United States
Environmental Protection
Agency

Office of Emergency and
Remedial Response
Emergency Response Division

Environmental
Response
Team

EPA

Safety and Health Decision-Making for Managers

Environmental Response Training Program

SAFETY AND HEALTH DECISION-MAKING FOR MANAGERS (165.8)

3 DAYS

This course is for experienced personnel responsible for developing, implementing or managing safety programs for hazardous waste clean-up operations, treatment, storage and disposal facilities, or responding to chemical emergencies. This advanced course compliments EPA basic safety courses and provides a forum for information and idea exchanges among instructors and participants on hazardous waste operations and emergency response safety topics. Greater than fifty percent of class time involves problem solving and class discussion.

The objectives of this course are:

- To discuss the impact of 29 CFR 1910.120 and other related OSHA, EPA, NIOSH, NFPA, and ANSI standards on personnel at hazardous waste operations and emergency response.

- To detail the elements and development of a site-specific safety plan which includes personnel training, medical monitoring, personal protective equipment selection, air surveillance strategies, and emergency/contingency planning.

Upon completion of this course, participants will be able to organize essential information into a site-specific safety plan and better understand the decision-making associated with hazardous waste operations and emergency response safety programs.

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Emergency and Remedial Response
Environmental Response Team

FOREWORD

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

This manual has been developed with a goal of providing the best available current information. Individual instructors may provide additional material to cover special aspects of their presentations.

Due to the limited availability of the manual, it should not be cited in bibliographies or other publications.

References to products and manufacturers are for illustration only: they do not imply endorsement by the U.S. Environmental Protection Agency.

Constructive suggestions for the improvement in the coverage, content and format of the manual are welcome.

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SECTION 1

OCCUPATIONAL SAFETY AND HEALTH REGULATIONS AND STANDARDS

OCCUPATIONAL SAFETY AND HEALTH REGULATIONS AND STANDARDS

SECTION OBJECTIVE

The objective of this section is to provide students with a copy of the following occupational health and safety standards and guidance documents:

- U.S. Department of Labor/Occupational Safety and Health Administration Hazardous Waste Operations and Emergency Response Worker Protection Standard 29 CFR 1910.120 (1989)
- U.S. Environmental Protection Agency Health and Safety Requirements for Employees Engaged in Field Activities Order 1440.2 (1981)
- Other OSHA, Federal, and NFPA Regulations and Standards Related to Hazardous Waste Operations and Emergency Response Worker Protection
- NIOSH Criteria for Recommended Standard for Working in Confined Spaces (1979)
- U.S. Department of Labor/Occupational Safety and Health Administration Hazard Communication Standard 29 CFR 1910.1200 (1985)

STUDENT PERFORMANCE OBJECTIVES

After completing this section and related lesson(s), the student will be able to:

- Discuss each paragraph and appendixes of OSHA's 29 CFR 1910.120.
- Identify other OSHA, Federal, and NFPA regulations and standards related to occupational health and safety at hazardous waste operations and emergency response.

SECTION 1

OCCUPATIONAL SAFETY AND HEALTH REGULATIONS AND STANDARDS

PART 1

29 CFR 1910.120

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE

1910.120—HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE

(a) Scope, application, and definitions.

(1) **Scope.** This section covers the following operations, unless the employer can demonstrate that the operation does not involve employee exposure or the reasonable possibility for employee exposure to safety or health hazards:

(i) Clean-up operations required by a governmental body, whether Federal, state, local or other involving hazardous substances that are conducted at uncontrolled hazardous waste sites (including, but not limited to, the EPA's National Priority Site List (NPL), state priority site lists, sites recommended for the EPA NPL, and initial investigations of government identified sites which are conducted before the presence or absence of hazardous substances has been ascertained);

(ii) Corrective actions involving cleanup operations at sites covered by the Resource Conservation and Recovery Act of 1976 (RCRA) as amended (42 U.S.C. 6901 *et seq.*);

(iii) Voluntary clean-up operations at sites recognized by Federal, state, local or other governmental bodies as uncontrolled hazardous waste sites;

(iv) Operations involving hazardous wastes that are conducted at treatment, storage, and disposal (TSD) facilities regulated by 40 CFR Parts 264 and 265 pursuant to RCRA; or by agencies under agreement with U.S.E.P.A. to implement RCRA regulations; and

(v) Emergency response operations for releases of, or substantial threats of releases of, hazardous substances without regard to the location of the hazard.

(2) **Application.**

(i) 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).

(ii) Hazardous substance clean-up operations within the scope of paragraphs (a)(1)(i) through (a)(1)(iii) of this section must comply with all paragraphs of this section except paragraphs (p) and (q).

(iii) Operations within the scope of paragraph (a)(1)(iv) of this section must comply only with the requirements of paragraph (p) of this section.

Exceptions: For large quantity generators of hazardous waste who store those wastes less than 90 days and for small quantity generators of hazardous wastes, who have emergency response teams that respond to releases of, or substantial threats of releases of, hazardous substances, for their RCRA workplaces only paragraph (p)(8) of this section is applicable. Such generators of hazardous wastes who do not have emergency response teams that respond to releases of, or substantial threats of releases of, hazardous substances are exempt from the requirements of this section.

(iv) Emergency response operations for releases of, or substantial threats of releases of, hazardous substances which are not covered by paragraphs (a)(1)(i) through (a)(1)(iv) of this section must only comply with the requirements of paragraph (q) of this section.

(3) **Definