

- Monitor for airborne contaminants
- Sample rinsate for contaminant migration through CRC
- Perform swipe tests on decontaminated PPE

substances have penetrated or permeated the garment. Swipe tests can also be performed on skin or inside clothing.

Another way to test the effectiveness of decontamination procedures is to analyze for contaminants left in the cleaning solutions. Elevated levels of contaminants in the final rinse solution may suggest that additional cleaning and rinsing are needed.

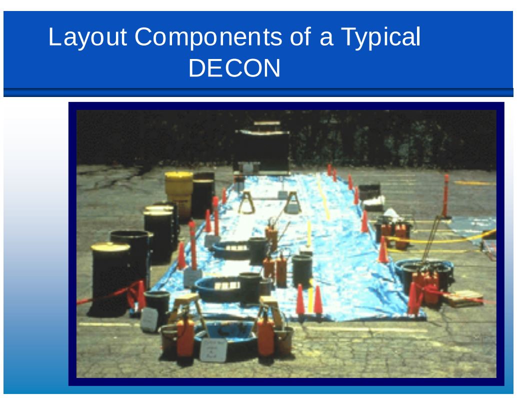
For decontamination from a safety and health standpoint, the two key questions that must be addressed are:

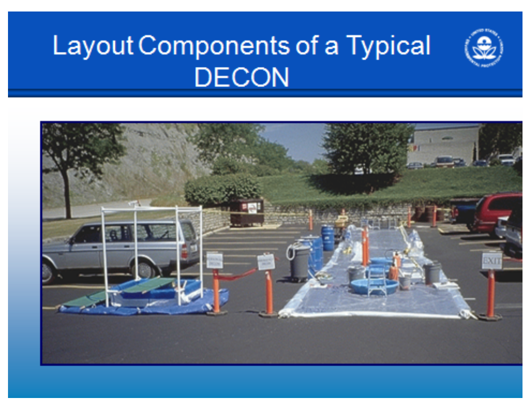
- Is the method effective for the substances present?
- Does the method itself pose any safety or health hazard?

LAYOUT COMPONENTS OF TYPICAL CRZ

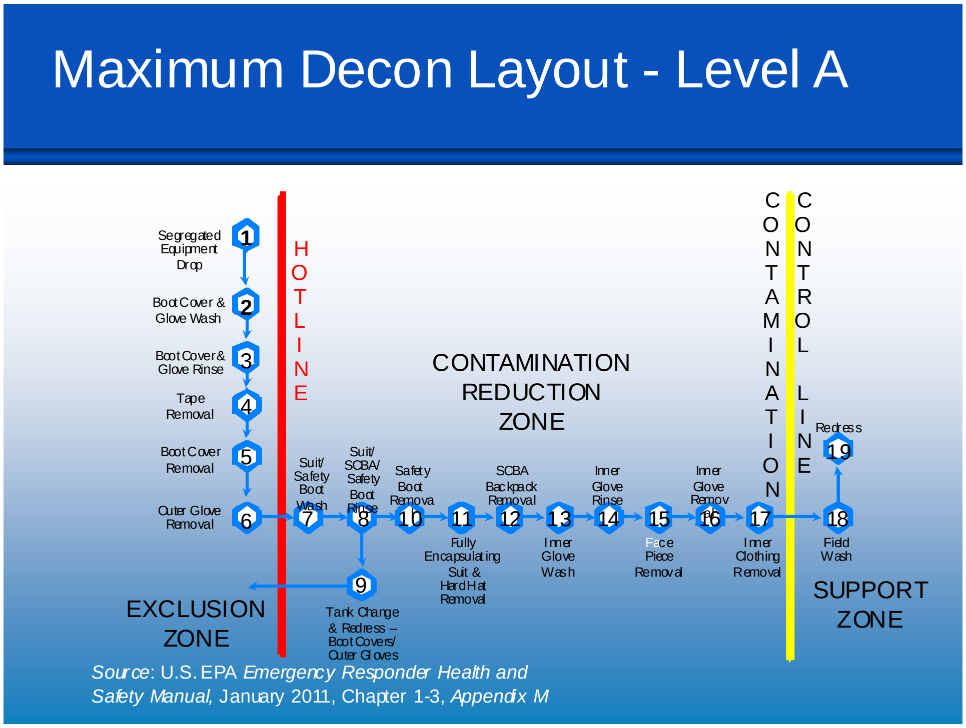
Layout is applicable for Level A, B, or C decontamination. Workers in Level A PPE have a basically smooth surface to decontaminate. Decontamination of workers in Level B PPE may be difficult due to the SCBA backpack assembly and straps. Workers in Level C PPE can easily get wash and rinse water in the filter of their APR.

CAUTION: Use care not to splash solution into the cartridge or canister of your APR.





MAXIMUM LEVEL A DECON



Be sure to rinse the bottom of the boots last.

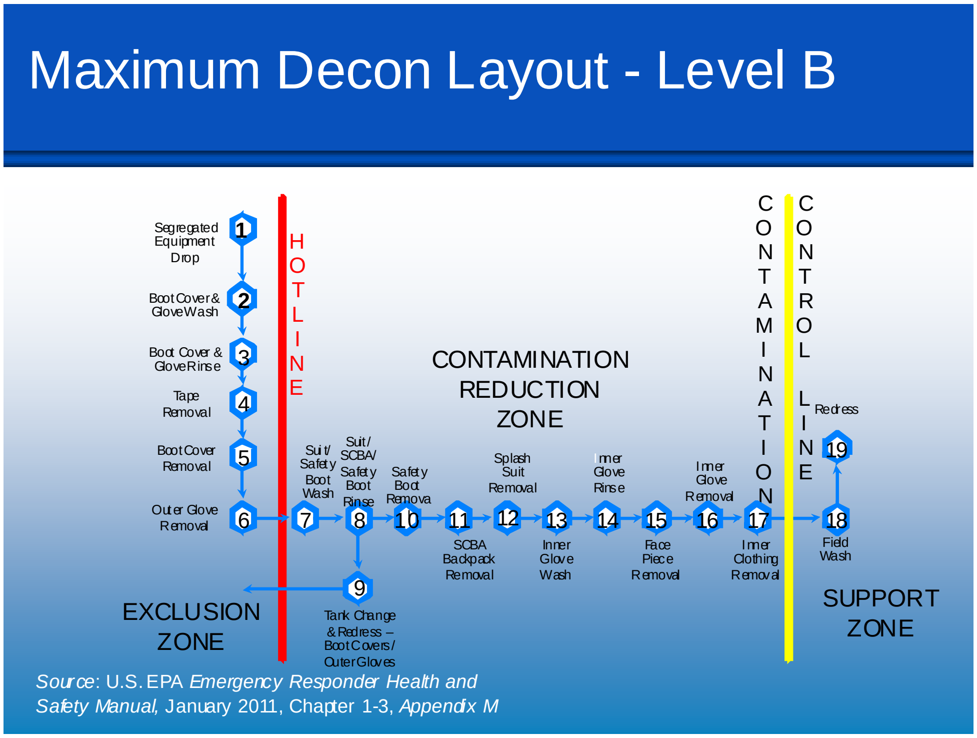
The SCBA cylinder is exchanged if the entry worker is to resume operations. Remember to replace outer gloves, boot covers, and tape that were previously removed.

From here on out, the entry worker must perform all of the remaining steps to prevent cross-contamination.

Be careful not to contaminate face or head.

The removed inner clothing must be contained to prevent the spread of even small amounts of hazardous substances.

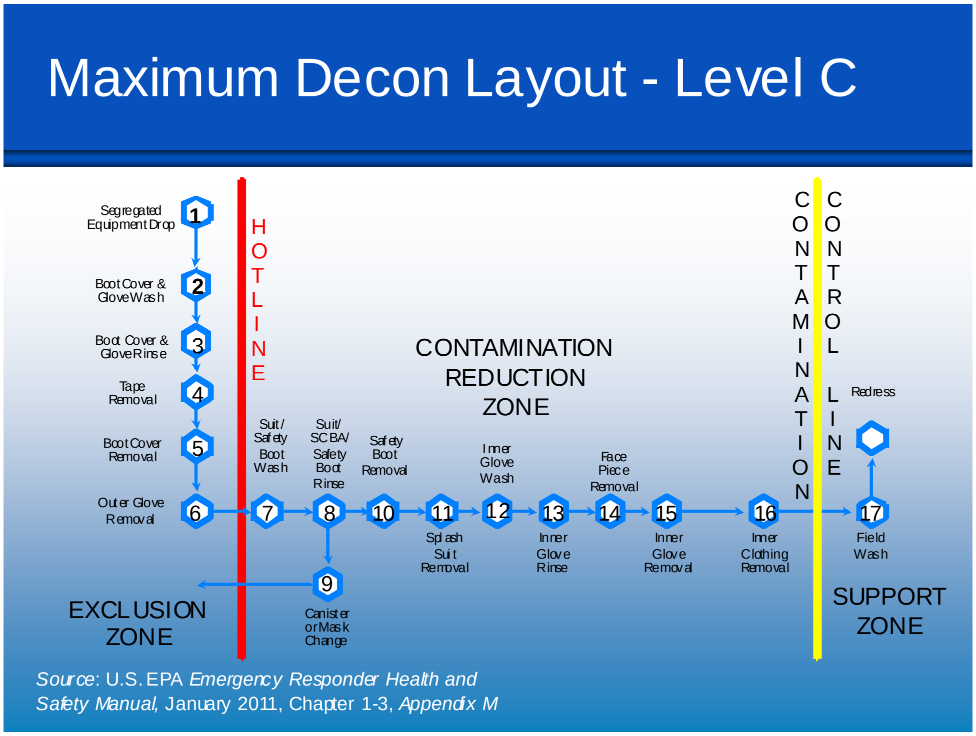
MAXIMUM LEVEL B DECON



At Station 11 the breathing tube is disconnected and the backpack is removed. If a respiratory hazard is present, the site worker may remain on breathing air until suit is removed.

Once the chemical suit is removed, and any respiratory hazards have been eliminated, the site worker removes the breathing tube from the SCBA.

MAXIMUM LEVEL C DECON



Decontamination is the same as for Level B decontamination, except a canister or mask change is done at Station 9. For Level C decontamination, there is no backpack to remove.

Stations 12-19 are the same as for Level B, except at Station 14 the APR filters are removed from the mask and disposed of separately.

Once operations workers have been decontaminated, the Decontamination Team members must decontaminate themselves and one another.

REFERENCES

U.S. DHHS. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute of Occupational Safety and Health. Washington, DC. 1985.

U.S. EPA. Standard Operating Safety Guides. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Emergency Response Division, Environmental Response Team. Washington, DC. 1984.

U.S. EPA. Standard Operating Safety Guides. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Emergency Response Division, Environmental Response Team. Washington, DC. 1988.

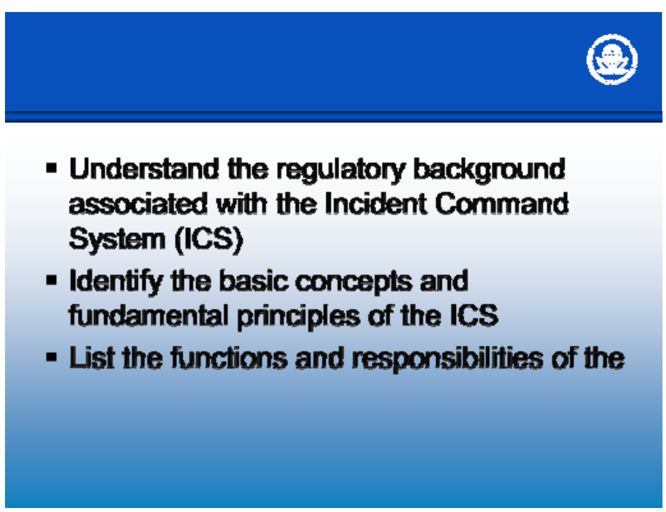
U.S. EPA. Standard Operating Safety Guides. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Emergency Response Division, Environmental Response Team. Washington, DC. 1992.

THIS PAGE INTENTIONALLY BLANK.

INCIDENT COMMAND SYSTEMS OVERVIEW

Student Performance Objectives

1. Identify the Key ICS positions.
2. Define Span of Control.
3. Identify the purpose of the US EPA Incident Management Handbook (IMH).



THIS PAGE INTENTIONALLY BLANK.

INCIDENT COMMAND SYSTEM DEFINED

- A system for organizing a response in a manner that is systematic and easily expandable to meet incident requirements

Evolution of ICS–History

Created in early 70s in Southern California as the result of wildfires an a need to control response activities over large areas

- Large population
- Rapid urban growth
- Many agencies with no common approach to large interagency responses
- Problems in organization, leadership and communications during emergencies
- Safety was a key factor

Evolution of ICS–Growth of ICS

- Gradually matured throughout the 70s and began to spread through other areas and agencies
- Adopted nation-wide by the National Wildfire Coordinating Group (NWCG) in 1980 for large wildfires
- From 1980 to 2002 many other agencies, states and local governments across the U.S. chose to adopt ICS

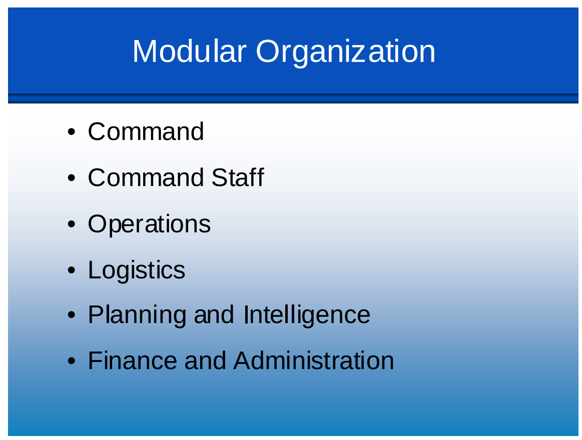
Evolution of ICS–Current Status

- 2003-Presidental Directive HSPD-5 directs development of National Incident Management System (NIMS) for use by all federal agencies
- 2004 National Response Plan (NRP) to be consistent with and compliment NIMS
- 2004 first version of NIMS employs ICS as a key element

Evolution of ICS–Future

- Has become the most widespread, well known management system for responses in the U.S.
- DHS Science and Technology Directorate has developed ICS training delivery systems for state and local governments

KEY ELEMENTS



The number of people needed to respond to an incident involving the release or potential release of hazardous substances can vary greatly. The responders needed for an incident may range from a few to hundreds. They represent many government agencies and private industries. The functions and responsibilities of each responders' group differ. To successfully accomplish the primary response goal, that of protecting public health and the environment, requires a cohesive unit that can manage and direct the coordinated, cooperative effort of these people.

A response organization, once established, must be flexible enough to adapt to the ever-changing conditions created as the incident progresses.

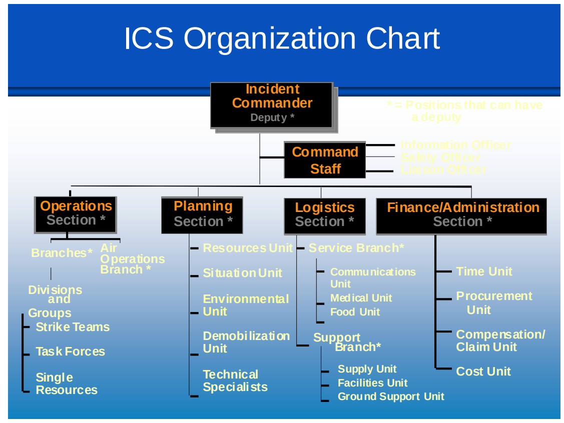
The regulatory minimum is four trained people, but the practical minimum is six people. No person should ever take direction from more than one individual, and no individual should be responsible for more than five people. This is called the "span-of-control."

Once the personnel and organizations who are available for a response are identified, the inter-agency lines of responsibility can be established. Internal communication should ensure that all information gathered is shared with all of the response personnel who need it. External communication provides pertinent information to the public via news releases to the media, reports to governmental agencies, and liaisons with other responding agencies.

INCIDENT COMMAND STRUCTURE

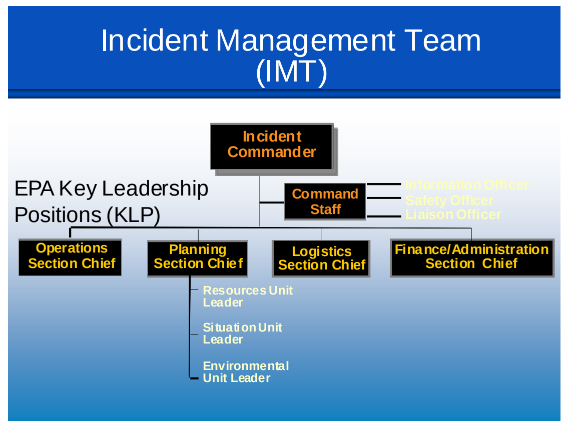
Every incident is unique. However, common to all incidents are planning, organizational considerations, personnel, and the implementation of operations. The Incident

Command System is what is typically used for federal agency incident and emergency responses.

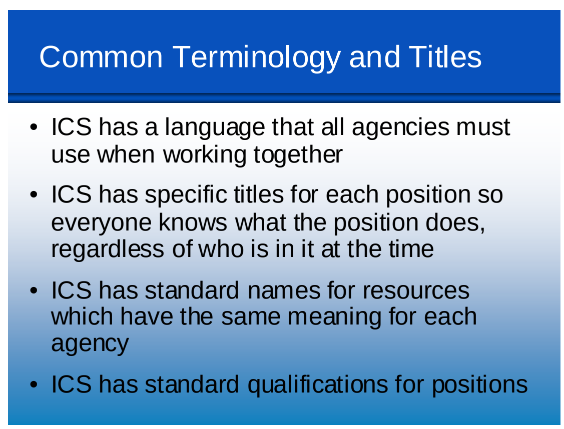


In any incident involving more than a few responders, it is generally necessary to develop an organizational chart. This chart depicts the organization's structure. It links personnel and functions, defines lines of responsibility, and establishes internal communication channels.

The Incident Commander (IC) has clearly defined authority and overall responsibility to manage and direct all response personnel and operations while ensuring the protection of the health and safety of both on-site personnel and the general public. The Command Staff Officers include the Information Officer (IO), Safety Officer (SO), and the Liaison Officer (LO). Normally, the LO is assigned only to large or multi-agency responses.



The Section Chiefs include Operations, Planning, Logistics, and Finance/Administration. These are functional positions that are staffed depending on the needs of the incident. At complex or large-scale incidents, additional units within each section may be established to eliminate any span-of-control problems. These units include branches, divisions, and groups.



Information gathered during the preliminary evaluation phase for HASP and work plan development for an emergency response is called an "Incident Action Plan" (IAP). The development of this plan helps to focus the objectives.

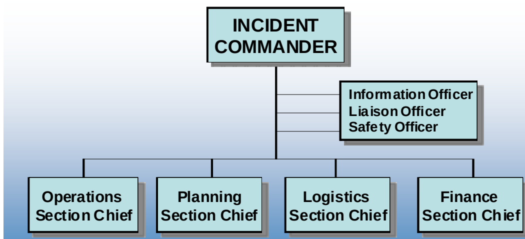
While the Logistics Officer is responsible for acquiring the necessary equipment, supplies, and resources, the Planning Officer tracks the deployment and availability of the equipment and resources that are either needed or are in short supply.

The Staging Area Unit identifies where resources will be placed until needed, and the Air Operations Branch coordinates the airborne resources.

Common ICS Titles

- Incident Commander, IC
- Safety Officer
- Operations Section Chief
- Resource Unit Leader
- Environmental Unit Leader
- Division Supervisor
- Group Supervisor
- Branch Director

Command and General Staff Officers and Chiefs



Integrated Communications

- Radio systems must be compatible
- Standard communication frequency configuration (base outline)
  - Command
  - Tactics
  - Air to Ground
  - Air to Air
  - Logistics

Incident Action Planning

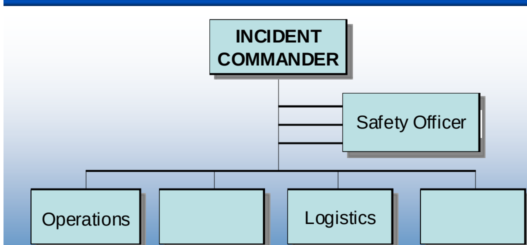
Incident Action Plan–(IAP)

- May be verbal on small incidents
- Formal written document on larger incidents
- Required for each operational period
- Copied and distributed to all key personnel
- Key part of incident documentation

Ability to Expand and Contract

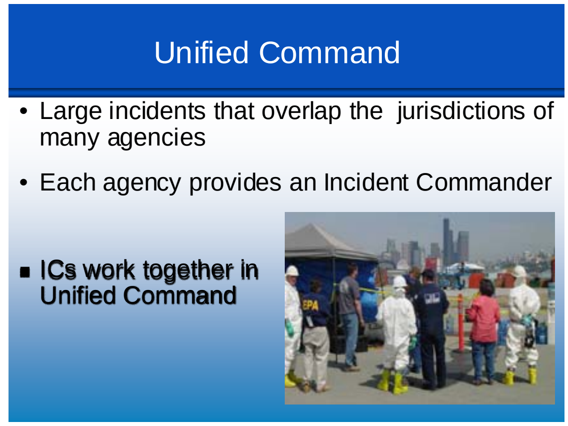
- ICS organization may be adjusted to meet incident needs
- Fill only those positions the incident requires
- Duties of unfilled positions go up to the next higher level of authority
- The organization can change constantly throughout the life of an incident

"Modular Organization" Fill Only the Positions Required



UNIFIED COMMAND

The Responsible Party (RP) knows the facility and hazards better than any organization, and they have a vested interest in how the response is handled. Federal agencies address regulatory matters and provide overall guidance in multi-jurisdictional situations. State agencies address statutory concerns, as they are stakeholders in the affected geographical area. The IC addresses the concerns of all these parties while directing the response.

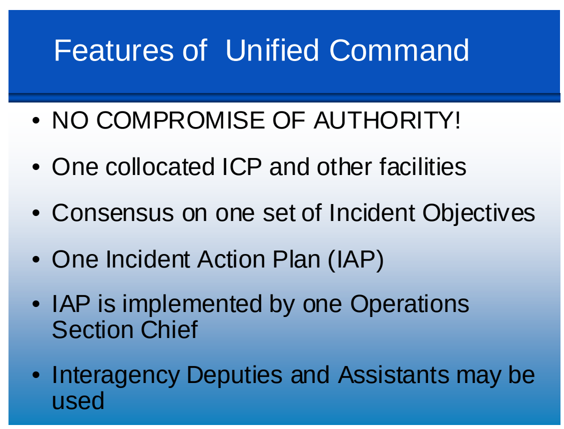


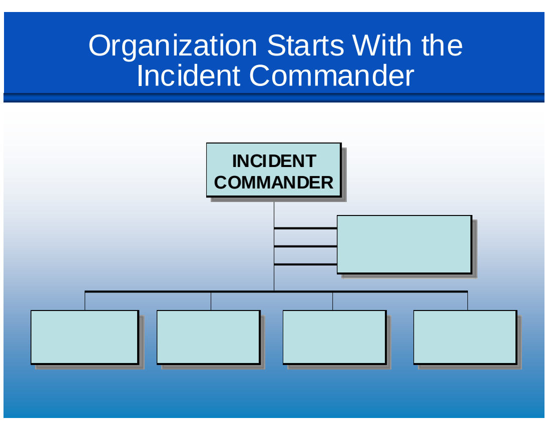
GENERAL COMMAND GUIDELINES

Clear communication entails using standardized terminology, and routine and/or emergency communication protocols; clearly defining which decisions can be made by personnel at each level in the response organization; and ensuring that each job, duty, or function is specifically assigned.

ADDITIONAL TECHNICAL SUPPORT

The Local Emergency Planning Committee (LEPC) coordinates the emergency fire-fighting response. The police or DOD provide explosive disposal units. For new or rarely used chemicals or for routine chemicals used under abnormal conditions, hazardous chemical experts provide technical guidance. Experts on the environment can provide guidance on the potential impact of a release to a particular organism or ecosystem, while health physicists can guide decisions on



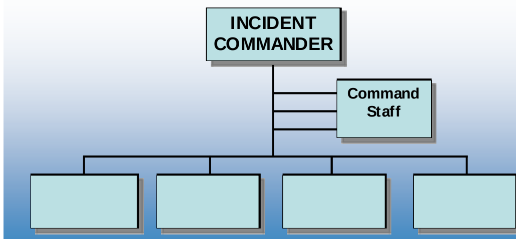


radiation hazards. Chemicals that have highly toxic characteristics and are new, rarely used, or banned require the expertise of a toxicologist.

Incident Commander (IC)

- Overall management of incident
  - Determine incident goals and objectives
  - Establish command, command post, and initial staging area
  - Develop ICS structure and assignments
  - Ensure development of IAP and approve it
  - Authorize release of information
  - Ensure development of adequate safety measures

Command Staff



Command Staff

- Safety Officer (SO)
- Public Information Officer (PIO)
- Liaison Officer (LO)

Duties of the Safety Officer

•Responsible to insure all aspects of the incident are managed in compliance with safety rules and guidelines.

•Identifies hazardous and dangerous situations associated with the incident.

•Working closely with the Operations Chief, provides specific safety input to the Incident Action Plan (IAP) and Health and Safety Action Plan (HASP).

Duties of the Public Information Officer

•The PIO is responsible for developing and releasing information about the incident to the press and public after command approval.

•Obtain media information that maybe useful to incident planning.

•Maintains communication flow with the Joint Information Center (JIC)

•Establishes community information systems and provides information updates for incident personnel.

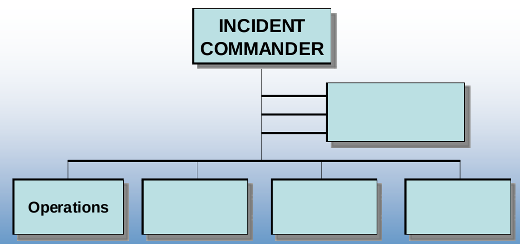
Duties of the Liaison Officer

•Primary focal point and contact for Agency Representatives for coordination and information exchange.

•Keeps IMT informed of status, capabilities and limitations of the resources of the cooperating and assisting agencies.

•Insures information on cooperating and assisting agencies is incorporated into the IAP.

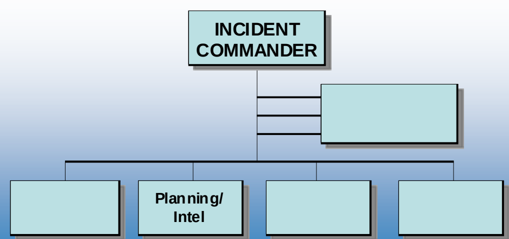
Operations Section Chief



Duties of the Operations Section Chief

- Provides advice to IC when analyzing strategies.
- Uses all available information to plan and execute the incident tactics.
- Supervises all tactical resources.
- Orders resources required to accomplish the Incident Objectives.

Planning Section Chief

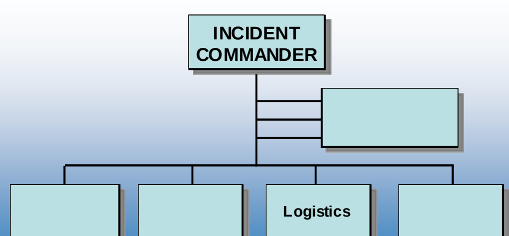


Duties of the Planning Section Chief

Gather, analyze and process all the available information required to make appropriate decisions and document activities.

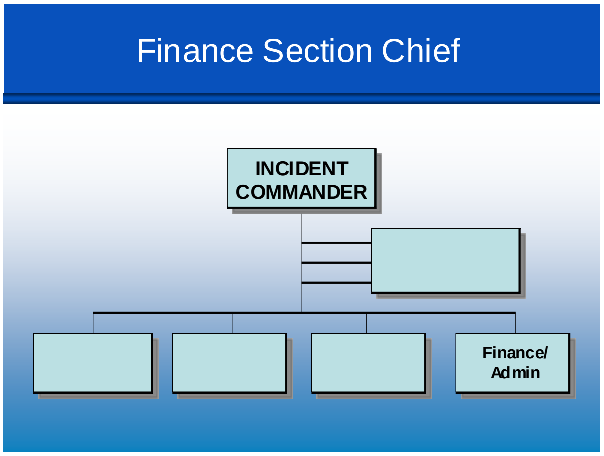
- Responsible for publishing the Incident Action Plan, based on the Operations Section Chief's chosen tactics.
- Planning Section Chief facilitates all planning meetings and briefings.

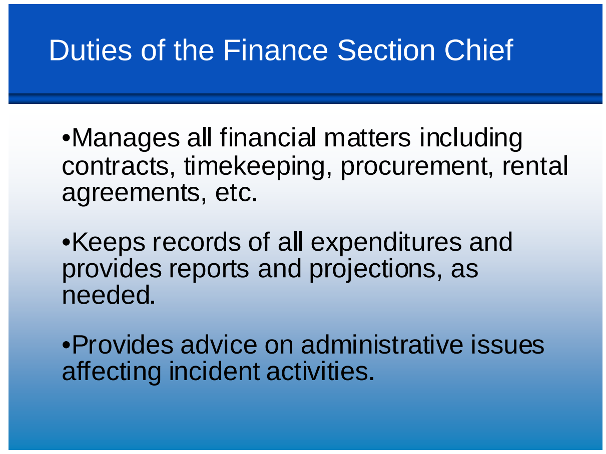
Logistics Section Chief

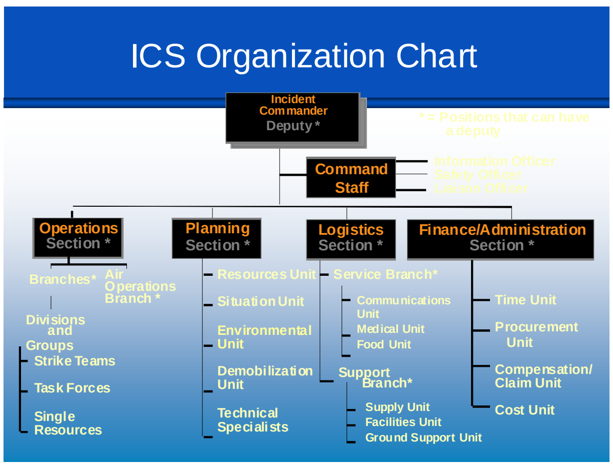


Duties of the Logistics Section Chief

- Provides all logistical support including necessary supplies, food, lodging, vehicles, facilities, security maintenance, etc.
- Manages the on-scene resource ordering system, working closely with the Emergency Operations Center (EOC) to place orders and track the status of the orders.
- Provides medical services to IMT personnel.







REFERENCES

U.S. DHHS. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute of Occupational Safety and Health. Washington, DC. 1985.

BIOLOGICAL HAZARDS
(Optional Lecture)

Student Performance Objectives

1. Identify biological hazards.
2. Recognize adverse effects.
3. Identify treatment methods.
4. Identify specific prevention methods.

THIS PAGE INTENTIONALLY BLANK

BIOLOGICAL HAZARDS

Student Performance Objectives

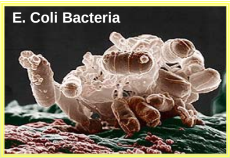
1. Identify biological hazards.
2. Recognize adverse effects.
3. Identify treatment methods.
4. Identify specific prevention methods.

BIOLOGICAL HAZARDS

- Identify biological hazards
- Recognize adverse effects
- Identify treatment methods
- Identify specific prevention methods

Western Diamondback Rattlesnakes

BIOLOGICAL HAZARD GROUPS



- Microbes
- Plants
- Animals

Prevention Methods-General

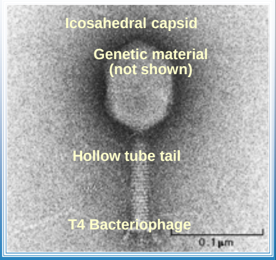
- Vaccination
- Personnel protective equipment (PPE)
- Sanitation and hygiene
- Safe work practices

MICROBES

- Virus
- Fungi
- Bacteria
- Amoeba
- Others

VIRUS

- Small =100 x smaller than bacteria
- Multiplies only in living cells
- Protein coat surrounding genetic core
- Different capsid (head) shapes
  - Icosahedral-soccer ball
  - Helical-rod
  - Others
- Protect against direct contact, inhalation

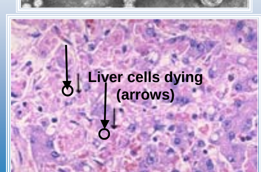


VIRUS – Hantavirus

- Transmitted by infected rodents urine, droppings, saliva (between mice)
- Inhale aerosolized virus
- Early symptoms are flu-like, coughing and shortness of breath
- Control rodents, wear protective equipment to prevent contact

VIRUS – Hepatitis A - G

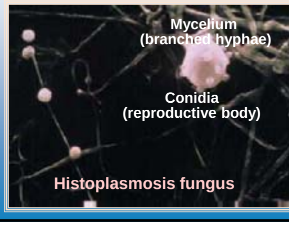
- Affects liver
- Contact with food or water or blood
- A-, B-types vaccines
- Avoid contact



Rev. 07/12

FUNGI, MOLDS – General

- 100,000 species, break down plant debris
- Require water
- Reproductive spores
- May also produce toxic mycotoxins



Mold – Indoor Practices

- Habitat
- Prevention, control, and treatment
- Guidelines
- Avoid direct contact, wear proper respirator

MOLD – Histoplasmosis

- Vertebrate host
- Inhale dried animal waste, soil
- Infects lungs, other organs
- Avoid contact, wear respirator

Rev. 07/12

BACTERIA – Lyme Disease

- Deer Tick, Black-legged tick
- Tick spread bacteria from infected deer or mice to people
- Possible "bulls eye" around bite
- Cover skin, DEET, check

BACTERIA – Gastroenteritis

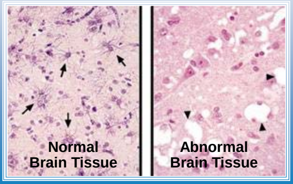
- Ingest contaminated food or water
- Diarrhea, nausea
- Poor cleaning
- Gloves, good hygiene

AMOEBA – Cryptosporidium, Giardia

- Wildlife hosts
- Ingest contaminated surface water
- Diarrhea, belching, gas and cramps
- Seldom fatal but debilitating
- Don't drink the water

OTHER MICROBES – Prions

- Definition-infectious "naked" protein
- Converts normal cell proteins into prions
- Examples: "Mad Cow" (BSE) transmissible spongiform encephalopathies (TSE), Chronic wasting disease (Deer)
- Protect food supply

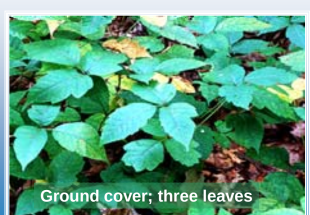


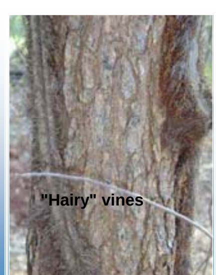
HAZARDOUS PLANTS

- ***Urushiol*** containing: poison ivy, poison oak and poison sumac
- 2 micrograms, not contagious
- Cover skin, decon everything

PLANTS – Poison Ivy

- Pioneer species
- Three leaflets
- Prevention-cover skin



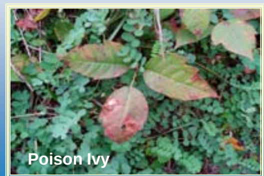


3 separate poison ivy vines growing up a pine tree. Notice the VERY hairy vines. Urushiol is in the vine as well as the leaves - approach with extreme caution!

Rev. 07/12

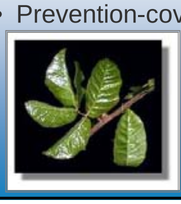
Poison Ivy-Identification

- End leaf longer stalk
- Changes red early
- Similar to Box Elder bush



PLANTS – Poison Oak

- West coast variety of poison ivy
- Contains urushiol (toxin)
- Three leaflets
- Prevention-cover skin



PLANTS – Poison Sumac

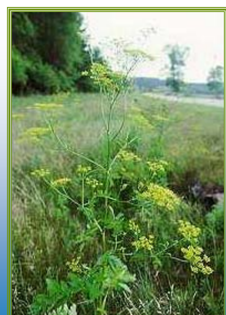
- Wet, acid swamps
- Caribbean shrubs
- Prevention-cover skin

PLANTS – Stinging Nettles

- Forest floor
- Causes white itchy bumps on "thin" skin
- Prevention-cover skin

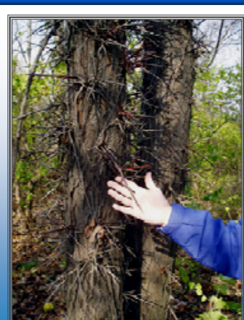
PLANTS – Wild Parsnip

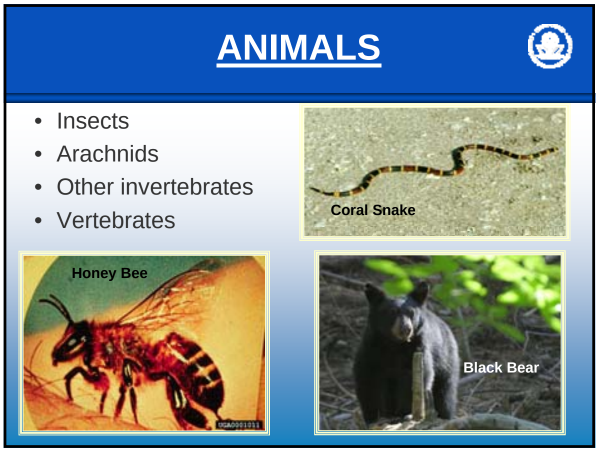
- Member of the carrot family
- Invasive species
- Reaction caused by "phyto-photo-dermatitis"
- Prevention-cover skin

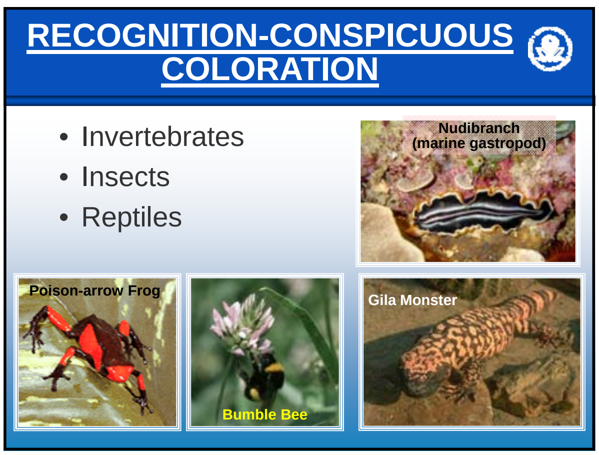


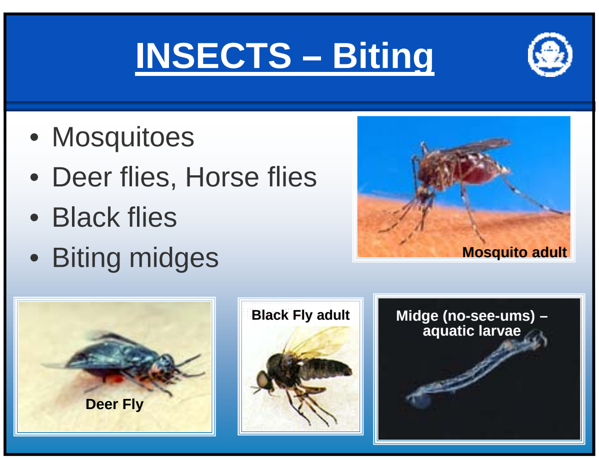
PLANTS – Thorns

- Briers, bushes and thorny trees such as locust and hawthorns
- Can rip protective clothing
- Can cause exposures through cuts and scrapes




ANIMALS
• Insects
• Arachnids
• Other invertebrates
• Vertebrates
Coral Snake
Honey Bee
Black Bear


RECOGNITION-CONSPICUOUS COLORATION
• Invertebrates
• Insects
• Reptiles
Nudibranch
(marine gastropod)
Poison-arrow Frog
Bumble Bee
Gila Monster

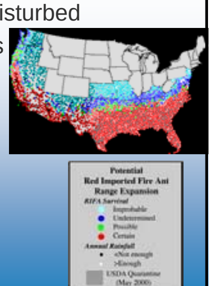

INSECTS – Biting
• Mosquitoes
• Deer flies, Horse flies
• Black flies
• Biting midges
Mosquito adult
Deer Fly
Black Fly adult
Midge (no-see-ums) –
aquatic larvae

INSECTS – Stinging

- Bees, wasps, hornets
- Caution for allergic "Shock"
- Remove stinger

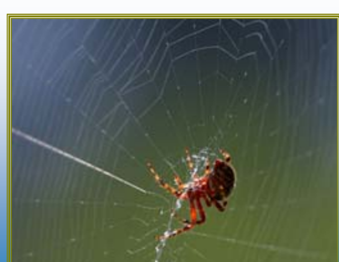
STINGING INSECTS – Fire Ants

- Conical soil mounds
- Attack in seconds when nest disturbed
- Bites and stings, cause blisters
- Watch for allergic reaction
- Chemical, biological control



ARACHNIDS

- Spiders
- Ticks
- Scorpions



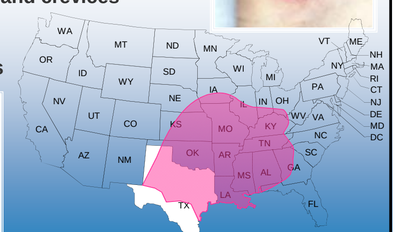
SPIDERS – Black Widow

- Female 0.5 inch body length (BL)
- Reddish-orange hour glass on underside
- Outbuildings, under rocks
- Widely distributed In U.S. but common in the south
- Most venomous in U.S.
- Wear gloves, check shoes

From below with "hour glass"

SPIDERS – Brown Recluse

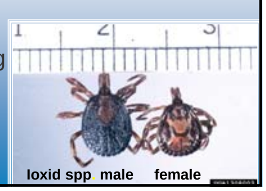
- Smaller than black widow
- Darker brown, violin shape stripe
- Found in cracks and crevices
- Ugly bite
- Wear gloves
- Use care indoors



Brown Recluse Distribution

ARACHNIDS – Ticks

- Parasites that can carry diseases including:
  - Spotted fever; relapsing fever; tularemia; Texas cattle fever
- "Hitch ride" from vegetation
- Prevention:
  - Tuck in pant-legs
  - Wear light colored clothing



Ioxid spp male female

Rev. 07/12

SCORPIONS

- 1" to 5" BL, 40 species
- Color - straw pink to black
- In southern and western United States
- Nocturnal
- Thick claw, less venomous

Scorpion

•Treatment - apply ice, if a child get to hospital
•DO NOT swat

VENOM TYPES – Hemotoxin

- Thickening/thinning of blood
- Pit vipers
- Destroys tissue
- Extremely painful
- Causes swelling
- "Hinged" fangs

Mexican Ring-Nosed Rattlesnake

VENOM TYPES – Neurotoxin

- Coral snake, cobras, sea snakes
- Attacks nervous system causing heart failure, suffocation
- Not immediately painful
- Usually without fangs, "hangs on"

Coral Snake

PIT VIPERS – Rattle Snakes

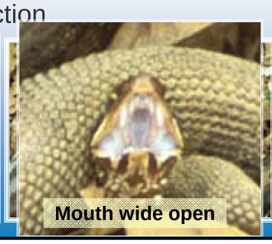
- 32 species, 70 subspecies
- Rattle on tail
- Can strike ½ BL, seldom fatal
- Get to hospital
- **DO NOT** use kit, cut, suck etc.
- Watch step, use rod


Western Diamondback Rattlesnake

POISONOUS SNAKES – Cottonmouth ("water moccasin")

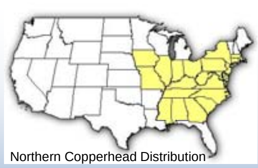
- 3-6' thick bodied, black stripe on head
- Aggressive, aquatic fish eater, near waterways
- White inside mouth
- Severe tissue destruction

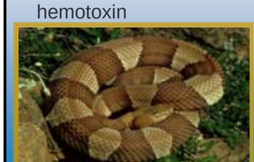

US Distribution – Western Cottonmouth


Mouth wide open

POISONOUS SNAKES – Northern, Southern, Osage, and Broad-Banded Copperhead

- 2.5" – 4' BL
- Copper color head, bands, no rattle
- From near waterways to woods
- Not aggressive
- Less toxic venom, but a hemotoxin


Northern Copperhead Distribution



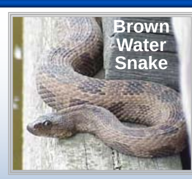

Copperhead – note "pits" ahead of eye

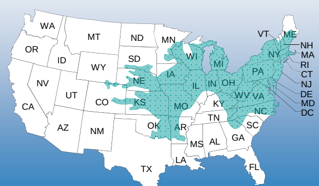
POISONOUS SNAKES – Coral Snake

- 25-30" small black head
- Red meets black, friend to Jack (King Snake)
- Red meets yellow, kill a fellow (Coral Snake)
- Burrowers in woods, swamps scrub
- Potent neurotoxin

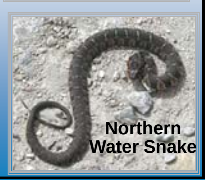
COMMON NON-POISONOUS SNAKE – Common water snake

- 2 – 4' BL
- Tan to Brown bands
- Common near freshwater
- Can be aggressive
- Non-venomous



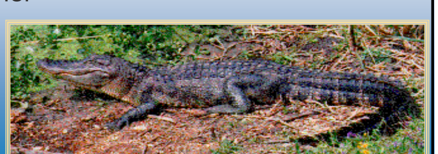


Northern Water Snake Distribution



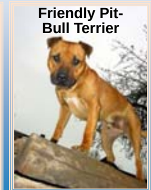
DANGEROUS VERTEBRATES – Alligators

- Coastal swamps, rivers, ponds NC, SC, and FL
- Marauders up to 30 mph (short distance)
- Breed in April, nest in July-territorial
- Keep 15 feet away at all times
- Make barrier



DANGEROUS VERTEBRATES – Others

- Stray domestic animal
- Stray wild animals



Questions?

RADIATION EXPOSURE HAZARDS AND MONITORING
Optional Lecture

Student Performance Objectives

1. Define the following terms:
   a. Radioactivity
   b. Rad
   c. Radiation
   d. Rem
   e. Radionuclide
   f. Quality Factor
2. Describe the characteristics of alpha, beta, and gamma radiation.
3. Describe the acute and chronic biological effects of ionizing radiation.
4. State the EPA Action Level for gamma radiation and the administrative dose guidelines for routine and emergency radiation exposure.
5. Explain the primary methods for reducing external radiation exposure.
6. List the limitations and considerations when using radiation detection instruments.
7. Identify the features on a gamma exposure survey instrument and take readings of actual radiation sources at their location.

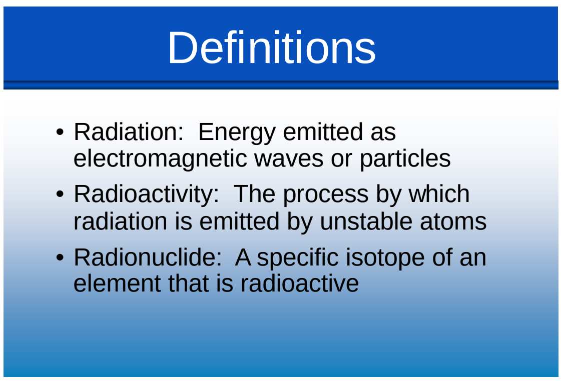
THIS PAGE INTENTIONALLY BLANK.

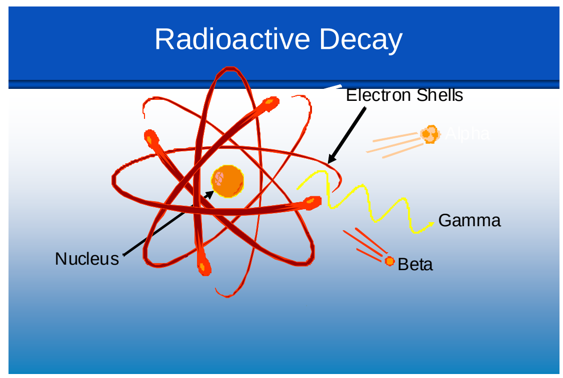
THE ATOM

The smallest unit of an element is the atom. An atom consists of a small, dense, positively charged nucleus surrounded by a cloud of negatively charged electrons. The nucleus consists of two fundamental particles – protons and neutrons.

RADIOACTIVE DECAY

In the radioactive decay process, radionuclides or isotopes are unstable because they have excess energy. This energy is emitted from a nucleus in the form of an electromagnetic wave (gamma rays) or high energy (alpha or beta) particles. When this radiation strikes another object, its energy is deposited in and absorbed by the target object causing damage.





MAJOR RADIATION CHARACTERISTICS

There are three primary categories of radiation that might be encountered in a field survey: (1) alpha particles, (2) beta particles, and (3) gamma rays. Each of these has unique properties that must be considered when selecting an instrument for use. Alpha particles are simply energetic helium ions (helium atoms that have lost their electrons). Because of their large size (compared to other forms of radiation) and their high charge, they cannot penetrate matter very far. Beta particles can penetrate through more material than alpha particles, but generally can be stopped by a thin piece of metal. Gamma radiation is simply high energy electromagnetic radiation, such as light, and is the most penetrating of the three radiation types. Gamma radiation can penetrate through several centimeters of lead.

The large mass and charge of an alpha particle makes it very efficient at interacting with other atoms causing numerous ionizations in air. Because of their high interaction efficiency they lose energy very rapidly. Therefore, they have low penetrating ability and travel only short distances in air, but all this energy is deposited in that short distance. Alpha particles cannot penetrate the dead skin layer (epidermis) on the human body. However, they can be a serious hazard if ingested or inhaled.

Beta particles ejected from the nucleus can have either a negative charge (electron) or a positive charge (positron). Their mass is very small compared to an alpha particle. Although beta particles can penetrate dead skin tissue and affect living tissue, they cannot reach the major organs of the body. Inside the body, beta-emitting radionuclides cause less damage than alpha emitters because the energy of the beta radiation is deposited over a larger volume of tissue than the energy deposited by alpha radiation.

Gamma radiation has no mass and no charge and is, therefore, relatively inefficient at interacting with matter. However, because of its high penetrating ability, gamma radiation poses both a serious *internal* and *external* radiation hazard. The internal damage caused by this type of radiation is less than that caused by alpha or beta radiation.

Radiation
Characteristics of the Major Types

Source	Symbol	Form	Mass (Charge)	# of Ionizations /cm in Air	Path Length in Air	Hazard Location
ALPHA	α	2 Protons 2 Neutrons	4 (+2)	100,000's	<1 inch	Internal Only
BETA	β	1 Electron	0.00055 (+/-1)	100's	Several Meters	Internal and External
GAMMA	γ	Photon (Electro-magnetic Waves)	0 (0)	1	100s of Meters	Internal and External

DEFINITIONS

There are hazards associated with human exposure to radiation, but if the exposure is limited to low levels, this hazard is not very serious. In fact, humans are exposed to natural background radiation every day. Naturally occurring radioactive materials can be found in the soil, building materials, certain foods, and even the human body. The average dose to an individual in the United States due to natural background radiation and naturally occurring radioactive materials in the environment is about 0.2 rem/year.

Definitions

Roentgen (R) – That amount of "X" or gamma radiation that will produce 1 electrostatic unit of charge per cm^3 of dry air

(1R = 2.58×10^{-4} Coulombs / Kg)

- Most radiation exposure instruments measure in µR/hr, mR/hr, R/hr (dose rate)

Definitions

REM (Roentgen Equivalent Man) – A unit of Dose Equivalent for any type of radiation that represents the equivalent damage caused by depositing 1 RAD of gamma radiation

(1 REM = 0.01 Sievert)

Definitions

RAD (Radiation Absorbed Dose) – The amount of energy absorbed in material, such as living tissue, from any type of radiation

- 1 RAD = 100 ergs/g of energy
- 1 RAD = .01 Gray (Gy)

Definitions

Quality Factor (QF) – A numerical value multiplied by the absorbed dose to determine the "dose equivalent"

(RAD x QF = REM)

– Gamma 1 RAD x 1 = 1 REM
– Beta 1 RAD x 1 = 1 REM
– Neutron 1 RAD x 10 = 10 REM
– Alpha 1 RAD x 20 = 20 REM

RADIATION SUBUNITS

Units of Measurement

The Quality Factor (QF) is a numerical quantity that corrects for the differences in the way that various types of radiation deposit their energies. A *rem* for any type of radiation represents the relative biological risk associated with a particular dose.

ACUTE EXPOSURE EFFECTS

Biological Effects and Exposure to Radiation

The actual health risk from low levels of radiation is quite small. As radiation passes through matter, it may interact and lose energy. The damage done by radiation as it interacts with the body results from the way it affects molecules that are essential to the normal functioning of human cells. The statistical risk of a cancer death from 7 mrem of radiation is equivalent to that associated with smoking a single cigarette.

Radiation Subunits

- 1 rem = 1,000 mrem (millirem)
- 1 mrem = 1,000 µrem (microrem)

The characteristic mechanism of ionizing radiation that causes biological effects is its localized release of large amounts of energy. This energy is enough to break any chemical bond. This makes ionizing radiation a major concern because it can disrupt the functions of living cells.

ACUTE EXPOSURE GUIDELINES

Radiation exposure produces two types of effects: acute and chronic. The effects of acute exposure are Lethal Dose (LD), Toxic Dose (TD), and Effective Dose (ED). ED is indicated by a depressed white blood cell count. Acute exposures generally result from an incident, accident, event, or entry. Exposures are prevented through the use of engineered controls, administrative work practices, and training.

Acute Exposure Effects

700 RAD = LD_{100}	Within days
600 RAD = LD_{99}	Within days
450 RAD = LD_{50}	Within 30 days
200 RAD = LD_{LO}	Within several weeks
100 RAD = TD_{LO}	Immunosuppressive reaction
25 RAD = ED_{LO}	Blood serum changes

Chronic Exposure Effects

Any member of the U. S. population has about a 33% chance of contracting cancer and about a 25% chance of dying of cancer

- Cancer risk is approximately .02%/rem
- 50 rem = 1% increased risk of cancer

Possible Effects of Radiation On Cells

- Cells may not be damaged
- Cells may be damaged, but can fully repair at lower levels and operate normally
- Cells may be damaged and operate abnormally
- Cell death may result at higher doses

EPA's Radiation Safety Program

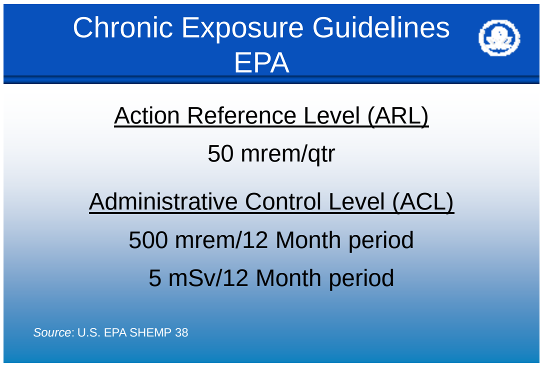
- U.S. EPA Safety, Health and Environmental Management Program (SHEMP) Guide 38
- Guide 38 – "Radiation Safety and Health Protection Program"

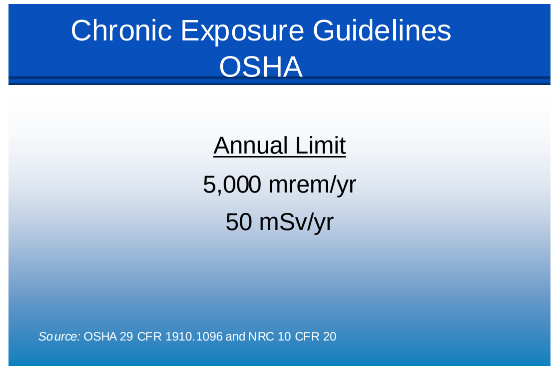
CHRONIC EXPOSURE RISKS

Chronic exposures occur over a long, but not necessarily continuous, period of time. Any member of the U.S. population has about a 33% chance of contracting cancer and about a 25% chance of dying of cancer.

EXPOSURE RISKS AND GUIDELINES

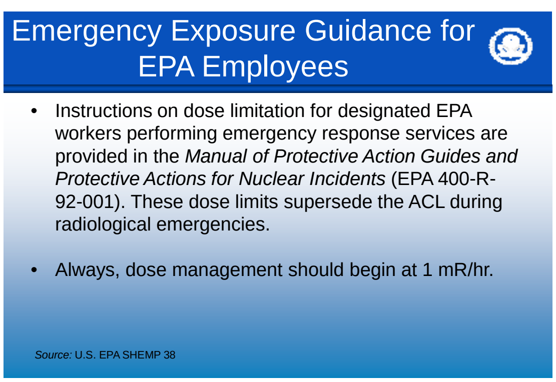
Mandated exposure limits for workers keep this risk to a minimum. Action Reference Levels (ARL) and Administrative Control Levels (ACL) are only used by EPA personnel, while OSHA's Annual Limit applies to all radiation workers in the U.S.

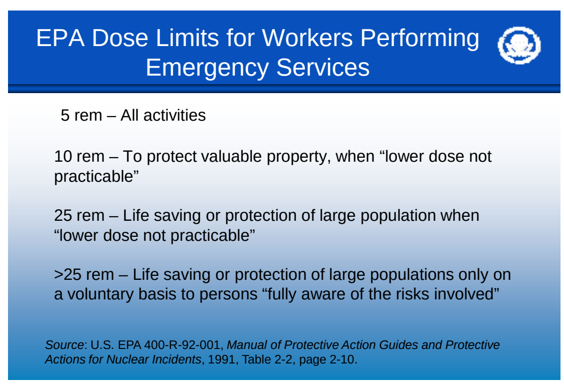




Emergency Exposure Guidance for EPA Employees

U.S. EPA SHEMP 38 states that instructions on dose limitation for designated EPA workers performing emergency response services are provided in the *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents* (EPA 400-R-92-001). These dose limits supersede the ACL during radiological emergencies.





Emergency Exposure Guidance for EPA Employees

In addition to the Protective Action Guides, workers in radiological emergency responses may be confronted with high radiation exposure rates. “Turnback level” guidelines for EPA workers performing emergency response under the EPARERP are provided in “Guidance for U.S. EPA Personnel Responding to Radiological Emergencies.”

Emergency Exposure Guidance "Turnback Levels"

Time Period	Stop-and-Check	Condition
Early Phase	10 R/h	Voluntary, with supervisor review, for lifesaving or critical actions ONLY – evaluate anticipated doses against dose limits above
Intermediate Phase	1.5 R/hr	Dose management imperative
Late or Recovery Phase	Site-specific according to site health and safety plan	EPA Action Reference Level: 50 mrem/quarter *and* Administrative Control Level: 500 mrem/year

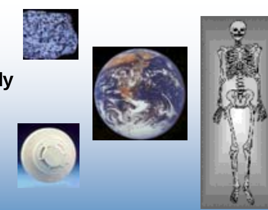
Source: U.S. EPA SHEMP 38

Methods to Control External Exposure

Due to the nature of ionizing radiation, worker exposure to external radiation can only be minimized, not prevented. This is why ionizing radiation is the only exposure hazard for which OSHA allows the rotation of workers as the method of choice for keeping their exposures below the established limits.

Routinely Occurring Radiation Exposure

- External terrestrial
- External cosmic
- Radionuclides in the body
- Inhaled radionuclides
- Medical equipment
- Consumer products



The average nationwide dose from naturally occurring and manmade background radiation is 360 millirem per year.

Average Annual Dose

- The average annual dose to the general population is about 625 mrem. This estimate is for non-smokers.

SOURCE: 2009 NCRP Report No. 160 Ionizing Radiation Exposure of the Population of the United States

Sources of Radiation Exposure of the U.S. Population

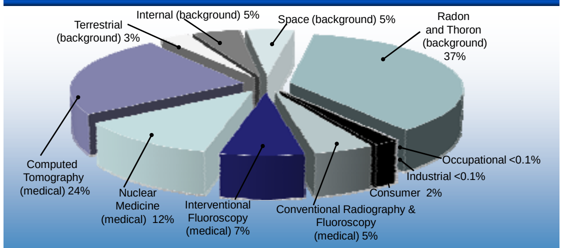
SOURCE	SOURCE (mrem/year)	% of TOTAL
TOTAL NATURAL	311.0	50%
TOTAL MANMADE (Non-smokers)	313.8	50%
TOTAL OF MANMADE AND NATURAL (Non-smokers)	624.8	100%

SOURCE: 2009 NCRP Report No. 160 Ionizing Radiation Exposure of the Population of the United States

CONTROLLING RADIATION EXPOSURE

“As Low as Reasonably Achievable” (ALARA) is the principle which is practiced to control an individual’s exposure by evaluating the processes and procedures that lead to exposures. Once these processes and procedures are evaluated, methods are then selected that limit these exposures as much as is practical.

Sources of Radiation Exposure of the U.S. Population



SOURCE: 2009 NCRP Report No. 160 Ionizing Radiation Exposure of the Population of the United States

Radiation Exposure Safe Guidance Principle

ALARA

(As Low As Reasonably Achievable)

Adopted by:

- International Commission on Radiological Protection (ICRP)
- National Council on Radiation Protection and Measurements (NCRP)

U.S. EPA ACTION GUIDELINES AND RADIATION MONITORING

The purpose of radiation monitoring is to determine (1) the risk of exposure, which is the first priority, and (2) the type(s) of radiation (alpha, beta, and/or gamma) that is present.

Radiation is nothing more than energetic particles or photons and cannot be detected by any of the human senses. Because we cannot taste, smell, feel, see, or hear it, we must rely upon instruments that respond to an interaction between the radiation and the instrument itself.

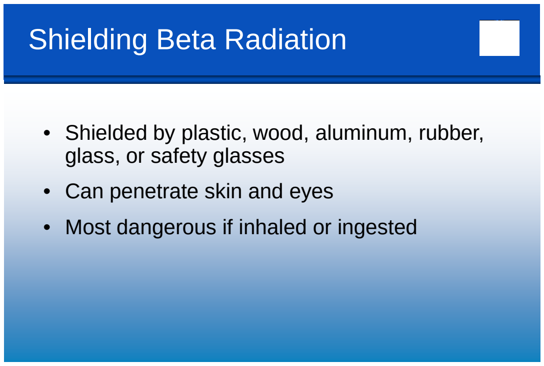
As the radiation passes through matter, it interacts with the material's electrons and loses some of its energy. This energy either excites or ionizes the atoms it interacts with. Depending upon the type of detector the monitoring instrument utilizes, either the excitation or the ionization is sensed, quantified, and processed by the instrument to produce a response which is proportional to the total amount of radiation present in the area being monitored or surveyed.

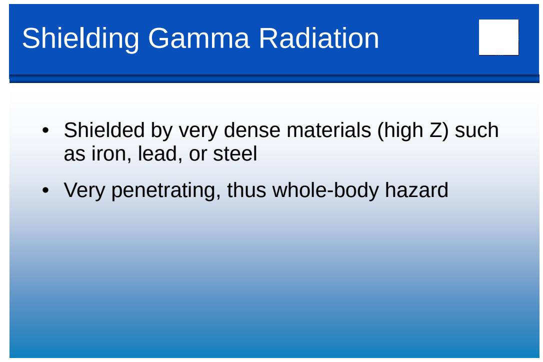
Exposure Reduction Methods

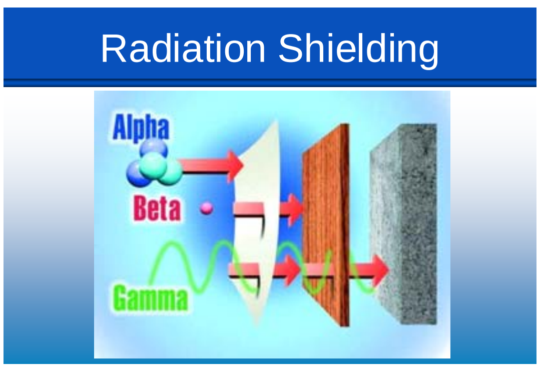
- Time – Minimize the time of exposure
- Distance – Maximize the distance to reduce exposure rate
- Shielding – Use appropriate absorber materials to reduce exposure

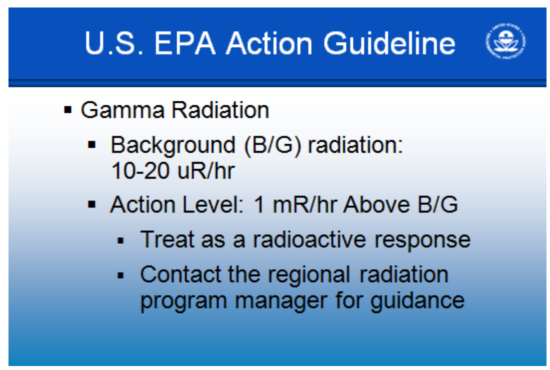
Shielding Alpha Radiation

- Most alpha particles are stopped by a few centimeters of air, a sheet of paper, or the dead layer of skin
- Alpha particles are considered an internal hazard only. If ingested or inhaled, they can cause great damage









RADIATION MONITORING TECHNIQUES

Radiation instruments respond rapidly (usually within a few seconds) and provide good *qualitative* data.

Instruments that display readout in mR/hr and µR/hr are used to measure extended radiation fields, such as those experienced in the vicinity of radioactive material storage or disposal sites.

Instruments that read out in counts per minute (CPM) are usually used to monitor for low-level surface contamination, particularly on hard, nonporous surfaces.

Radiation Monitoring Techniques

Personnel Exposure Monitoring

Type Instrument	Units
Exposure rate	µR/hr, mR/hr, R/hr

Radiation Type

beta, gamma

Radiation Monitoring Techniques

Contamination Monitoring

Type Instrument	Units	Radiation Type
Count rate	CPM	alpha, beta, gamma

INSTRUMENT LIMITATIONS AND CONSIDERATIONS

Portable survey instruments may require more frequent calibration due to many activities. These instruments are calibrated specifically to detect one emission type and energy.

One of the difficulties in measuring radiation is that there is always some background level of radiation present. Background levels vary depending on the location, for example, some

Instrument Limitations and Considerations

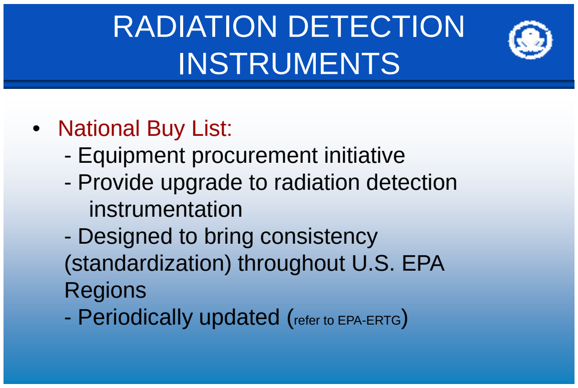
- Calibrate *at least once* annually
- Relative response
  - Exposure rate usually within ±20%
  - Count rate could be low by as much as 10 times

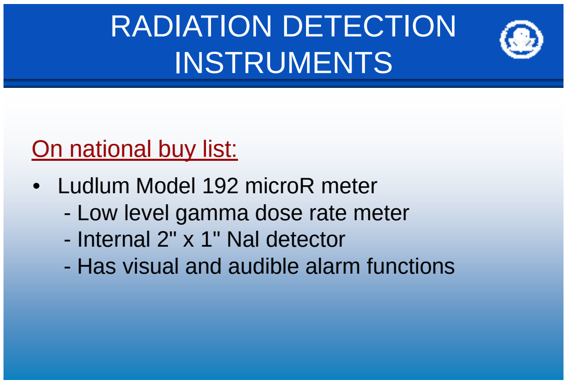
regions of the country have higher background levels than others, and brick buildings have higher backgrounds than wooden buildings.

Because of these variations, when any survey instrument is used, a determination of the local background level must be made in an area that is not believed to contain any radioactive materials. Any reading significantly above the background (two to three times background) indicates the presence of radioactive materials.

Background levels throughout the United States typically range between 5 and 100 µR/hr. The U.S. EPA limits radiation exposure to workers to 1 mR/hr above background. This action level is specified in the EPA's Standard Operating Safety Guides.

Radiation Detection Instruments





RADIATION DETECTION INSTRUMENTS

On national buy list:

- Ludlum Model 2241-2 Scaler/Ratemeter
  - Ludlum Model 44-9 pancake GM detector
  - Ludlum Model 43-90 alpha scintillation detector

RADIATION DETECTION INSTRUMENTS

National buy list upgrade:

- Ludlum Model 2241-3
  - Det. 1, model 133-2 high range gamma G-M probe, up to 1 R/hr (Red Dot)
  - Det. 2, model 44-9 G-M pancake probe, cpm (Yellow Dot)
  - Det. 3, model 43-90, ZnS alpha scintillation probe, cpm (Blue Dot)
  - Det. 4, model 44-10 NaI gamma scintillation probe, cpm (White Dot)

Ludlum Model 2241-3

Ludlum Model 133-2

Ludlum Model 44-9

Ludlum Model 43-90

Ludlum Model 44-10

RADIATION DETECTION INSTRUMENTS

On national buy list:

- Thermo Eberline RO-20 air ionization chamber
  - High level gamma dose rate meter
  - Range 0-50 R/hr
  - Sliding shield for beta measurements (thin beta window composed of two layers of aluminized polycarbonate)

RADIATION DETECTION INSTRUMENTS

On national buy list:

- Ludlum Model 15 alpha, beta, gamma, and neutron detector
  - With Ludlum Model 44-7 alpha, beta, gamma detector
  - With BF_3 proportional neutron detector

RADIATION DETECTION INSTRUMENTS

On national buy list:

- BNC Model SAM-935
  - With 2" x 2" external NaI detector
  - Radionuclide identification
  - Can be equipped with neutron detector, but high cost ($4500)

SAM-940

National buy list upgrade:

- Portable radioisotope identification (RID) system
- Detects and identifies multiple nuclides
- Provides quantified results

EPA's Radiation Protection Program

- Radiation Protection Program Information
- Naturally occurring radionuclides
- Man-made radionuclides

See: www.epa.gov/radiation
and
www.epa.gov/oar

REFERENCES

U.S. EPA. *Standard Operating Safety Guides*. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Emergency Response Division, Environmental Response Team. Washington, DC. 1992.

CONFINEMENT AND CONTAINMENT
(Optional Lecture)

Student Performance Objectives

1. Define difference between Containment and Confinement
2. List two containment techniques
3. List two confinement techniques

THIS PAGE INTENTIONALLY BLANK


CONFINEMENT AND
CONTAINMENT
(Optional)

LEAK AND SPILL CONTROL

- Reduce the effects of the incident
  - Responder
  - Civilians
  - Environment
- Stabilize the incident

DEFENSIVE TACTICS

- Confinement
  - Actions taken remote from the spill site to prevent the spread of product over a larger area

DEFENSIVE TACTICS

- Advantages
  - Personnel not exposed to high concentration levels
  - Specialized equipment not always needed

DEFENSIVE TACTICS

- Disadvantages
  - Most incidents cannot be completely stabilized

CONFINEMENT

- Dike, dam, or boom
- Cover
- Absorption/adsorption
- Diversion
- Retention

Diking, Diverting, & Damming

Diking & Diverting

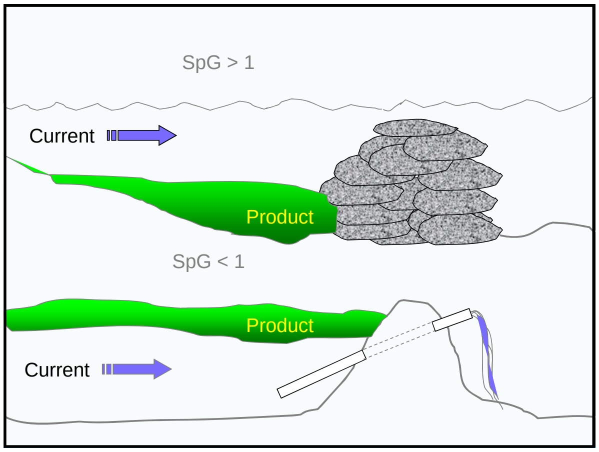
- On the ground:
  - Diking or diverting are methods of directing the flow away from the environment
  - Use available resources including tarps & ladders, soil, sand bags, fire hoses

Diverting

- Polyurethane spill dams and drain covers can be used to quickly divert a running spill away from environmental resources

Damming

- In the water:
  - Non-soluble hazmat may be recovered from even moving waters
  - Methods vary depending on environment and the product's specific gravity



Damming

- Dam is staked to bank
- Water escapes underneath
- Adsorbent pillows capture product trapped on surface

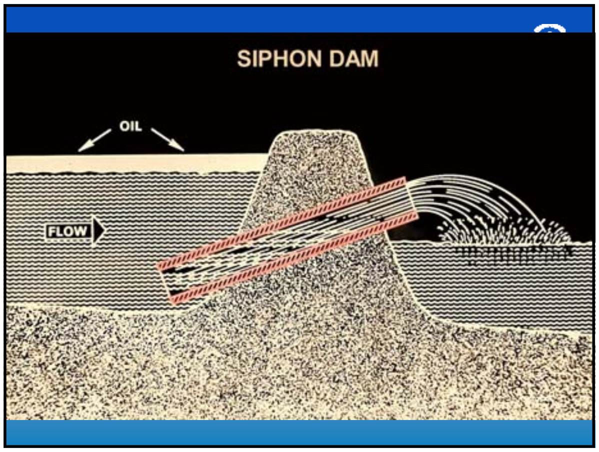
Adsorption

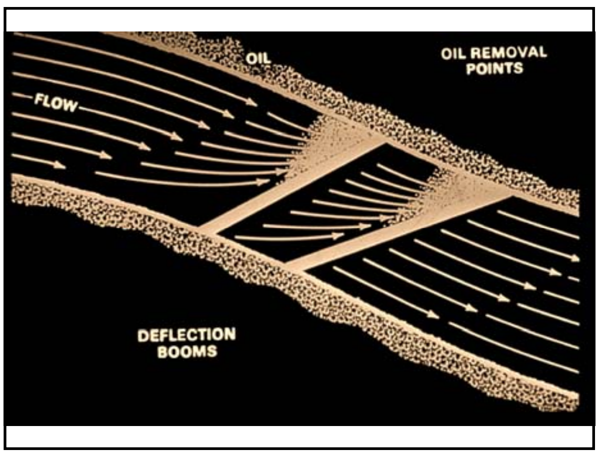
- Example of adsorbent towels used on floating contaminate

Drafting

- Used for non-soluble chemicals with a specific gravity >1

Rev. 07/12





Absorbents Vs Adsorbents

- Absorbents:
  - The “surround & drown method”
  - Requires large quantities of spill product
- Adsorbents:
  - Chemically solidifies the liquid
  - Some are able to treat the spill

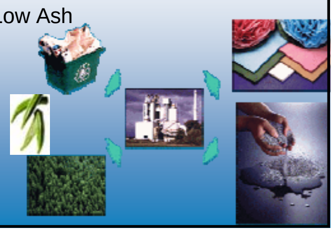
Comparing Spill Absorbents

- Clay Products (Kitty Litter)
  - + Most common
  - + Inexpensive 12 to 30 cents per Lb.
  - - Poor efficiency ratio
  - - Cannot be incinerated or fuel blended

Absorbents require a 10 to 1 ratio

Comparing Spill Absorbents

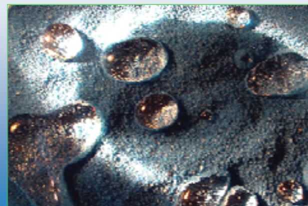
- **All-Natural, Industrial Spill Absorbents**
  - + Natural Products (sawdust, Corn, Peat Moss)
  - + Low Cost
  - + Can be Burned With Low Ash
  - - Poor Efficiency
  - - Hygroscopic
  - - Biodegradable



Rev. 07/12

Comparing Spill Adsorbents

- **Polypropylene**
  - \+ Very Efficient, Adsorbs 20 Times it's Weight
  - \+ Broad Range of Compatibility
  - \+ Hydrophobic
  - \- High Cost

Comparing Spill Adsorbents

- **Phenolic Granules**
  - +Solidifies & treats the wastes
  - \+ Absorbs 15 times its weight
  - \+ Non-biodegradable & Low Ash
  - \- Reacts With Nitric Acids, Cyanides, and Peroxides


Rev. 07/12

OFFENSIVE TACTICS

- Containment
  - Actions taken to stop or control the source of the leak or spill

OFFENSIVE TACTICS

- Advantages of containment
  - Stabilize the incident
  - Reduce operating time
  - Reduce the area affected by vapor clouds or spills

OFFENSIVE TACTICS

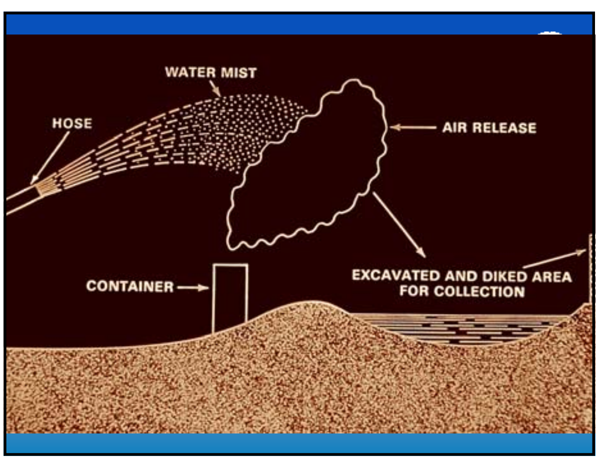
- Disadvantages
  - Personnel will be in, or in close proximity to, leaking product
  - Requires use of specialized protective clothing and equipment

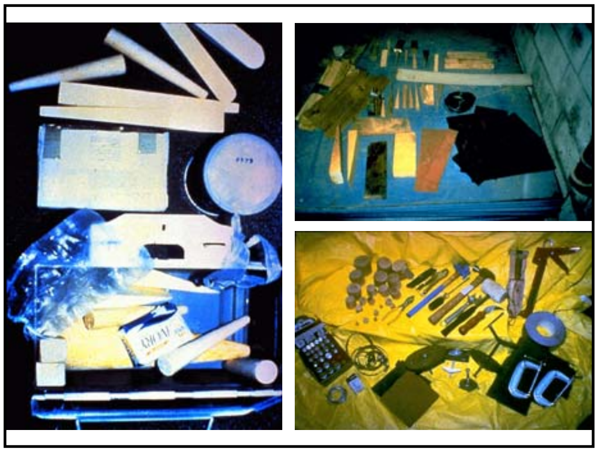
CONTAINMENT

- Valve or cap
- Position
- Vacuum
- Catch
- Plug or patch
- Cool
- Separate
- Burn
- Other
  - Do nothing
  - Combination

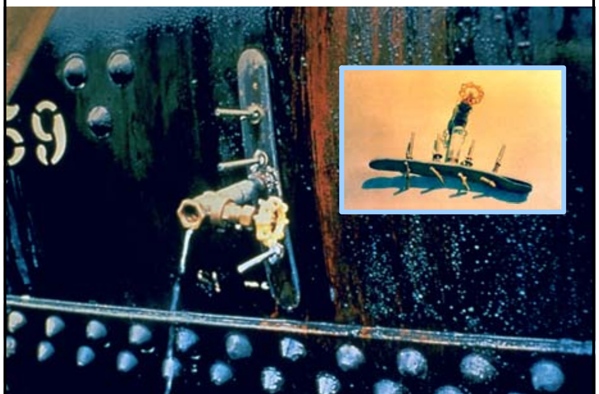

DISPOS-ALL DRUM
RECOVERY DRUM
RECOVERY DRUM

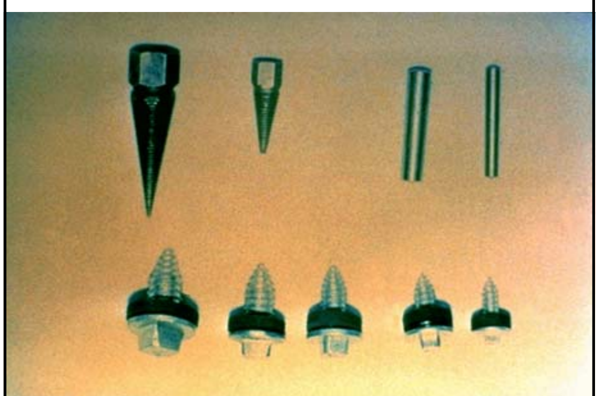

RECOVERY DRUM

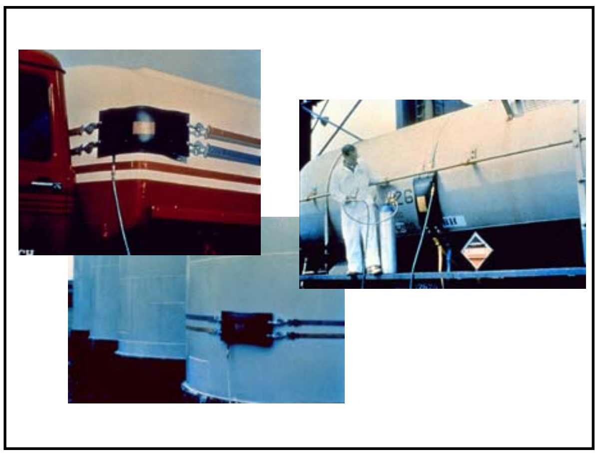

WATER MIST
HOSE
AIR RELEASE
CONTAINER
EXCAVATED AND DIKED AREA FOR COLLECTION

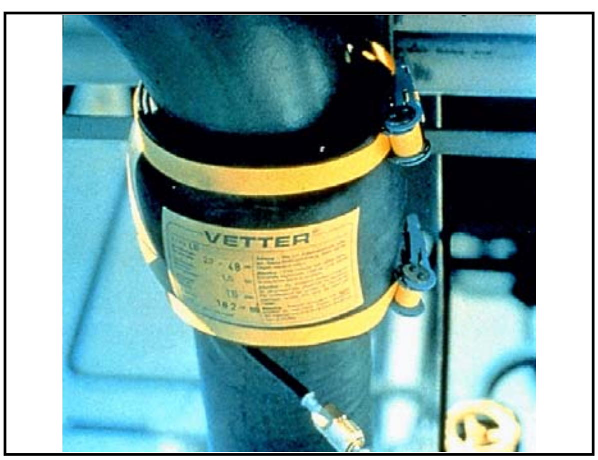


Rev. 07/12

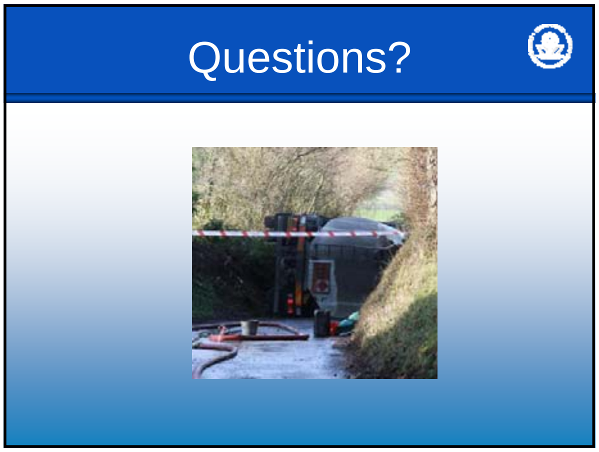








Rev. 07/12


Questions?

CHEMICAL AND BIOLOGICAL WEAPONS (Long)
Optional Lecture

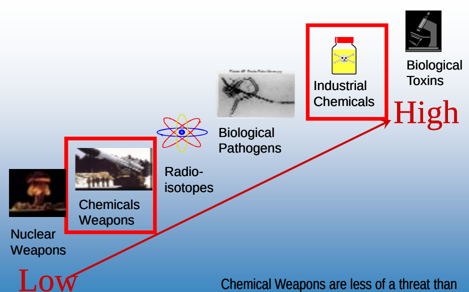
Student Performance Objectives

1. List in order the WMD threat spectrum
2. Identify major Chemical Warfare Agents
3. Identify major Biological Warfare Agents
4. Identify major Toxic Industrial Chemicals (TICs)

THIS PAGE INTENTIONALLY BLANK

Chemical & Biological Warfare Agents, Toxic Industrial Chemicals

WMD Incident Threat Spectrum



Chemical Weapons are less of a threat than Toxic Industrial Chemicals (TICs)!

Chemical Warfare Agents(CWA)

- What is a CWA?
- Types of CWAs
- Physical & chemical properties
- Decontamination methods
- Special concerns

Rev. 07/12

What is CWA?
What makes a CWA a WMD?

- Chemical compounds specifically designed or implemented to deny access, disable or kill large numbers of people
- Includes commonly used toxic industrial compounds (TICs) deliberately used to inflict harm
  - Solid
  - Liquid
  - Aerosol
  - Gas

CWAs – It's Nothing New

- Ancient Use – Greek fire, arsenic smoke
- World War I – First modern military use
- Post WWI – England, Spain, France and Italy
- World War II – Japan
- Iran-Iraq War – Both sides
- Iraq – Kurds target of Hussein's wrath
- Gulf Wars – Questionable
- Terrorist Groups – Modern nightmare

Types of CWAs

- Choking agents
- Blood agents
- Blister agents
- Nerve agents
- Other

Choking (Pulmonary) Agents

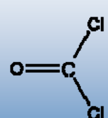
- Attack the eyes, nose and airways causing severe irritation, coughing, and eventually pulmonary edema
  - Damages the membrane that separates the alveolus (air sac) from the capillaries, allowing plasma to fill the air sac preventing air from entering
  - Victim can not get enough oxygen and dies from suffocation, called "dry land drowning"
  - Examples
    - Phosgene (CG)
    - Chlorine (CL)
    - Diphosgene (DP)

Chlorine (CL)

- Cl_2, used during WWI as a pulmonary agent.
- Widely used in industry and household products (pools, water treatment, cleaners)
- *Caution!* Household bleach can release chlorine if mixed with other cleaning agents

Phosgene (CG)

- Used during WWI, and responsible for a lot of fatalities
- Used in industry to make plastics and pesticides



phosgene

Physical Properties
- Forms a white to pale yellow cloud
- Odor of newly mown hay
- VP = 1215 mm Hg
- VD = 3.4

Signs of Exposure
- Coughing, watery eyes, burning throat
- Blurred vision
- Difficulty breathing, shortness of breath
- Nausea, vomiting
- Skin lesions similar to frostbite or burns

Blood Agents

- Inhibit the transfer of oxygen in the blood stream to the cells of the body; cells are deprived of oxygen and die
- CK and SA also cause irritation of the eye, nose and mucous membrane similar to tear gas
- Examples
  - Arsine (SA)
  - Cyanogen Chloride (CK)
  - Hydrogen Cyanide (AC)

Hydrogen Cyanide (HCN, AC)

Easily made: $NaCN (s) + HCl (aq) \rightarrow HCN (g) + NaCl (s)$
(cyanide salt + acid = hydrogen cyanide)

Physical Properties	Symptoms of Exposure
VP = 740 mm/Hg	reddening of the eyes
	throat irritation
BP = 25.7 ºC	nausea
	headache
Odor of bitter almonds	palpitation and salivation
	numbness
VD = 0.98	convulsions

Exposure to HCN in concentrations of 100-200 ppm is fatal within 30 min. to one hour. Exposure to a concentration of 300 ppm is rapidly fatal with no treatment.

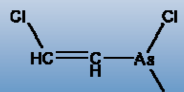
Blister Agents (Vesicants)

- React with proteins and enzymes in tissue to alter DNA, causing cell death (local/systemic)
- Large blisters or edema are formed upon contact with tissue
- Onset of symptoms for mustards can be delayed for 2-24 hours; L and CX are more immediate
- Examples
  - Lewisite (L), also MD, PD, ED
  - Sulfur Mustard (HD) / Mustard (H)
  - Nitrogen-Mustards (NH-1, NH-2, NH-3)
  - Phosgene Oxime (CX)

Blister Agents (Vesicants)

Lewisite

An arsenical vesicant similar to mustard in its effects, however clinical effects appear within seconds (compared to hours for mustard).



Lewisite

- Synthesized in 1918
- No verified use on battlefield
- Mixed with HD to lower FP
- Enzyme inhibitor
- Pain is less severe then lesions from mustard
- Antidote: British Anti-Lewisite (BAL)

Physical Properties of Lewisite

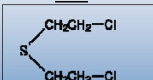
- Oily, colorless liquid when pure (impure=amber to black)
- Odor of geraniums
- More volatile and persistent in colder climates (VP = 0.350 mm/Hg vs. 0.072 mm/Hg for mustard)
- VD = 7.1
- Remains liquid at lower temperatures-good for dispersal
- Hydrolyzes rapidly, so when humid, maintaining an active concentration of vapor is difficult.

Blister Agents (Vesicants)

Mustard (H)

sulfur

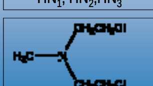
nitrogen



Sulfur Mustard (HD)

First used in WWI July 1917

Three forms: HN_1, HN_2, HN_3



Nitrogen Mustard, HN-1

References to Mustard usually mean sulfur mustard. Nitrogen mustard was never used on the battlefield!

Physical Properties of Mustard

- Yellow to dark brown oily yellow liquid
- Low volatility (VP = 0.072 mm/Hg)
- Vapor density = 5.4 (VD_{air} = 1)
- Freezing Point = 57º C (unsuitable for delivery via aircraft)

Mustard Exposure and Effects

- Skin
- Pulmonary system
- Eyes
- Gastrointestinal tract
- Central nervous system
- Cellular interaction: 1 to 2 minutes
- Clinical effects: 2 to 48 hours

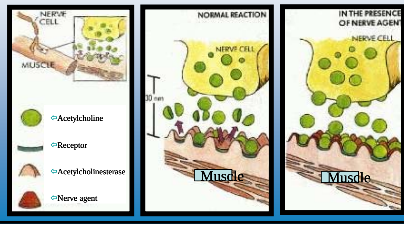
  Commonly 4 to 8 hours

Sulfur Mustard

19/20 July 04 Dover (Bridgeville), Delaware 75mm Mustard Round Incident

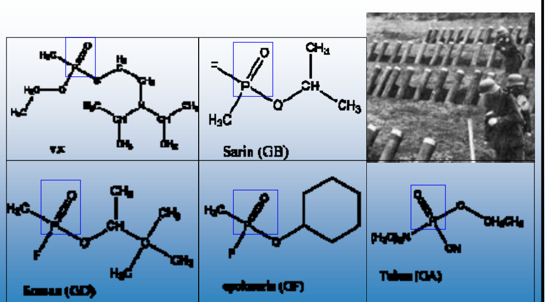
Nerve Agents

- Act on all parts of the nervous system
- Similar to pesticides in function



Nerve Agents

Developed by Germany, 1930's (Organophosphates)

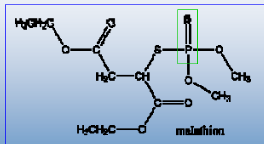


Nerve Agents – G & V Series

- Potent inhibitor of acetylcholinesterase enzyme
  - Acetylcholine enables transmission of nerve signals between synapses; when acetylcholinesterase is inhibited, acetylcholine builds up at the synapses
  - Interferes with the transmission of nerve signals throughout the body leading to numerous CNS disruptions, various characteristic symptoms, convulsions and eventually to death
  - Similar in structure to common insecticides
- Examples
  - G Series: Tabun (GA), Sarin (GB), Soman (GD), and Cyclosarin (GF)
  - V Series: VX
- Atropine and PAM-2 antidote

Physical Properties of Nerve Agents

- Clear, colorless liquids (when pure)
- Not “nerve gas”
- Most are odorless
- Freeze/melt <0º C
- Boil >150º C
- Volatility: GB>GD>GA>GF>VX
- Toxic by all routes
- Structurally similar to pesticides



Nerve Agents are similar in structure to pesticides.

Physical Properties of Nerve Agents

GD (Soman)
VP = 0.4 mm/Hg
BP = 388 F
VD = 6.33

GA (Tabun)
VP = 0.037 mm/Hg
BP = 464 F
VD = 5.63

VX
VP = 0.007 mm/Hg
BP = 568 F
VD = 9.20

GB (Sarin)
VP = 2.9 mm/Hg
BP = 316 F
VD = 4.86

GF (Cyclosarin)
VP = 0.068 mm/Hg
BP = 239 F
VD = 6.20

Volatility: GB > GD > GF > GA > VX

VD_{air} = 1
VP_{water} = 25 mm/Hg
VP_{ether} = 440 mm/Hg

LD_{50} of VX

Rev. 07/12

Other Agent Types

- Riot control agents – tear gases, with various levels of toxicity
  - CN, CNS used by law enforcement
  - CS (toxic), DA, DC
- Incapacitating agents
  - BZ (psychochemical gas)
- Vomiting agents
  - Adamsite (DM)

Key CWA Characteristics
"What Makes a CWA a Threat?"

- Persistence
  - Physical & chemical characteristics / terrain
- Toxicity
  - Inhalation
  - Dermal
  - Ingestion
- Ease of use
  - Production
  - Deployment

CWAs Persistence

- Lower vapor pressure, volatility, solubility and higher boiling points increase persistence
  - Nerve agents > blister > choking
  - Thickened agents persist longer
- Environmental conditions / terrain effects
- TICs: typically non-persistent, volatile gases and liquids

CWAs Persistence

GB (Sarin)

Agent Persistency Information (in hours)

Temperature		Terrain	
C	F	Sandy terrain	Grassy terrain
-30	-22	496.53	193.10
-20	-4	203.67	79.21
-10	14	90.41	35.16
0	32	42.48	16.52
10	50	21.15	8.23
20	68	11.03	4.29
30	86	6.08	2.36
40	104	3.42	1.33
50	122	1.98	0.77
55	131	1.53	0.60

- GB evaporates at the approximately same rate as water or kerosene and is less persistent than GA. Duration depends upon munitions used and the weather.

Toxicity and Routes of Entry

- Inhalation – All agents, in particular Choking/Blood agents
- Dermal contact – Mustards, Nerve
- Ingestion – Food, water, incidental ingestion

Comparative Toxicity - PEL

- CL = 1.0 ppm — Choking Agents
- CG = 0.1 ppm
- AC = 10.0 ppm — Blood Agents
- CK = 0.2 ppm
- HD = 0.0005 ppm — Blister Agents
- HN-1 = 0.0004 ppm
- L = 0.00035 ppm
- GA = 0.000015 ppm — Nerve Agents
- GB = 0.000017 ppm
- GD = 0.000004 ppm
- VX = 0.0000009 ppm

Why Sarin ? - Ease of Use

- Easily produced
- Easily deployed
  - Binary agents can be made and mixed prior to releasing on target
  - Can be sprayed as a liquid or aerosol or allowed to evaporate
- Extremely Toxic

Sarin Toxicity

- Lethal Respiratory Dose: 100 mg-min/m^3

Structure	Volume (m^3)	Lethal Amount
Domed Stadium	1.07 x 10^6	107 kg, ~26 ga
Movie Theater	12,000	1.2 kg, ~ 5 cups
Auditorium	630	52 g, ~ ¼ cup
Conf. Room (80-100 People)	400	33 g, 1 shot glass

Symptoms – Nerve Agents

Stage 1 – Initial Exposure
(Parasympathetic Nervous System)

- **D** - Diarrhea
- **U** - Urination
- **M** - Miosis (constriction of the pupil)
- **B** - Bradycardia, bronchorrhea, bronchospasm
- **E** - Emesis (vomiting)
- **L** - Lachrimation (tears)
- **S** - Salivation, sweating

Symptoms – Nerve Agents
Stage 2 – Continued Exposure
(Parasympathetic Nervous System)

- **M - Mydriasis (pupil dilation)**
- **T - Tachycardia**
- **W - Weakness**
- **H - Hypertension, hyperglycemia**
- **F – Fasciculations (muscle twitching)**

Sarin

- Question: How easy is Sarin to make?
- Answer: Easy.

Nerve Agent Attack

- **Aum Shinrikyo**
  - Disseminated Sarin on Tokyo subway system, March 20th 1995
  - 13 dead, 3500 casualties
  - Sarin produced in laboratory at Aum facility
  - Series of attacks leading up to March 20th
  - Use of biological agents

Shoko Asahara, Aum Leader


Tokyo Subway


Matsumoto

Mis-Uses of Industrial Chemicals

- 5 Common Industrial Chemicals + 5 Processing Steps = Sarin
- 3 Common Industrial Chemicals + 2 Processing Steps = RDX (High Explosive)
- 1 Common Fertilizer + 1 Blasting Cap = 1 Large Explosion (1947 Galveston, Texas)

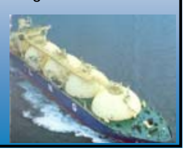
Why do TICs (normally less toxic) pose a greater threat then CWAs?

- **Availability**

  -used all over (pools, industry, hardware stores, hospitals)
  -transported via railways and sea all over the US and abroad

- **Quantity**

  -transported and produced in large quantities (tons of material)
  -large amounts of material can be employed to hit targets (lethality vs. amount of material)



BIOLOGICAL AGENTS

In General:

- Are 1000 times more lethal than chemical agents
- Cause immune system response
- Are solids, nonvolatile
- Are obtained from nature

BIOLOGICAL AGENTS

In General (cont)

- Are invisible to the senses
- Have delayed effects from incapacitating to lethal
- Are primarily an inhalation threat

BIOLOGICAL AGENTS

EPIDEMIOLOGY

Biological attacks on a population will be different from natural outbreaks of disease in the following ways:

- Incidents will occur over a period of hours vs. days
- Illness may occur in an unusual environment or time of year
- Large number of sick and dead animals
- Large number of rapidly fatal cases with few recognizable symptoms due to very low LD_{50}

BIOLOGICAL AGENTS

PATHOGENS: Bacteria, Viruses

- Cause disease
- Enter the body through inhalation, ingestion, cutaneous and mucous membranes of body openings
- Multiply and overcome the body's immune system
- Have delayed effects
- Some can cause epidemics

BIOLOGICAL AGENTS

TOXINS: Neurotoxins, Cytotoxins

- Poisonous substances produced as byproducts of microorganisms, plants and animals
- Some can be chemically produced
- Are not living organisms
- Are not contagious

BIOLOGICAL AGENTS

BACTERIA

- Anthrax
- Plague
- Tularemia

BIOLOGICAL AGENTS

Anthrax

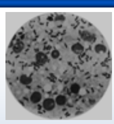
- Infectious disease caused by a spore forming bacterium *Bacillus anthracis*
- Symptoms of inhalation may resemble a common cold
- Early antibiotic treatment is essential

BIOLOGICAL AGENTS

Anthrax

- Persistent in soil as a spore for many years

BIOLOGICAL AGENTS



Plague

- Caused by the bacterium *Yersina pestis*
- Transmitted by rodents and their fleas
- Easily destroyed by sunlight

BIOLOGICAL AGENTS

Plague

Three types :

- Pneumonic Plague-
  - Transmitted person to person through the air
- Bubonic Plague-
  - Does not spread from person to person
- Septicemic Plague-
  - Does not spread from person to person

BIOLOGICAL AGENTS

Pneumonic Plague

- Infects the lungs
- Fever, headache, weakness, rapidly developing pneumonia
- Pneumonia progresses for 2 to 4 days and may cause respiratory failure

BIOLOGICAL AGENTS

Bubonic Plague

- The most common form of plague
- Transmission when an infected flea bites a person or when material contaminated enters through a break in the skin

BIOLOGICAL AGENTS

Bubonic Plague Symptoms

- Swollen lymph glands (called buboes), fever, headache, chills, and weakness

BIOLOGICAL AGENTS

Septicemic Plague

- Occurs when plague bacteria multiplies in the blood stream
- Can be a complication from one of the other types or occur independently
- Buboes do not develop
- Fever, chills, abdominal pain, shock, bleeding into the skin and other organs

BIOLOGICAL AGENTS

Plague First Aid

- Antibiotic treatment must be given within 24 hours of the first system
- Antibiotic treatment for 7 days will protect people who have had direct contact with infected patients.
- Plague vaccine is not available in the United States

BIOLOGICAL AGENTS

Tularemia

- Caused by the bacteria *Francisella tularensis*
- Transmitted by insect(tick, deerfly), handling infected carcass, eating or drinking infected food or water, or breathing in *F. tularensis*

BIOLOGICAL AGENTS

Tularemia

Symptoms

- Sudden fever, chills, headache, muscle aches, joint pain, dry cough, progressive weakness, and pneumonia
- Not known to spread human to human

BIOLOGICAL AGENTS

Tularemia

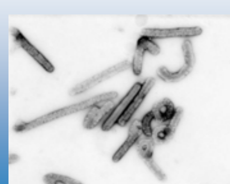
First Aid

- Isolation and antibiotics
- No vaccine in the US

BIOLOGICAL AGENTS

VIRUSES

- Viral hemorrhagic fevers (Ebola, Marburg, Rift Valley, Dengue)



BIOLOGICAL AGENTS

Viral Hemorrhagic Fevers

(Ebola, Marburg, Rift Valley, Dengue)

- Survival is dependent on animal or insect host, called the natural reservoir
- Virus geographically restricted to the areas where their host species lives
- Humans are not the natural reservoir for any of these viruses.

BIOLOGICAL AGENTS

Viral Hemorrhagic Fevers

Symptoms

- Fever, fatigue, dizziness, muscle aches, loss of strength, and exhaustions
- Severe cases show bleeding under the skin, in organs, or from body orifices like the mouth, eyes, or ears

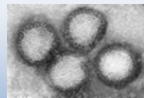
BIOLOGICAL AGENTS

Viral Hemorrhagic Fevers

First Aid

Supportive therapy

BIOLOGICAL AGENTS

- Ebola 
- Rift valley 
- Dengue 

BIOLOGICAL AGENTS

TOXINS

- Botulinum (Neuro)
- Ricin (Cytoto)

BIOLOGICAL AGENTS

Botulinum (Neuro)

- A muscle-paralyzing disease caused by a toxin made by a bacterium
- Symptoms : double vision, blurred vision, drooping eye lids, slurred speech, weakness in upper body then lower, paralysis of breathing muscles can cause death

BIOLOGICAL AGENTS

Ricin (Cytoto)

- Made from left over extract of castor beans
- Can be in powder form, mist, or pellet form, or can be dissolved in water or weak acid
- Symptoms depend on route of exposure

BIOLOGICAL AGENTS

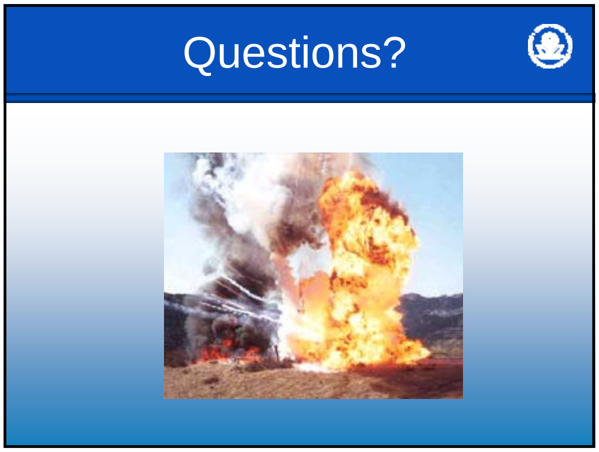
Ricin (Cytoto) Routes of Entry
And Symptoms

- Inhalation — Dry land drowning
- Ingestion — Internal bleeding of stomach, and eventual stoppage of liver, spleen, and kidneys.
- Injection — muscles and lymph nodes near injection point would dies and eventual stoppage of liver, spleen, and kidneys.

BIOLOGICAL AGENTS

Ricin (Cytoto) First Aid

No antidote exists


Questions?

CHEMICAL AND BIOLOGICAL WEAPONS (Short)
Optional Lecture

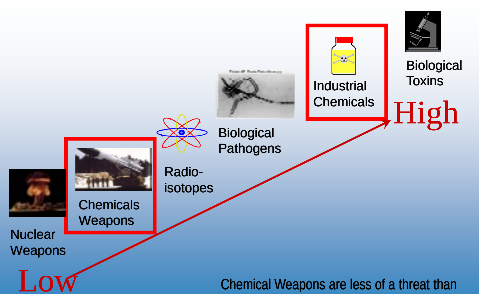
Student Performance Objectives

1. List in order the WMD threat spectrum
2. Identify major Chemical Warfare Agents
3. Identify major Biological Warfare Agents
4. Identify major Toxic Industrial Chemicals (TICs)

THIS PAGE INTENTIONALLY BLANK

Chemical & Biological Warfare Agents, Toxic Industrial Chemicals

WMD Incident Threat Spectrum



Chemical Weapons are less of a threat than Toxic Industrial Chemicals (TICs)!

Chemical Warfare Agents(CWA)

- What is a CWA?
- Types of CWAs
- Physical & chemical properties
- Decontamination methods
- Special concerns

What is CWA?
What makes a CWA a WMD?

- Chemical compounds specifically designed or implemented to deny access, disable or kill large numbers of people
- Includes commonly used toxic industrial compounds (TICs) deliberately used to inflict harm
  - Solid
  - Liquid
  - Aerosol
  - Gas

CWAs – It's Nothing New

- Ancient Use – Greek fire, arsenic smoke
- World War I – First modern military use
- Post WWI – England, Spain, France and Italy
- World War II – Japan
- Iran-Iraq War – Both sides
- Iraq – Kurds target of Hussein's wrath
- Gulf Wars – Questionable
- Terrorist Groups – Modern nightmare

Types of CWAs

- Choking agents
- Blood agents
- Blister agents
- Nerve agents
- Other

Choking (Pulmonary) Agents

- Attack the eyes, nose and airways causing severe irritation, coughing, and eventually pulmonary edema
  - Damages the membrane that separates the alveolus (air sac) from the capillaries, allowing plasma to fill the air sac preventing air from entering
  - Victim can not get enough oxygen and dies from suffocation, called “dry land drowning”
  - Examples
    - Phosgene (CG)
    - Chlorine (CL)
    - Diphosgene (DP)

Blood Agents

- Inhibit the transfer of oxygen in the blood stream to the cells of the body; cells are deprived of oxygen and die
- CK and SA also cause irritation of the eye, nose and mucous membrane similar to tear gas
- Examples
  - Arsine (SA)
  - Cyanogen Chloride (CK)
  - Hydrogen Cyanide (AC)

Blister Agents (Vesicants)

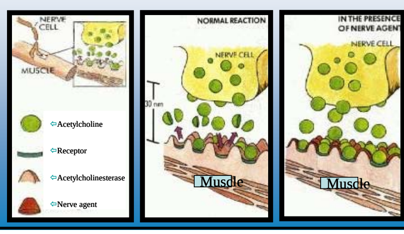
- React with proteins and enzymes in tissue to alter DNA, causing cell death (local/systemic)
- Large blisters or edema are formed upon contact with tissue
- Onset of symptoms for mustards can be delayed for 2-24 hours; L and CX are more immediate
- Examples
  - Lewisite (L), also MD, PD, ED
  - Sulfur Mustard (HD) / Mustard (H)
  - Nitrogen-Mustards (NH-1, NH-2, NH-3)
  - Phosgene Oxime (CX)

Sulfur Mustard

19/20 July 04 Dover (Bridgeville), Delaware 75mm Mustard Round Incident

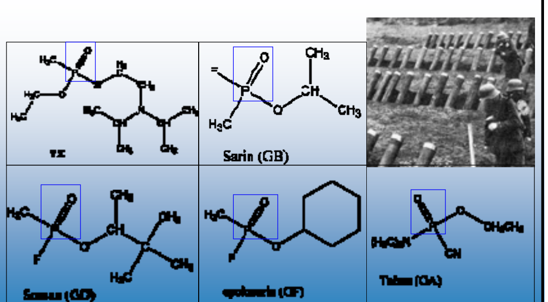
Nerve Agents

- Act on all parts of the nervous system
- Similar to pesticides in function



Nerve Agents

Developed by Germany, 1930's (Organophosphates)



Rev. 07/12

Nerve Agents – G & V Series

- Potent inhibitor of acetylcholinesterase enzyme
  - Acetylcholine enables transmission of nerve signals between synapses; when acetylcholinesterase is inhibited, acetylcholine builds up at the synapses
  - Interferes with the transmission of nerve signals throughout the body leading to numerous CNS disruptions, various characteristic symptoms, convulsions and eventually to death
  - Similar in structure to common insecticides
- Examples
  - G Series: Tabun (GA), Sarin (GB), Soman (GD), and Cyclosarin (GF)
  - V Series: VX
- Atropine and PAM-2 antidote

Other Agent Types

- Riot control agents – tear gases, with various levels of toxicity
  - CN, CNS used by law enforcement
  - CS (toxic), DA, DC
- Incapacitating agents
  - BZ (psychochemical gas)
- Vomiting agents
  - Adamsite (DM)

Key CWA Characteristics
"What Makes a CWA a Threat?"

- Persistence
  - Physical & chemical characteristics / terrain
- Toxicity
  - Inhalation
  - Dermal
  - Ingestion
- Ease of use
  - Production
  - Deployment

Toxicity and Routes of Entry

- Inhalation – All agents, in particular Choking/Blood agents
- Dermal contact – Mustards, Nerve
- Ingestion – Food, water, incidental ingestion

Comparative Toxicity - PEL

CL =	1.0 ppm	Choking Agents
CG =	0.1 ppm	
AC =	10.0 ppm	Blood Agents
CK =	0.2 ppm	
HD =	0.0005 ppm	Blister Agents
HN-1 =	0.0004 ppm	
L =	0.00035 ppm	
GA =	0.000015 ppm	Nerve Agents
GB =	0.000017 ppm	
GD =	0.000004 ppm	
VX =	0.0000009 ppm	

Why Sarin ? - Ease of Use

- Easily produced
- Easily deployed
  - Binary agents can be made and mixed prior to releasing on target
  - Can be sprayed as a liquid or aerosol or allowed to evaporate
- Extremely Toxic

Sarin Toxicity

- Lethal Respiratory Dose: 100 mg-min/m^3

Structure	Volume (m^3)	Lethal Amount
Domed Stadium	1.07 x 10^6	107 kg, ~26 ga
Movie Theater	12,000	1.2 kg, ~ 5 cups
Auditorium	630	52 g, ~ ¼ cup
Conf. Room (80-100 People)	400	33 g, 1 shot glass

Symptoms – Nerve Agents

Stage 1 – Initial Exposure
(Parasympathetic Nervous System)

- **D** - Diarrhea
- **U** - Urination
- **M** - Miosis (constriction of the pupil)
- **B** - Bradycardia, bronchorrhea, bronchospasm
- **E** - Emesis (vomiting)
- **L** - Lachrimation (tears)
- **S** - Salivation, sweating

Nerve Agent Attack

- **Aum Shinrikyo**
  - Disseminated Sarin on Tokyo subway system, March 20th 1995
  - 13 dead, 3500 casualties
  - Sarin produced in laboratory at Aum facility
  - Series of attacks leading up to March 20th
  - Use of biological agents

Shoko Asahara, Aum Leader


Tokyo Subway


Matsumoto

Mis-Uses of Industrial Chemicals

- **5 Common Industrial Chemicals + 5 Processing Steps = Sarin**
- **3 Common Industrial Chemicals + 2 Processing Steps = RDX (High Explosive)**
- **1 Common Fertilizer + 1 Blasting Cap = 1 Large Explosion (1947 Galveston, Texas)**

Why do TICs (normally less toxic) pose a greater threat then CWAs?

- **Availability**
  - -used all over (pools, industry, hardware stores, hospitals)
  - -transported via railways and sea all over the US and abroad
- **Quantity**
  - -transported and produced in large quantities (tons of material)
  - -large amounts of material can be employed to hit targets (lethality vs. amount of material)

BIOLOGICAL AGENTS

In General:

- Are 1000 times more lethal than chemical agents
- Cause immune system response
- Are solids, nonvolatile
- Are obtained from nature

BIOLOGICAL AGENTS

In General (cont)

- Are invisible to the senses
- Have delayed effects from incapacitating to lethal
- Are primarily an inhalation threat

BIOLOGICAL AGENTS

EPIDEMIOLOGY

Biological attacks on a population will be different from natural outbreaks of disease in the following ways:

- Incidents will occur over a period of hours vs. days
- Illness may occur in an unusual environment or time of year
- Large number of sick and dead animals
- Large number of rapidly fatal cases with few recognizable symptoms due to very low LD_{50}

BIOLOGICAL AGENTS

PATHOGENS: Bacteria, Viruses

- Cause disease
- Enter the body through inhalation, ingestion, cutaneous and mucous membranes of body openings
- Multiply and overcome the body's immune system
- Have delayed effects
- Some can cause epidemics

BIOLOGICAL AGENTS

TOXINS: Neurotoxins, Cytotoxins

- Poisonous substances produced as byproducts of microorganisms, plants and animals
- Some can be chemically produced
- Are not living organisms
- Are not contagious

BIOLOGICAL AGENTS

BACTERIA

- Anthrax
- Plague
- Tularemia

BIOLOGICAL AGENTS

Anthrax

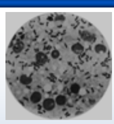
- Infectious disease caused by a spore forming bacterium *Bacillus anthracis*
- Symptoms of inhalation may resemble a common cold
- Early antibiotic treatment is essential

BIOLOGICAL AGENTS

Anthrax

- Persistent in soil as a spore for many years

BIOLOGICAL AGENTS



Plague

- Caused by the bacterium *Yersina pestis*
- Transmitted by rodents and their fleas
- Easily destroyed by sunlight

BIOLOGICAL AGENTS

Plague

Three types :

- Pneumonic Plague-
  - Transmitted person to person through the air
- Bubonic Plague-
  - Does not spread from person to person
- Septicemic Plague-
  - Does not spread from person to person

BIOLOGICAL AGENTS

Pneumonic Plague

- Infects the lungs
- Fever, headache, weakness, rapidly developing pneumonia
- Pneumonia progresses for 2 to 4 days and may cause respiratory failure

BIOLOGICAL AGENTS

Bubonic Plague

- The most common form of plague
- Transmission when an infected flea bites a person or when material contaminated enters through a break in the skin

BIOLOGICAL AGENTS

Septicemic Plague

- Occurs when plague bacteria multiplies in the blood stream
- Can be a complication from one of the other types or occur independently
- Buboes do not develop
- Fever, chills, abdominal pain, shock, bleeding into the skin and other organs

BIOLOGICAL AGENTS

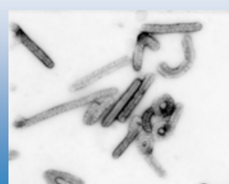
Tularemia

- Caused by the bacteria *Francisella tularensis*
- Transmitted by insect(tick, deerfly), handling infected carcass, eating or drinking infected food or water, or breathing in *F. tularensis*

BIOLOGICAL AGENTS

VIRUSES

- Viral hemorrhagic fevers (Ebola, Marburg, Rift Valley, Dengue)



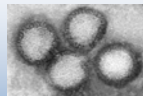
BIOLOGICAL AGENTS

Viral Hemorrhagic Fevers

(Ebola, Marburg, Rift Valley, Dengue)

- Survival is dependent on animal or insect host, called the natural reservoir
- Virus geographically restricted to the areas where their host species lives
- Humans are not the natural reservoir for any of these viruses.

BIOLOGICAL AGENTS

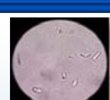
- Ebola 
- Rift valley 
- Dengue 

BIOLOGICAL AGENTS

TOXINS

- Botulinum (Neuro)
- Ricin (Cytoto)

BIOLOGICAL AGENTS



Botulinum (Neuro)

- A muscle-paralyzing disease caused by a toxin made by a bacterium
- Symptoms : double vision, blurred vision, drooping eye lids, slurred speech, weakness in upper body then lower, paralysis of breathing muscles can cause death

BIOLOGICAL AGENTS

Ricin (Cytoto)

- Made from left over extract of castor beans
- Can be in powder form, mist, or pellet form, or can be dissolved in water or weak acid
- Symptoms depend on route of exposure

Questions?

WORKING AT HAZARDOUS WASTE SITES:

Keeping Your Workers Safe

Health and Safety Information for Small Businesses

Opportunities abound for small businesses in hazardous waste site clean-up. Part of the skills required in getting and fulfilling these types of contracts is knowing how to keep your workers safe and healthy. Like construction workers, hazardous waste site workers are surrounded by physical hazards and rapidly changing conditions. Hazardous waste site workers, however, must also be prepared to perform their jobs around chemical hazards. The success of any hazardous waste site contractor depends, in part, on being able to meet government health and safety regulations for this type of work and on training workers to perform their jobs safely and well in these environments.

This brochure is designed to help small businesses protect their hazardous waste site employees. The information contained within is a compilation of publications, telephone hotlines, Internet resources, and federal regulations that pertain to hazardous waste site health and safety. Small business can draw on these resources to become familiar with regulatory requirements, training needs and sources, and health and safety considerations involved in hazardous waste site work. Contractors performing site work can also use this information to get clarifications of requirements and recommended procedures. When performing or planning to perform hazardous waste site work, however, small businesses should coordinate their health and safety plans and procedures with the site's prime contractor to ensure safe and well-organized procedures throughout the site.

This brochure was developed by the EPA/Labor Superfund Health and Safety Task Force. The Task Force includes members representing the EPA, OSHA, DOE, NIOSH, NIEHS, the Laborer's Safety and Health Fund of North America, the International Association of Firefighters, the International Brotherhood of Teamsters, the USACE, and the International Union of Operating Engineers. For more information about the Task Force and available health and safety resources, visit the Task Force website at:

http://204.46.140.12/hslab.htm.

PUBLICATIONS

SOURCE	TITLE	PHONE
GENERAL		
EPA	EPA Hazardous and Solid Waste Publications	(800)424-9346 (703) 412-9810
OSHA	OSHA Publications Catalog. Document number 2019	(202) 219-4667
NIOSH	Hazardous Waste Bibliography	(800) 356-4674
EPA/NTIS	Numerous Health and Safety Publications	(800) 553-6847
NTIS	Health and Safety Audit Guidelines. EPA 540/G-89/010	(800) 553-6847
EPA/NTIS	EPA Fact Sheet 9285.2-09FS, April 1991, Hazardous Waste Operations and Emergency Response: General Information and Comparisons. PB 91-921338	(800) 553-6847
EPA/NTIS	EPA Fact Sheet 9285.1-02, July 1991, Health and Safety Roles and Responsibilities at Remedial Sites. PB 91-921362	(800) 553-6847
EPA	EPA Quick Reference Fact Sheet - Hazardous Waste Operations and Emergency Response: Available Guidance	(908) 321-6740
DOE	Health and Safety Plan (HASP) Guidelines	(800) 473-4375
GPO	U.S. Army Corps of Engineers (USACE) Safety and Health Requirements Manual, EM 385-1-1	(202) 512-1800
USACE	USACE Guide Specification (CEGS) 1351 - Safety, Health and Emergency Response (HTRW/UST)	(202) 761-8566
NIOSH	NIOSH/OSHA/USCG/EPA Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities	(800) 356-4674
EPA	Health and Safety Plan (HASP) software, Version 3.0c, Pub. No. 9285.8-01	(800) 999-6990
EPA	Protecting Health and Safety at Hazardous Waste Sites, EPA/625/9-85/006	(800) 424-9346
EPA	Understanding the Hazardous Waste Rules, A Handbook for Small Businesses, EPA-530-K-95-001	(703) 603-9230
EPA/NTIS	EPA Fact Sheet 9285.8-06FS, Sept. 1993, EPA Ensures Oversight of Worker Safety and Health at Superfund Incinerator Sites. PB 93-963417	(800) 553-6847
OSHA	OSHA 3114 - Hazardous Waste and Emergency Response	(202) 219-4667
OSHA	Protocol for Safety and Health Inspections at Superfund Incinerator Sites	(202) 219-4667

OSHA	Summary Report on OSHA Inspections of Incinerator Sites	(202) 219-4667
OSHA	Field Inspection Reference Manual (FIRM)	(202) 219-4667
OSHA	Interpretive Quips: HAZWOPER	(202) 219-4667
OSHA	OSHA 3110 - Access to Medical and Exposure Records	(202) 219-4667
EPA/NTIS	Standard Operating Safety Guides. PB 92-963414	(800) 553-6847
HAZARD IDENTIFICATION / RECOGNITION		
EPA/NTIS	Health and Safety Audit Guidelines, EPA 540/G-89/010	(800) 553-6847
EPA/NTIS	Establishing Work Zones at Uncontrolled Hazardous Waste Sites, PB91-921342	(800) 553-6847
DOE	HAZWOPER Handbook, Handbook for Occupational Health and Safety During Hazardous Waste Activities, DOE/EH-0535	(800) 473-4375
FEMA/EPA/ DOT	Technical Guidance for Hazards Analysis, Emergency Planning for Extremely Hazardous Substances	(202) 646-3484
DOE	Preparation Guide for US DOE Nonreactor Nuclear Facility Safety Analysis Reports, DOE-STD-3009-94	(301) 903-1961
DOE	Hazard Baseline Documentation, DOE-STD-5502-94	(301) 903-1961
CONFINED SPACE ENTRY		
OSHA	OSHA 3138 - Permit-Required Confined Spaces	(202) 219-4667
DOE	Department of Energy (DOE) OSH Technical Reference, Confined Space Entry	(202) 586-9642
PROCESS SAFETY MANAGEMENT		
OSHA	OSHA 3133 - Process Safety Management Guidelines for Compliance	(202) 219-4667
DOE	DOE Handbook, Process Safety Management for Highly Hazardous Chemicals	(301) 903-6514
DOE	DOE Handbook, Chemical Process Hazards Analysis	(301) 903-6514
CHEMICAL EXPOSURE LIMITS		
NIOSH	NIOSH Pocket Guide to Chemical Hazards	(800) 553-6847
ACGIH	TLVs and BEIs (Updated Annually)	(513) 742-2020
PERSONAL PROTECTIVE EQUIPMENT		
OSHA	OSHA 3077 - Personal Protective Equipment	(202) 219-4667
NIOSH	Personal Protective Equipment for Hazardous Materials Incidents: A Selection Guide (1984)	(202) 619-0257

EMERGENCY RESPONSE		
EPA	EPA Quick Reference Fact Sheet - Hazardous Waste Operations and Emergency Response: RCRA TSD and Emergency Response Without Regard to Location	(908) 321-6740
EPA/NTIS	EPA Fact Sheet 9285.2-06FS, April 1991, Hazardous Waste Operations and Emergency Response: Uncontrolled Hazardous Waste Sites and RCRA Corrective Actions. PB 91-921339	(800) 553-6847
EPA/NTIS	An Overview of the Emergency Response Program , EPA 540/8-91/015	(800) 553-6847
EPA	Emergency Responders Agreements for Fund-Lead Remedial Actions, EPA 540-F-93-041	(800) 553-6847
EPA	NRT One Plan Guidance	(800) 424-9346
OSHA	Field Directive for 1910.120(q), CPL 2-2.59 A	(202) 219-4667
OSHA	Post-Emergency Response Operations Directive, CPL 2-2.51 (addresses oil spills)	(202) 219-4667
DOE	DOE Emergency Management Guide	(202) 586-9642
DOE	Emergency Response/Contingency Plan	(202) 586-9642
CMA	Site Emergency Response Planning	(202) 741-5000
DOT	DOT Emergency Response Guidebook	(800) 752-6367
EXPOSURE SAMPLING		
EPA	Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. EPA-600-4-84-010. PB 87-168688	(800) 424-9346
ACGIH	OSHA Sampling and Analytical Methods Manual	(513) 742-2020
OSHA	Field Inspection Reference Manual (FIRM)	(202) 219-4667
HEAT STRESS/COLD STRESS		
ANL-W	Environment, Safety and Health Manual, Heat/Cold Stress	(208) 553-7446
FNL	Work Smart, Set Standard, ACGIH TLV for Heat Stress/Cold Stress	(708) 840-3000

BLOODBORNE PATHOGENS		
EPA/NTIS	The Effect of OSHA's Bloodborne Pathogens Standard on Hazardous Waste Cleanup Activities	(800) 553-6847
OSHA	OSHA 3130 - Occupational Exposure to Bloodborne Pathogens: Precautions for Emergency Responders	(202) 219-4667
OSHA	Interpretive Quips: Bloodborne Pathogens	(202) 219-4667
HAZARD COMMUNICATION		
OSHA	OSHA 3084 - Chemical Hazard Communication	(202) 219-4667
OSHA	Interpretive Quips: Hazard Communication	(202) 219-4667
LEAD IN CONSTRUCTION		
OSHA	Lead in Construction Directive, CPL 2-2.58	(202) 219-4667
OSHA	OSHA 3142 - Lead in Construction	(202) 219-4667
PACKAGING & TRANSPORT		
DOE	DOE G 460.2, Departmental Materials Transportation and Packaging Management	(202) 586-9642

**Many of these publications are available on the Internet.*

INTERNET RESOURCES

PROVIDER	TYPE OF RESOURCE	INTERNET ADDRESS
EPA	EPA Home Page	www.epa.gov
EPA	Hazardous Waste Cleanup Information	www.clu-in.com
EPA	EPA - Office of Solid Waste and Emergency Response (OSWER)	www.epa.gov/epaoswer
EPA	CERCLIS database (also available in CD-ROM format from NTIS)	www.epa.gov/superfund/oerr/impm/impm.htm
EPA	EPA's Environmental Response Team	204.46.140.12
OSHA	OSHA's Computerized Information System (OCIS) and Hazardous Waste Technical Links	www.osha-slc.gov
DOE	DOE-EH, Chemical Safety	tis.eh.doe.gov/web/chem_safety
DOE	DOE-EH, Safety & Health Technical Information Services	tis.eh.doe.gov:80/map.html
DOE	DOE-EH, Environmental Management Home Page	www.em.doe.gov/index.html
DOE	DOE-EH, Worker Protection Program and Hazards Management	tis-nt.eh.doe.gov/wpphm/
DOD	Department of Defense (DOD) - Environmental Restoration	www.dtic.mil/envirodod/smallbiz.html
DOE/DOD/EPA/DOI	Federal Remediation Technologies Roundtable	www.frtr.gov
NIEHS	NIEHS Worker Education and Training Program	www.niehs.nih.gov/wetp/home.htm
USACE	USACE Safety and Health Requirements	www.usace.army.mil
NIOSH	NIOSH home page and access to NIOSHtic, published health and safety articles	www.cdc.gov/niosh/homepage.html

INFORMATION HOTLINES

EPA RCRA, Superfund and EPCRA Hotline
Interpretations of EPA Policy
(800) 424-9346 / (703) 412-9810

OSHA Health Compliance Assistance
Interpretations of OSHA Policy
(202) 219-8036 ext.42

NIOSH Hotline
Chemical and Physical Hazards
(800) 356-4674

EPA Small Business Hotline
(800) 368-5888/(703) 305-5938

DOE Workers' Safety Standards
(800) 292-8061

REGULATIONS THAT MAY APPLY

TOPIC	REGULATION
CERCLA, Superfund, Emergency Planning, and Community Right to Know Programs, EPA	40 CFR 300 Subchapter J
RCRA, Hazardous Waste Management System, EPA	40 CFR 260 Subchapter I
Hazardous Waste Operations and Emergency Response (HAZWOPER), OSHA	29 CFR 1910.120 29 CFR 1926.65
Toxic and Hazardous Substances, OSHA	29 CFR 1910 Subpart Z
Personal Protective Equipment, OSHA	29 CFR 1910 Subpart I
Respiratory Protection, OSHA	29 CFR 1910.134
Construction Safety, OSHA	29 CFR 1926
Packaging and Offsite Transportation of Nuclear Components, and Special Assemblies Associated with the Nuclear Explosives, DOE-DP	DOE O 5610.12
Hazardous Material Packaging for Transport - Administrative Procedure, DOE-EH	DOE O 1540.2
Hazardous and Radioactive Mixed Waste Program, DOE-EH	DOE 5400.3
Accident Response Group, DOE-DP	DOE O 5530.1A
Planning and Preparedness for Operational Emergencies, DOE-EH	DOE O 5500.3
Comprehensive Emergency Management System, DOE-NN	DOE O 151.1
Worker Safety and Health Program, DOE-EH	DOE O 440.1
Facility Safety, DOE-EH	DOE O 420.1
Hazardous Material Transportation, DOT	49 CFR 172-179
Safety and Occupational Health Document Requirements for Hazardous, Toxic, and Radioactive Waste (HTRW) Activities, USACE	ER 385-1-92

TRAINING MATERIALS

VENDOR	TRAINING TOPIC	TYPE OF MATERIAL
OSHA (202) 219-4667	OSHA 2254 (Revised) - Training Requirements in OSHA Standards and Training Guidelines	Book
OSHA	Small Business Training Outreach Program.	Instructor / Student Guide - www.osha-slc.gov/SLTC/ SmallBusiness/index.html
DOE	DOE- Radiation Safety Training	Book
DOE	Methodology on Setting Priorities for Hazardous Waste Minimization	Book
DOE	Hazardous-Radioactive Waste Management Training Series	Book
DOE	Pretransport Requirements for Waste Generators	Book
DOE	Solid Radioactive Waste Management	Book
DOE	Managing High-Level and Transuranic Waste	Book

All the DOE materials above and additional related materials and documents can be downloaded from the DOE's Office of Environment, Safety and Health (EH) website:

http://tis-nt.eh.doe.gov/whs/whs.html-ssi

TRAINING PROVIDERS

TYPE OF TRAINING	PROVIDER	`PHONE
HAZWOPER	EPA	(513) 251-7669
HAZWOPER	NIEHS*	(919) 541-0217
OSHA Training for Hazardous Waste Operations, DOE/EH-0227P	DOE-EH	(301) 903-4527
HAZWOPER Elements and Safety Program	DOE-EH	(301) 903-4527
Confined Space, Tank, and Vault Hazards	DOE-EH	(301) 903-4527
Use of Monitoring Equipment	DOE-EH	(301) 903-4527
Effect of Chemical Exposures	DOE-EH	(301) 903-4527
Emergency Response and First Aid	DOE-EH	(301) 903-4527
Personal Protective Equipment (PPE) Program and Use of PPE	DOE-EH	(301) 903-4527
HAZWOPER	IUOE**	(202) 429-9100
HAZWOPER	Laborers-AGC	(860) 974-0800

**NIEHS can supply the names of multiple HAZWOPER training courses provided across the country.*

*** IUOE has approximately 75 Locals that provide HazMat training. Please contact the union for the appropriate Local in your state of interest.*

OTHER GOVERNMENT AGENCIES

The following government agencies may also have some information related to health and safety and hazardous waste remediation, although it is not their primary focus.

DOT Research and Special Programs Administration
http://www.rspa.dot.gov/
(202) 366-5064

Federal Emergency Management Agency
http://www.fema.gov
(202) 646-3484

Agency for Toxic Substances and Disease Registry (ATSDR)
http://atsdr1.atsdr.cdc.gov:8080/atsdrhome.html
(404) 639-0500

ABBREVIATIONS USED WITHIN

ACGIH	American Conference of Governmental Industrial Hygienists
ANL-W	Argonne National Laboratory-West (DOE)
CMA	Chemical Manufacturers Association
DOE	U.S. Department of Energy
DOE-DP	DOE-Office of Defense Programs
DOE-EH	DOE-Office of Environment, Safety & Health
DOE-NN	DOE-Office of Nonproliferation and National Security
DOI	Department of the Interior
DOT	Department of Transportation
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FNL	Fernald National Laboratory (DOE)
GPO	U.S. Government Printing Office
IUOE	International Union of Operating Engineers
NIEHS	National Institute of Environmental Health Sciences
NIOSH	National Institute for Occupational Safety & Health
NRT	National Response Team
NTIS	National Technical Information Service
USACE	U.S. Army Corps of Engineers

APPENDIX B

WARNING CONCENTRATIONS OF VARIOUS CHEMICALS

The following table is a compilation of warning concentrations of various chemicals taken from several sources. A warning concentration is *that concentration in air at which a person can detect the material either by its odor, by its taste, or by it causing irritation*. A material has adequate warning properties if the effects (e.g., odor, taste, or irritation) are detectable and persistent at concentrations "at" or "below" the exposure limit.

Note that some sources give a statement like "adequate" or "inadequate" for the warning properties. Some of the chemicals have a range of concentrations because the different sources have different values. This can be due to the variability of human perceptions or different test methods. The sources may have used different endpoints for their testing. This value could be when the first person detected the odor, when everyone could smell it, or when 50% of the test subjects could detect it. Because of these variations, the full range of warning concentrations is given so that the user can decide which value to use.

The warning concentrations given are generally odor thresholds with irritation thresholds given in parentheses. Taste thresholds are noted as special cases. The concentration units used in the table are parts per million unless otherwise noted.

Chemical	Warning Concentration[a]
Acetaldehyde	0.0001 - 2.3 (50)
Acetamide	"odorless when pure"
Acetic acid	0.1 - 24 (10-15)
Acetic anhydride	0.1 - 81.2 (5)
Acetone	0.1 - 699
Acetonitrile	40 - 170
Acetophenone	0.002 - 0.60
Acetyl bromide	5.0×10^{4}
Acetyl chloride	1
Acrolein	0.05 - 16.6 (0.21-0.5)
Acrylamide	"odorless"
Acrylic acid	0.1 - 1
Acrylonitrile	1.6 - 100, fatigue
Akrol	10
Aldrin	0.2536 - 0.4027 mg/m^3
Allyl alcohol	0.08 - 7.2 (0.75-25)
Allylamine	6.3 - 28.7
Allyl chloride	0.1 - 10 (50-100)
Allyl chloroformate	1.4
Allyl disulfide	0.0012
Allyl glycidyl ether	<10
Allyl isocyanide	0.018
Ally isothiocyanate	0.15 - 0.42
Allyl mercaptan	0.00005 - 0.21
Ammonia	0.04 - 55 (55-140)
Ammonium hydroxide	50
Ammonium sulfanate	"odorless"
n-Amyl acetate	0.00090 - 10 (200)
sec-Amyl acetate	0.0017 - 0.082
tert-Amyl acetate	0.0017
n-Amyl alcohol (1-pentanol)	0.0065 - 35
Amylene (2-methyl-2-butene)	0.0022 - 2.3
Amyl isovalerate	0.11
n-Amyl mercaptan	0.07

Chemical	Warning Concentration[a]
N-Amyl methyl ketone	0.0009 - 0.35
Amyl sulfide	0.0030 - 0.005
Anethole	0.003
Aniline	0.5 - 70
Apiol	0.0063
Arsenic anhydride (arsenic pentoxide)	1
Arsine	0.21 - 0.63
Benzaldehyde	0.003 - 0.69 (4.6)
Benzene	1.4 - 120 (2817)
Benzoyl peroxide	"odorless"
Benzyl alcohol	5.5
Benzyl chloride	0.01 - 0.31 (8)
Benzyl mercaptan	0.00019 - 0.04 (4.5
Benzyl sulfide	0.0021 - 0.07
Bornyl acetate	0.0078
Boron oxide	"immediate irritation"
Boron trifluoride	1 - 1.5
Bromine	0.05 - 3.5 (0.6 intolerable)
Bromoacetone	0.090
Bromoacetophenone	0.015 - 0.17 (0.04)
Bromoform	1.3 - 530
1,3-Butadiene	0.16 - 1.8 (>8000)
n-Butane	5.5 - 5000
2-Butoxyethanol	0.1 - 60 (100-195)
Butyl acetate	0.037 - 20 (300)
sec-Butyl acetate	3 - 7
tert-Butyl acetate	0.004 - 47
Butyl acrylate	0.04 - 0.9
Butyl alcohol	0.1 - 20 (25-100)
sec-Butyl alcohol	0.1 - 43
tert-Butyl alcohol	0.1 - 73 (100)
Butylamine	0.1 - 5 (10-15)
sec-Butylamine	0.24 (as n-Butylamine)
tert-Butylamine	0.24 (as n-Butylamine)

Chemical	Warning Concentration[a]
Butyl cellosolve (see 2-Butylamine)	
Butyl cellosolve acetate	0.20
n-Butyl chloride	0.9 - 13
1-Butylene (1-Butene)	0.07 - 26
2-Butylene (2-Butene)	0.57 - 22
Butylene oxide	0.71
Butyl ether	0.24 - 0.47
n-Butyl formate	17 - 20
n-Butyl lactate	1 - 7
n-Butyl mercaptan	0.00082 - 0.38
tert-Butyl mercaptan	0.00009 - 0.06
Butyl sulfide	0.015 - 0.18
p-tert-Butyltoluene	5 (5-8)
n-Butyraldehyde	0.0046 - 0.039
Butyric acid	0.00056 - 0.001
Cadmium dust	"inadequate"
Cadmium fume	"inadequate"
Calcium dodecylbenzene sulfonate	
Calcium hydroxide	"odorless"
Calcium hypochlorite	3.5 (as Chlorine)
Calcium phosphide	0.13 - 13.4
Camphor-synthetic	0.003 - 200 (1.77)
Caprolactam	0.001 - 0.065
Carbaryl (Sevin®)	"essentially odorless"
Carbitol acetate	0.157 - 0.263
Carbon dioxide	"odorless"
Carbon disulfide	0.0011 - 7.7
Carbon monoxide	"odorless"
Carbon tetrachloride	2 - 700
Cavacrol	0.0023
Chloral	0.047
Chlordane	"odorless"
Chlorine	0.01 - 5 (1-6)
Chlorine dioxide	0.1 (5.0)

Chemical	Warning Concentration[a]
Chloroacetaldehyde	0.93 (0.01-1)
Chloracetic acid	0.045
Chloroacetophenone (CN, Tear Gas)	0.01 - 1.35 (0.024-0.063)
Chlorobenzene	0.1 - 60
o-chlorobenzylidene malononitrile	(0.2)
Chlorobromomethane	100 - 400
Chloroform	50 - 307, fatigue (>4096)
Chloromethane (see Methyl chloride)	
Chlorophenol	0.034
o-Chlorophenol	0.0036
p-Chlorophenol	1.2 - 30
Chloropicrin	0.8 - 1.1 (0.3-0.37)
B-Chloroprene	0.1 - 138
Chlorosulfonic acid	1 - 5 (from HC1 produced)
o-Chlorotoluene	0.32
Chlorovinyl arsine	1.6
Cinnamaldehyde	0.0026
Citric acid	"odorless"
Cobalt, Metal Fume & Dust	(>1 mg/m^3)
Coumarin (Coumaphos, Baymix)	0.0033 - 0.2
Crag® Herbicide	"none"
m-Cresol	0.25 - 0.68
o-Cresol	0.26 - 0.68
p-Cresol	0.00047 - 0.0455
Crotonaldehyde	0.01 - 7.35 (45)
Crotyl mercaptan	0.00016 - 0.0099
Crude-heavy (Loganillas-Crude)	0.1 - 0.5
Crude-light (Louisiana-Crude)	0.1 - 0.5
Crude-medium (Barbados-Crude)	0.1 - 0.5
Cumene	0.04 - 1.2
Cyanogen chloride (CNCL)	1
Cyclohexane	0.1 - 300 (300)
Cyclohexanol	0.06 - 160 (100)
Cyclohexamone	0.01 - 4

Chemical	Warning Concentration[a]
Cyclohexene	0.18 - 300
Cyclohexylamine	2.6
Cyclopentadiene	0.01 - 250
2,4-D esters	0.02 - 0.1
DDT (Dichlorodiphenyl trichloroethane)	2.9 mg/m^3
Decaborane	0.05 - 0.35 (fatigue)
Decanoic acid	0.0020 - 0.35
Decanal	0.0064 - 0.168
1-Decylene	0.12
Diacetone alcohol	0.1 - 1.7
Diacetyl	0.025
Diallyl ketone	9.0
Diazomethane	"inadequate"
Diborane	1.8 - 4, "not reliable"
Di-N-Butyl amine	0.08 - 0.48
Dibutyl phosphate	"inadequate"
Dichlorobenzene	0.005
o-Dichlorobenzene	0.3 - 50 (20-30)
p-Dichlorobenzene	0.18 - 30 (80-160)
Dichlorodiethyl sulfide (Mustard Gas)	0.0023 - 0.19
Dichlorodifluoromethane	"odorless"
1,3-Dichloro-5,5-dimethyl hydatoin	"adequate," 0.01 (1.14)
1,1-Dichloroethane	50 - 1350, "adequate"
1,2-Dichloroethylene	0.085 - 500
Dichloroethyl ether	0.0005 - 35 (100-200)
bis-a-Dichloroethyl sulfide	0.0023
Dichloroisopropyl ether	0.32
Dichloromethane (see Methylene chloride)	
dichloromonofluoromethane	"nearly odorless"
2,4-Dichlorophenol	0.21 - 0.008
1,2-Dichloropropane	0.1 - 70
2,2-Dichloropropionic acid (Dalapon)	428
Dichlorotetrafluoroethane	"nearly odorless"
Dicyclopentadiene	0.003 - 0.020

Chemical	Warning Concentration[a]
Dieldrin	0.041
Diesel Fuel No. 1-D	0.25
Diesel Fuel No. 2-D	0.08
Diesel Fuel No. 4-D	0.01
Diethanolamine	0.011 - 0.27
Diethylamine	0.01 - 38 (50, animals)
Diethylaminoethanol	0.01 - 0.25
Diethylene glycol	"almost odorless"
Diethylene triamine	10
Diethyl ketone	1 - 10
Diethyl selenide	0.00014
Diethyl succinate	0.021
Difluorodibromomethane	"inadequate"
Diglycidyl ether	5
Diisobutyl carbinol	0.048 - 0.160
Diisobutyl ketone	0.11 - 0.31 (25.8)
Diisopropylamine	0.1 - 4 (25-50, injury)
Dimethyl acetamide	21 - 47
Dimethylamine	0.01 - 6 (97-183, animals)
Dimethylaminoethanol	0.015 - 0.045
Dimethylaniline	0.001 - 0.2
Dimethyl ether	0.3 - 9
Dimethylformamide	0.1 - 100
1,1-Dimethylhydrazine	1 - 14
Dimethyl sulfate	"nearly odorless"
dimethyl sulfide	0.001 - 0.020
Dimethyl sulfoxide	"practically no odor"
Dimethyl trichiocarbonate	0.0058 - 0.18 mg/m^3
Dinitro-o-cresol	"odorless"
2,6-Dinitrophenol	0.21 (as phenol)
Dinitrotoluene	"inadequate"
Dioxane	0.003 - 278 (200-300)
Dioxolane	64 - 128
Diphenyl (Biphenyl)	0.0008 - 0.06 (3-4)

Chemical	Warning Concentration[a]
Diphenyl chloroarsine	0.030
Diphenylcyanoarsine	0.3
Diphenyl ether (see Phenyl ether)	
Diphenyl sulfide	0.00034 - 0.0047
Diphosgene (Trichloromethyl chloroformate)	1.2
Dipropylamine	0.02 - 55
Dipropylene glycol	"practically odorless"
Dipropylene glycol methyl ether	34.7 - 1000 (74.3)
dithioethylene glycol	0.031
Dodecanol	0.0064
Dodecycibenzene sulfonic acid	0.4 - 8
Epichlorohydrin	0.1 - 16 (100)
EPN	"inadequate"
Ethane	150 - 899
1,2-Ethanedithiol	0.0042
Ethanol	1 - 5100 (5041)
Ethanolamine	2 - 4
2-Ethyoxy-3,4-dihydro-1, 2-pyran	0.10 - 0.60
2-Ethoxyethanol (Cellosolve acetate)	0.55-50
2-Ethoxyethyl acetate (Cellosolve acetate)	0.056 - 50 (600, animals)
Ethyl acetate	0.01 - 50 (200-400)
Ethyl acrylate	0.00024 - 1 (75)
Ethylamine	0.01 - 1 (100, delayed)
Ethyl benzene	0.1 - 200 (200)
Ethyl bromide	3.1 - 200 (6500)
2-Ethylbutanol	0.07 - 0.77
Ethyl butyl ketone	0.1 - 10
Ethyl butyrate	0.0082 - 0.015
Ethyl chloride (Chloroethane)	4.2
Ethyl disulfide	0.0028
Ethylene	261 - 4010
Ethylene bromide (see Ethylene dibromide)	
Ethylene chloride (see Ethylene dichloride)	
Ethylene chlorohydrin	"odorless," 0.4

Chemical	Warning Concentration[a]
Ethylene diamine	1 - 11.2 (100)
Ethylene dibromide	10 - 25
Ethylene dichloride	6.2 - 185
Ethylene glycol	0.08 - 40
Ethylene imine	"inadequate" 1 - 100+
Ethylene oxide	0.1 - 700
Ethyl ether	0.1 - 9 (200)
Ethyl formate	18 - 33 (330)
Ethyl glycol	25
Ethyl hexanol	0.075 - 0.138
Ethyl hexanoate	0.0056
Ethyl hexyl acetate	0.18
Ethyl hexyl acrylate	0.007 - 0.073
Ethyl isothiocyanate	1.6 - 10.7
Ethyl mercaptan	0.00051 - 0.075
Ethyl methacrylate	0.0067
n-Ethylmorpholine	0.1 - 25, fatigue (40 - 100)
Ethyl pelargonate	0.0014
Ethyl phthalate	"odorless"
Ethyl selenide	0.0003 - 0.014 mg/m^3
Ethyl selenamercaptan	0.0003
Ethyl silicate	17 - 85 (250)
Ethyl sulfide	0.00060 - 0.068
Ethyl isovalerate	0.12
Ethyl decanoate	0.00017
Ethyldichlorarsine	0.14 - 1.4
Ethyl n-valerate	0.060
Ethyl undecanoate	0.00054
Eugenol	0.0046
Fluoride dust	(5.0 mg/m^3)
Fluorine	0.035 - 3 (25-100)
Fluorotrichloromethane	5 - 100, "odorless"
Formaldehyde	0.01 - 60 (0.25-2)
Formic acid	0.024 - 340 (15)

Chemical	Warning Concentration[a]
Fuel Oil #1 (Kerosene, Jet Fuel)	0.082 - 1
Fuel Oil #2 (Diesel Oil)	0.082
Fuel Oil #4	0.5
Fuel Oil #6 (Bunker-C)	0 - 13
Furfural	0.006 - 5 (12.2-50)
Furfuryl alcohol	8
Fumaric Acid (trans-Butenedioic)	"odorless"
Gasoline	0.005 - 10
Glutaraldehyde	0.04
Glycol diacetate	0.077 - 0.312
Halothane	33
n-Heptal chloride	0.060
Heptachlor	0.306 mg/m^3
Heptaldehyde	0.050
n-Heptane	0.5 - 329
Heptanol	0.057 - 20
HETP (see TEPP)	
Hexachlorocyclopentadiene	0.03 - 0.33
Hexachloroethane	0.13
Hexamethylenediamine	0.0009
n-Hexane	65 - 248 (1400-1500)
Hexanoic acid	0.0061
Hexanol	0.0050 - 0.09
Hexanone (see Methyl Butyl Ketone)	
sec-Hexyl acetate	0.1 - 100 (100)
Hexylene glycol	50
Hydrazine	3 - 4
Hydrocinnamyl alcohol	0.00027
Hydrogen bromide	2 (3-6)
Hydrogen chloride	1 - 10 (35)
Hydrogen cyanide	0.00027 - 5, fatigue
Hydrogen fluoride	0.04 - 0.163
Hydrogen peroxide	"odorless" (100)
Hydrogen selenide	0.0005 - 3.6, fades fast (1.5)

Chemical	Warning Concentration[a]
Hydrogen sulfide	0.00001 - 1.4 (50-100) (fatigue at high concentration)
2-Hydroxpropyl acrylate	0.05
Indene	0.02
Iodine	1.73 (1.63 - disappears within 2 minutes)
Iodoform	0.0004 - 0.5
Ionone	5.9×10^{-8} -73
Isoamyl acetate	0.001 - 1
Isoamyl alcohol	0.01 - 35 (100-150)
Isoamyl mercaptan	0.0043 - 0.7
Isobutyl acetate	0.002 - 7 (<150)
Isobutyl acrylate	0.009 - 0.012
Isobutyl cellosolve	0.114 - 0.191
Isobutyl mercaptan	0.00054 - 0.00097
Isobutylraldehyde	0.047 - 0.336
Isobutyric acid	0.001
Isocyanochloride	0.98
Isodecanol	0.31 - 0.042
Isopentanoic acid	0.005 - 0.026
Isopentyl acetate (see Isoamyl acetate)	
Isophorone	0.18 - 8.85 (8.85)
Isoprene (2-methylbutadiene)	0.005
Isopropanolamine dodecylbenzene sulfate	0.3
Isopropyl acetate	0.5 - 400 (200)
Isopropyl alcohol	7.5 - 300 (400)
Isopropylamine	0.1 - 10 (10-20)
Isopropyl ether	0.02 - 300 (800)
Isopropyl glycidyl ether	300
Isopropyl Mercaptan	0.00025
Kerosene	0.082 -1
Ketene	(23)
Kuwait-Crude	0.1 - 0.5
Lactic acid	4×10^{-7}

Chemical	Warning Concentration[a]
Lauric acid	0.0034
Lauryl mercaptan	4 mg/m^3
Light Gasoline	800
Lindane	"practically odorless" 3.9 mg/m^3 - 21.3 mg/m^3
Linoleyl acetate	0.0016
Lithium hydride	(0.1 mg/m^3)
LPG	20000 (propane)
Magnesium dodecyl sulfate	0.2
Malathion	10 13.5 mg/m^3
Maleic anhydride	0.1 - 0.5 (0.25-1.83)
Menthol	1.5
2-Mercaptoethanol	0.12 - 0.65
Mercury, Inorganic (except Mercury pernitrate)	"odorless"
Mercury, vapor	"odorless"
Mesitylene (see Trimethylbenzene)	
Mesityl oxide	0.017 - 25
Methoxynaphthalene	0.00012
3-Methoxypropylamine	0.2 - 42
Methyl acetate	0.2 - 300 (10000)
Methyl acetylene- Propadiene Mixture	100
Methyl acrylate	0.0005 - 20 (75)
Methylacrylonitrile	2 - 14 (fatigue)
Methyl alcohol	10 - 20482 (7500 - 69000)
Methylamine	0.001 - 10 (fatigue) (20-100)
Methyl amyl acetate	0.002 - 1048 (1048)
Methyl amyl alcohol (Methyl isobutyl carbinol)	0.01 - 50 (24-50)
n-Methylaniline	1.6 - 2
Methyl anthranilate	0.00066 - 0.06
Methyl bromide	20.6 - 1030
2-Methyl-2-butanol (tert-Amyl alcohol)	0.23 - 2.3
Methyl n-butyl ketone	0.07 - 0.09
Methyl n-butyrate	0.0026
Methyl cellosolve	0.0925 - 92.5 (118)

Chemical	Warning Concentration[a]
Nethyl cellosolve acetate	0.64 - 50
Methyl chloride	10 - 250, "no odor" (500-1000)
Methyl chloroform	20 - 714 (500-1000)
Methyl 2-cyanoacrylate	1 - 3
Methylcyclohexane	500 - 630
Methyl dichloroarsine	0.11
Methyl biphenyl isocyanate (MDI) (Dichloromethane)	"can adapt to odor" 25 - 227 (5000)
Methyl ethanol amine	3,4
Methyl ethyl ketone (MEK)	0.25 - 85 (200)
Methylethyl pyridine	0.006 - 19
Methyl formate	204 - 3000, (fatigue (3563))
Methyl glycol (1,2-propylene glycol)	60 - 90
5-Methyl-3-heptanone (Ethyl amyl ketone)	6 (50)
Methyl hydrazine	1 - 3
Methyl iodide	(4300)
Methyl isoamyl alcohol	0.20
Methyl isoamyl ketone	0.01 - 0.28
Methyl isobutyl ketone	0.01 - 47 (100)
Methyl isocyanate	2.0 (2)
Methyl ispropyl ketone	0.1 - 4.8
Methyl mercaptan	0.0001 - 1.1
Methyl methacrylate	0.01 - 1 (170-250)
2-Methylpentaldehyde	0.09 - 0.136
2-Methyl-1-pentanol	0.024 - 0.082
2-Methylpropene (isobutylene)	0.57 - 20
Methyl salicylate	0.1 - 0.14
a-Methyl styrene	0.1 - 200 (200)
Methyl sulfide (see Dimethyl Sulfide)	
Methyl thiocyanate	0.25 - 3.2
Methyltrichlorosilane	1
Methyl vinyl ketone	0.2
Methylvinyl pyridine	0.040
Mineral spirits	30

Chemical	Warning Concentration[a]
Morpholine	0.01 - 0.14
Musk (Synthetic)	4.0×10^{-7}
Naphtha - coal tar	4.68 - 100 (200-300)
Naphtha - petroleum (rubber solvent)	<500
Naphthalene	0.001 - 0.8 (15)
2-Naphthol	1.3
Nickel carbonyl	1 - 3
Nitric acid	0.3 - 1.0 (62)
Nitric oxide	"odorless," 0.3 - 1, "poor"
p-Nitroaniline	"odorless"
Nitrobenzene	0.001 - 6
o-Nitrochlorobenzene	0.002
Nitroethane	2.1 - 200 (100-500)
Nitrogen dioxide	0.1 - 5.3 (5-20)
Nitrogen tetroxide	5
Nitrogen trifluoride	"no odor-warning properties at potentially dangerous levels"
Nitromethane	3.5 - 100 (200-500)
1-Nitropropane	11 - 300 (99-150)
2-Nitropropane	48 - 300
Nitrotoluene (m, o, p isomers)	
Nitrous oxide	"poor"
Nonane	0.1 - 47
n-Octane	0.5 - 235
Octanoic Acid	0.0014
1-Octanol	0.0021 - 0.31
2-Octanol	0.0026
Oenanthic acid (Heptanoic acid)	0.015
Oxygen difluoride	0.1 - 0.5, (fatigue)
Ozone	0.0005 - 0.5 (1-3.7)
Parathion	0.48 mg/m^3
Pelargonic acid (Nonyl Alcohol)	0.00086
Pentaborane	0.8 (1)

Chemical	Warning Concentration[a]
Pentachlorphenol	9.3 mg/m^3 (0.3 - 10.9 mg/m^3)
n-Pentane	2.2 - 1100
2,4-Pentanedione	0.01 - 0.024
2-Pentanone (Methyl propyl ketone)	3 - 14
Pentanol (see amyl alcohol)	
Pentene (n-Amylene)	2.2
n-Pentyl acetate (see n-Amyl acetate)	
1-Pentyl mercaptan	0.00021
Perchloroethylene (see Tetrachloroethylene)	
Perchloromethyl mercaptan	0.001
Perchloryl fluoride	10 (but not reliable)
Pro-Klean-No-818	0.005
Petroleum distillates (Petroleum naphtha)	<500
Phenol	0.005 - 5 (48)
Phenyl ether	0.001 - 0.10 (3-4)
Phenyl ether-biphenyl mixture	0.1 - 1 (3-4)
Phenyl isocyanide	0.029 mg/m^3
Phenyl isothiocyanate	0.43
Phosgene	0.125 - 6 (dulls senses) (1-2)
Phosphine	0.01 - 5 (7.7)
Phosphorous pentasulfide	"fatigue," 0.0047 (as H^2S)
Phosphorous trichloride	0.7 (2-4)
Phthalic anhydride	0.05 - 0.12 (30 mg/m^3)
2-Picoline	0.023 - 0.046
Propane	1000 - 20000
Propionaldehyde	0.04 -1
Propionic acid	0.001 - 20
n-Propyl acetate	0.05 - 200
Propyl alcohol	0.01 - 200 (5500)
Propylene	23 - 67.6
Propylene diamine	0.014 - 0.067
Propylene dichloride	0.25 - 130

Chemical	Warning Concentration[a]
Propylene glycol	"odorless"
Propylene glycol dinitrate	0.24
Propylene glycol monomethyl ether	10
Propylene oxide	10 - 210 (457-473, animals)
Propyl mercaptan	0.00075 - 0.02
n-Propyl nitrate	50 - 90
Propyl sulfide	0.011 - 0.17
Pyridine	0.001 - 5 (fatigue at 5, but taste remains)
Pyrolgallo (1,2,3-trihydroxybenzene)	20
Quinoline	0.16 - 71
Quinone	0.08 - 0.5, fatigue (0.1-0.5)
Resorchinol (1,3-dihydroxylbenzene)	40
Rotenone	"odorless," 222 mg/m^3
Safrole	0.0032
Selenium oxide	0.0002 mg/m^3
Silver Cyanide	"odorless"
Skatole (3-Methyl indole)	7.5×10^{-8} - 1.68
Sodium Butyldiphenol sulfonate	0.5 (as alky aryl sulfonate)
Sodium butylphenylphenol sulfonate	0.5 (as alky aryl sulfonate)
Sodium hydroxide	"odorless"
Sodium nitrochlorobenzene sulfonate	0.5 (as alky aryl sulfonate)
Sodium octyl sulfate	0.2
Sodium sulfate	"odorless"
Sorbitol	"odorless"
Stoddard solvent	1 - 30 (400)
Strychnine	"odorless"
Styrene	0.001 - 200 (200-400)
Styrene oxide	0.40
Sulfoxide	91
Sulfur dichloride ($SC1_1$)	0.001
Sulfur dioxide	0.2 - 5 (6-20), 0.3-taste
Sulfuric acid	0.6 - 2.4 mg/m^3
Sulfur monochloride (Sulfur chloride, S_2C1^2)	0.001 (2-9)

Chemical	Warning Concentration[a]
Sulfuryl fluoride	"odorless"
Tannic acid	2 - 4
TEPP (HETP, Bladex, Vaportone)	"odorless"
Terphenyls	>1
1,1,2,2-Tetrachloroethane	0.2 - 8
Tetrachlorethylene (Perchloroethylene)	2 - 50 (106-690)
Tetraethyl-o-silicate	5.0 - 7.2
Tetrahydrofuran	0.1 - 60
Tetramethylbenzene	0.0029
Tetranitromethane	(0.40)
Thiocresol (Toluenethiol)	0.0027 - 0.02
Thiophenol (Phenyl mercaptan)	0.001 - 85
Thymol	0.00086
Toluene	0.02 - 70, fatigue (300-400)
Toluene diisocyanate (TDI)	0.2 - 2.14
Toxaphene (Phenatox)	2.4 mg/m^3
1,2,4-Trichlorobenzene	1.4 - 3
1,1,2-Trichloroethane	0.5 - 167
o-Tolidine	0.0048 - 20
1,1,1-Trichloroethane (Methyl chloroform)	20 - 400 (500-1000)
Trichloroethylene	0.2 - 400 (160)
Trichlorofluoromethane	5 - 209
Trichlorophenol	0.1 - 0.667
1,2,3-Trichloropropane	100 (100)
1,1,2-trichloro-1,2,2-trifluoroethane	0.5 - 200
Triethanolamine dodecylbenzene sulfonate	0.3
Triethylamine	0.009 - 2.8 (50)
Triethylene glycol	"practically odorless"
Trimethylamine	0.0001 - 1.7
Trimethylbenzene (Mesitylene)	0.006 - 2.4
Trimethyl phosphite	0.001
Trinitrobutylxylene	6.5×10^{-6} - 0.0008
Triphenyl phosphate	"odorless"
Turpentine	50 - 200 (100-200)

Chemical	Warning Concentration[a]
n-Undecane	0.12
n-Valeraldehyde	0.001 - 8.2
Valeric acid	0.00060
ios Valeric acid	0.0018
Vanadium pentoxide - Dust/Fume	(0.5 - 2.2 mg/m^3)
Vanillin	3.2×10^{-8}
Vinyl acetate	0.1 - 1
Vinyl chloride	260 - 3000
Vinyl toluene	10 - 50 (50)
Warfarin	"odorless"
Xylene	0.05 - 200, fatigue (100-200)
m-Xylene	0.08 - 40
o-Xylene	0.08 - 40
p-Xylene	0.08 - 40
Xylidine	0.0048 - 0.06
Vinylidene chloride (1,1-Dichloroethylene)	190
V M & P Naphtha	10

[a] Fatigue - Indicates that the chemical can cause olfactory fatigue.

[b] Animal - Irritation concentration based on animal studies.

GLOSSARY, ACRONYMS, AND ABBREVIATIONS

Accident	An unexpected event generally resulting in injury, loss of property, or disruption of service.
Action Level	A quantitative limit of a chemical, biological, or radiological agent at which actions are taken to prevent or reduce exposure or contact.
Acute Exposure	A dose that is delivered to a receptor in a single event or in a short period of time.
Addition Interaction	The effect of an exposure to two or more chemicals, each having a certain toxic effect, that when combined, produces an effect which is the same as if the exposures occurred independently of one another.
Aging Resistance	The ability of a material to resist degrading over time while in storage.
Air Surveillance	Use of air monitoring/sampling devices during a response to identify/quantify airborne contaminants both on and offsite, and to monitor changes in air contaminants that occur over the incident's lifetime.
Alpha Particles (a)	Subatomic particles made up of two protons and two neutrons, which are emitted by atoms with excess energy. Alpha particles cannot penetrate the epidermis.
Animal Bioassay	Analysis of animal tissue exposed to chemical substances to determine the potential effects.
Antagonistic Interaction	The effect of an exposure to a combination of two toxic materials that produces an effect which is less than would be expected if the exposure to each material occurred independently of each other.
Beta Particles (ß)	Particles ejected from the nucleus of an atom that have a very small mass and either a negative (electron) or positive (positron) charge. Beta particles can travel up to

	10 meters in the air and can penetrate the dead skin layer on the body.
Breakthrough	When the challenge materials migrate through a filter.
Breakthrough Time	A measure of the elapsed time between the initial exposure of a material to a contaminant and when a specified amount (MDPR) of the contaminant is detected at the outlet level.
Carcinogen	A tumor or cancer causing agent.
Chemical Asphyxiation	When a chemical agent inhibits the body's ability to transport or take the oxygen into tissues. Even when there is sufficient oxygen to support life.
Ceiling Limit	An instantaneous value of concentration that *must not be exceeded* at any time.
Chemical Incompatibility	The combination of two or more reactive materials that results in uncontrollable and/or undesirable conditions.
Chemical Resistance	The ability of a material to impede chemical and physical change when exposed to a challenge chemical. Parameters include degradation, permeation rate, and permeation breakthrough time.
CHEMNET	A program established by CHEMTREC that provides chemical expertise at the scene of an emergency.
Chronic Exposure	Low doses repeatedly delivered to a receptor over a long period of time.
Cleanability	The relative ease of effectively decontaminating protective materials.
Cold Zone	See *Support Zone*.
Confined Space	A space which by design is large enough to enter and work, but has restricted entry or exit points, and is not meant for continuous occupancy.
Confinement	Control methods used to limit the physical area or size of a released material. Examples: dams, dikes, and absorption processes.

Containment	Control methods used keep the material in its container. Examples: plugging and patching.
Contaminant	An unwanted and nonbeneficial substance.
Contamination	Exposure to an unwanted and nonbeneficial substance.
Contamination Reduction Zone	The CRZ or “warm” zone acts as a buffer between the “hot” zone and the support or “cold” zone. It contains the decontamination line.
Control	Chemical or physical methods used to prevent or reduce the hazards associated with a material. Example: neutralizing an acid spill.
Corrosion	The electrochemical degradation of metals or alloys or the destruction of body tissues by exposure to concentrated acids or bases.
Decontamination	The process of physically removing contaminants from individuals and equipment, or changing their chemical nature to innocuous substances.
Degradation	A deleterious change in one or more physical properties of protective clothing material due to chemical contact.
Degree of Hazard	Relative measure of the harm a substance can do.
Direct-Reading Instruments	A portable device that rapidly measures and displays the concentration of a contaminant in the environment.
Dose	The amount of a substance administered or relative strength of a chemical agent.
Dose-Response Curve	A graphic representation of dose-response data in which the dose is displayed on the horizontal axis and the percentage of the experimental population effected on the vertical axis.
Dose-Response Indices	Non-graphical representations of points from a dose-response curve including lethality, toxicity, and effectiveness.
Dose-Response Relationship	A quantitative relationship between the dose of a chemical and an effect caused by the chemical.

Durability	The ability of a material to resist damage due to punctures, abrasions, and tears during normal conditions of wear.
Emergency Removal	Action(s) undertaken during a time-critical situation to prevent, minimize, or mitigate a release of material(s) that poses an immediate and/or significant threat(s) to human health or welfare, or to the environment (also see *Removal Action*).
Emergency Response	A response effort by employees from outside the immediate release or by designated responders to an occurrence which either will, or is likely to result in an uncontrolled release of hazardous substances.
Environmental Hazard	A condition capable of posing an unreasonable risk to air, water, or soil quality, and to plants or wildlife.
Epidemiologic Data	Information that describes a disease by comparing an exposed population with an unexposed population to show the incidence of a certain condition.
Exclusion Zone	The “hot” zone or area of contamination that is separated from the contamination reduction zone by the “hot” line.
Fire Tetrahedron	A model used to describe the components that make up a combustion reaction
Fire Triangle	An older model used to describe the necessary components to produce a fire.
First Responder	The first personnel to arrive on the scene of a hazardous materials incident to take defensive actions (often officials from local emergency services, firefighters, and police).
Fireman’s Toss	A method of positioning, and lifting a self-contained breathing apparatus (SCBA) over the head to put it on.
Flammable (explosive) Range	The concentration of an ignitable substance that falls between the upper and lower explosive limits.
Flashpoint	The temperature at which there are enough vapors present at the surface of a liquid to be ignited.

Frostbite	The freezing of body extremity tissue and skin due to exposure to very cold temperatures.
Gamma Ray (()	High frequency electromagnetic radiation that has neither mass nor charge, and can penetrate all parts of the body.
Groundwater	Water found in the saturated portions of geologic formations beneath the surface of land or water.
Hazard	A circumstance or condition that can do harm. Hazards are categorized into four groups: biological, chemical, radiation, and physical.
Hazard Classes	A series of nine descriptive terms, established by the UN Committee of Experts, to categorize the hazardous nature of chemical, physical, radiological, and biological materials. These categories are: 1. Explosives 2. Nonflammable and flammable gases 3. Flammable liquids 4. Flammable solids 5. Oxidizing materials 6. Poisons, irritants, and disease-causing materials 7. Radioactive materials 8. Corrosive materials 9. Miscellaneous dangerous goods.
Hazard Control	Methods utilized to eliminate hazards or reduce risks.
Hazard Evaluation	The impact or risk that a hazardous substance(s) poses to the public health and/or the environment.
Hazard Ratio	A numerical ratio of the actual concentration of the contaminant with respect to its exposure limit.
Hazard Recognition	Identification of the substances involved, the associated hazards, and the degree of hazard.
Hazardous	*"Capable of posing an unreasonable risk to health and safety"* (U.S. DOT). Capable of doing harm.

Hazardous Material

"*A substance or material which has been determined by the U.S. Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated*." (U.S. DOT)

Hazardous Atmosphere

A concentration of a flammable substance: within the flammable range for that substance; has an ignition source; and the potential for an exothermic reaction that can result in the ignition of an ignitable atmosphere.

Hazardous Substance

1. A material, its mixtures, or solutions that are listed in the Appendix to the Hazardous Materials Table, 49 CFR 172.101, when offered for transportation in one package; or in one transport vehicle, if not packaged; and when the quantity of the material therein equals or exceeds the reportable quantity.

2. Any substance designated pursuant to Section 311(b)(2):

   (A) Of the Federal Water Pollution Control Act;

   (B) Any element, compound, mixture solution, or substance designated pursuant to Section 102 of this Act;

   (C) Any hazardous waste having the characteristics identified under or listed pursuant to Section 3001 of the Solid Waste Disposal Act (but not including any waste suspended by Act of Congress) under the Solid Waste Disposal Act;

   (D) Any toxic pollutant listed under Section 307(a) of the Federal Water Pollution Control Act;

   (E) Any hazardous air pollutant listed under Section 112 of the Clean Air Act;

   (F) Any imminently hazardous chemical substance or mixture with respect to which the

Administrator has taken action pursuant to Section 7 of the Toxic Substances Control Act;

The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under subparagraphs (A) through (F) of this paragraph, and the term does not include natural gas, natural gas liquids, liquified natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas).

Hazardous Waste	Any material subject to the hazardous waste manifest requirements of the U.S. EPA specified in 40 CFR, Part 262, or would be subject to these requirements in the absence of an interim authorization to a state under 40 CFR, Part 123, Subpart F.
Heat Cramps	Severe cramping of the muscles due to an electrolyte imbalance caused by excessive perspiring.
Heat Exhaustion	Effects on the body when limits of the body's ability to dissipate heat have been reached.
Heat Rash	A mild red skin irritation caused by humid conditions and excessive perspiration.
Heat Stroke	Effects on the body when it cannot dissipate heat.
HIT	Hazardous Information Transmission: A program developed by CHEMTREC to provide registered organizations with documentation on specific products during an emergency.
Hot Zone	See *Exclusion Zone*.
Hypothermia	A lowering of the body's core temperature due to exposure to cold temperatures for extended periods of time.
IDLH Atmosphere	Immediately Dangerous to Life and Health: An atmosphere that poses an immediate threat to life; would cause irreversible adverse effects; or would impair an individual's ability to escape from a dangerous atmosphere.

Incident	The release or potential release of a hazardous substance or material into the environment.
Incident Characterization	The process of identifying the substance(s) involved in an incident; determining exposure pathways; and projecting the effects it will have on people, property, wildlife, vegetation, and the disruption of services.
Incident Command System	A system for organizing a response in a manner that is easily expandable to meet all incident requirements.
Incident Response Model	A systematic approach to handling hazardous situations.
Information	Knowledge acquired concerning the conditions or circumstances particular to an incident.
Intelligence	Information obtained from existing records or documentation, placards, labels, signs, special configuration of containers, visual observations, technical records, eye witnesses, and others.
Investigation	Onsite and offsite survey(s) conducted to provide a qualitative and quantitative assessment of the hazards associated with a site.
Jacket Method	A technique for positioning and donning a self-contained breathing apparatus like a jacket.
Limited Quantity	With the exception of Poison B materials, the maximum amount of a hazardous material for which there is a specific labeling and packaging exception.
Lower Explosive Limit	The minimum concentration of a substance needed to ignite and support combustion under normal atmospheric conditions.
Medical Surveillance	A program for verifying the workers' fitness to perform their assigned duties, as well as for documenting the effects of occupational exposures.
Microroentgen (µR)	A radiation subunit of the roentgen equal to one millionth of a roentgen (10^{-6} R).
Milliroentgen (mR)	A radiation subunit of the roentgen, rad or rem equal to one thousandth of a roentgen (10^{-3} R).

Mitigation	Actions taken to prevent or reduce the severity of threats to human health and the environment.
Monitoring	The process of sampling and measuring certain environmental parameters on a real-time basis for spatial and time variations. For example, air monitoring may be conducted with direct-reading instruments to indicate relative changes in air contaminant concentrations at various times.
Mutagen	A chemical, biological, or radiological agent that produces changes in genetic material, but does not kill the tissue. These genetic changes can passed on to future generations.
National Contingency Plan	Policies and procedures that the federal government follows when implementing responses to hazardous substance incidents.
Non-stochastic Effect	An effect whose severity is a function of dose, and is usually considered to have a threshold dose.
Normalized Breakthrough	The elapsed time required for the permeation rate to reach 0.1 $mg/cm^2/min$. A value that allows the comparison of different protective clothing materials.
Oxidizer	Any substance that has a strong affinity for the electrons of another substance which will support combustion.
Pathways of Dispersion	The environmental medium (water, groundwater, soil, or air) through which a chemical is transported.
Penetration	The flow of a chemical through closures, porous materials, seams, and pinholes or other imperfections on a non-molecular level in protective clothing material.
Permeation	The process by which a chemical moves through protective clothing material on a molecular level.
Permeation Rate	A measure of how much of a substance passes through suit material over a given period of time.
Permit-required Confined Space	Any confined space possessing an atmospheric or known physical hazard to a worker entering the space.

Persistent Chemicals	A substance that resists biodegradation and/or chemical transformation when released into the environment and accumulates in soils, air, water, or organic matter.
Photoionization	Ionization resulting from a collision between a molecule or atom and a photon.
Planned Removal	The removal from a site, within a non-immediate time (Non-Time-Critical) period, of released hazardous substances that pose a threat or potential threat to human health or welfare, or to the environment. Under CERCLA these are: *"Actions intended to minimize increases in exposure such that time and cost commitments are limited to 12 months and/or 2 million dollars."* (See also *Emergency Removal*).
Pollutant	A substance or mixture which, after being released into the environment will, or can be reasonably expected to cause adverse effects in any exposed organisms or their offspring.
Potentiation Interaction	The effect produced by the exposure to a combination of two materials, one being somewhat toxic and the other being relatively non-toxic, with a combined effect that is worse than the expected effects produced by each substance individually.
Preliminary Evaluation	A collection from interviews, records research, and perimeter reconnaissance for identifying site hazards and potential exposure pathways. this information is used to help determine the proper level of PPE and other safety measures incorporated in the Health and Safety Plan.
Quality Factor	A numerical value multiplied to the absorbed doses of radiation for determining dose equivalents.
RAD	Radiation Absorbed Dose: A measure of the amount of radiation energy absorbed into living tissue.
Radioactivity	The process by which unstable atoms emit radiation.
Radionuclide	A specific isotope of an element that is radioactive.

Radiation	Energy emitted as particles (a or ß-particles) or electro-magnetic waves ((-rays).
Regulated Material	A substance or material subject to the regulations set forth by the U.S. EPA, U.S. DOT, or any other federal agency.
Relative Vapor Density	A measure of gas or vapor density relative to air.
Release	Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of hazardous substances into the environment.
REM	Roentgen Equivalent to Man: A unit equivalent for any type of radiation that represents the equivalent damage caused by depositing one (1) RAD of gamma radiation.
Remedial Actions	According to the National Contingency Plan, these are: "*Responses to releases on a National Priority List that are consistent with treatment-oriented remedies that are protective of human health and the environment and that permanently and significantly reduce toxicity, mobility, or the volume of hazardous substances.*"
Removal Actions	Any appropriate actions(s) taken to abate, minimize, stabilize, mitigate, or eliminate the release or potential release of a substance(s) that poses a threat to human health or welfare, or to the environment. As set forth in the National Contingency Plan, "*These actions shall be terminated after $2 million has been obligated or 12 months have elapsed from the date of initial response.*"
Reportable Quantity	Reportable quantity, as set forth in the Clean Water Act, is: "*The minimum amount (pounds or kilograms) of a hazardous substance that may be discharged in a 24-hour period that requires notification of the appropriate government agency.*"
Response Actions	Actions taken to recognize, evaluate, and control an incident.
Risk	The degree of probability that loss or injury will occur.

Risk Assessment	The use of factual data to define the health effects of exposure of individuals or populations to hazardous materials and situations.
Risk Management	The process of weighing policy alternatives and selecting the most appropriate regulatory action(s) that integrates the results of the risk assessment with engineering data and social and economic concerns, to reach a decision.
Roentgen	The amount of gamma radiation that produces one electrostatic unit of charge per cubic centimeter of dry air.
Routes of Exposure	The manner in which a contaminant enters the body (examples: inhalation, ingestion, skin absorption, or injection).
Safety	Freedom from human, equipment, material, and environmental interactions that may result in injury or illness.
Sampling	The collection of a representative portion of the universe (example: collecting a water sample from a contaminated stream).
Sensitization	Exposure to an agent that makes the individual more susceptible to it during future exposures, or, when combined with other physical agents, takes less of a dose to elicit the same physiological response.
Service Life	Length of time required for an air-purifying element to reach 90% of its capacity before the breakthrough of a chemical occurs.
Severe	A relative term used to describe the degree to which hazardous material releases can cause adverse effects to human health and the environment.
Simple asphyxiation	Asphyxiation caused by an insufficient amount of oxygen to support life.
Site Safety Plan	Written, site-specific safety criteria that establish the requirements for protecting the health and safety of the responders during all activities conducted at an incident.

Solubility	A measure of the relative ease with which a substance dissolves into a given solvent at 68° F. Measurements are either g/100 ml of water or as a percent by weight.
Span of Control	A chain-of-command with no person taking directions from more than one person, and no person being responsible for more than five people.
Specific Gravity	A measure of a solid's or liquid's density relative to water (water = 1.0).
Steady State Permeation Rate	The point at which the permeation rate levels off during testing.
STEL	Short-Term Exposure Limits: Limits of exposure, usually 15-minute time-weighted averages (TWA), that should not be exceeded at any time during the work day. Chemicals which have a STEL could cause escape impairing irritation, narcotic effects, and chronic or irreversible damage.
Stochastic Effect	Effect whose probability of occurrence in an exposed population is a direct function of dose, usually having no threshold.
Support Zone	The "cold" zone. The zone at a site which is free of any contamination and contains the Command Post, equipment and supplies, field lab, administration, and support areas.
Synergistic Interaction	An effect produced by the exposure to a combination of two toxic materials, which is much worse than if the exposures occurred independently of one another.
Teratogen	A chemical, biological, or radiological agent that causes birth defects, usually in the first trimester of pregnancy, or if the male is exposed prior to conception.
Threshold Dose	That dose below which no observable effects occur in the average individual. Exposure limits set by the American Conference of Governmental Industrial Hygienists which are time-weighted averages over an 8-hour work day and 40-hour work week.

Time Weighted Average	The average concentration of a contaminant over a certain period of time.
Toxicity	The ability of a substance to produce an adverse effect(s) once it reaches a susceptible site in or on the body of a living organism.
Toxicology	The study of poisons: determining how they incapacitate or kill organisms, and defining their limits of safety.
Upper Explosive Limit	The maximum concentration of a substance that can be ignited and support combustion under normal atmospheric conditions.
Unified Command	A command structure that allows all agencies with responsibility for an incident (either geographically or functionally) to manage an incident by establishing a common set of objectives and strategies.
Vapor Pressure	A measure of the volatility of a substance in mm Hg.
Violent Polymerization	The process that causes many small molecules to join together to make macro-molecules producing both heat and a change in volume.
Warm Zone	See *Contamination Reduction Zone*.
Warning Properties	Those properties of a substance that provide detectable and persistent sensory inputs (odor, taste, irritation) to alert the individual of its presence.
Work Plan	Written directives that specifically describe all work activities that are to take place at a work site.

ACRONYMS AND ABBREVIATIONS

ACL	administrative control level
ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
APF	assigned protection factor
APR	air-purifying respirator
ARL	action reference level
ASR	atmosphere-supplying respirator
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BLEVE	boiling liquid expanding vapor explosion
BEI	biological exposure index
BOD	biological oxygen demand
BTU, btu	British thermal unit
C	ceiling
CAG	Carcinogen Assessment Group
CDC	Center for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGI	combustible gas indicator
CHEMTREC	Chemical Transportation Emergency Center
CHRIS	Chemical Hazard Response Information System
CMA	Chemical Manufacturers' Association
CPC	chemical protective clothing
CPE	chlorinated polyethylene
CPM, **cpm**	counts per minute

CRC	contamination reduction corridor
CRP	Community Relations Plan
CRZ	Contamination Reduction Zone
DDT	dichlorodiphenyltrichloroethane
DECON	decontamination
DFM	diesel fuel, marine
DHHS	U.S. Department of Health and Human Services
DOD	U.S. Department of Defense
DOI	U.S. Department of the Interior
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
DRI	direct-reading instruments
ED	Effective Dose
EL	Exposure Limit
EPA	U.S. Environmental Protection Agency
ERT	Environmental Response Team
ESCBA	Escape Self-contained Breathing Apparatus
ESLI	End of Service Life Indicator
eV	electron volt
FEMA	Federal Emergency Management Agency
FES	Fully Encapsulating Suit
FID	flame ionization detector
FM	Factory Mutual
GC	gas chromatograph or gas chromatography
GFCI	ground fault circuit interrupter
HASP	Health and Safety Plan
HazCom	federal hazard communications standard
HEPA	High Efficiency Particulate Air Filter
HMIS	Hazardous Materials Identification System

IAP	Incident Action Plan
IC	Incident Commander
ICS	Incident Command System
IDLH	Immediately Dangerous to Life or Health
IDW	investigation derived waste
IO	Information Officer
IP	ionization potential
IR	infrared radiation
IUPAC	International Union of Pure and Applied Chemists
LC_{50}	lethal concentration, 50%
LD_{50}	lethal dose, 50%
LC_{Lo}	lethal concentration lowest observed
LD_{Lo}	lethal dose lowest observed
LEL	lower explosive limit
LEPC	Local Emergency Planning Committee
LFL	lower flammable limit
LO	Liaison Officer
LOP	levels of protection
MACs	maximum allowable concentrations
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
MIRAN	trade name for the series of Foxboro Miniature Infrared Analyzers
MDPR	minimum detectable permeation rate
MOS	metal oxide semiconductor
mR/hr	milliroentgens per hour
MSD	mass spectroscopy detector
MSDS	material safety data sheets
MSHA	Mine Safety and Health Administration
MUC	maximum use concentration

NBR	nitrile-butadiene rubber (syn. Buna-N)
NCP	National Contingency Plan
NEC	National Electrical Code
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
n.o.s.	not otherwise specified
NPL	National Priorities List
NRC	National Response Center or Nuclear Regulatory Commission
NRR	noise reduction rating
NRT	National Response Team
OHMTADS	Oil and Hazardous Materials Technical Assistance Data System
ORM	other regulated material (specific classes such as ORM-A, ORM-E, etc.)
OSC	On-Scene Coordinator
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OVA	organic vapor analyzer
OVM	organic vapor meter
PCB	polychlorinated biphenyl
PEL	Permissible Exposure Limit
PF	protection factor
PID	photoionization detector
PLHCP	physician or licensed health-care professional
ppb	parts per billion
PPE	personal/personnel protective equipment
ppm	parts per million
ppt	parts per trillion
PVA	polyvinyl alcohol

PVC	polyvinyl chloride
QA/QC	Quality Assurance and Quality Control
RCRA	Resource Conservation and Recovery Act
REL	Recommended Exposure Limits
RI/FS	remedial investigation/feasibility study
RP	Responsible Party
RPF	required protection factor
RRP	Regional Response Plan
RRT	Regional Response Team
SAR	Supplied-air Respirator
SARA	Superfund Amendments and Reauthorization Act of 1986
SBR	styrene-butadiene rubber
SCBA	Self Contained Breathing Apparatus
SO	Safety Officer
SOPs	Standard Operating Procedures
SOSGs	Standard Operating Safety Guides
SpG	specific gravity
STEL	short-term exposure limit
TC_{Lo}	toxic concentration, lowest observed
TCDD	tetrachlorodibenzo-p-dioxin
TCE	trichloroethylene
TD_{Lo}	toxic dose, lowest observed
THR	toxic hazard rating
TLV	threshold limit value
TWA	time-weighted average
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
UEL	upper explosive limit
UFL	upper flammable limit

UL Underwriters Laboratories

UN United Nations

USCG U.S. Coast Guard

USGS U.S. Geological Survey

WEEL workplace environmental exposure levels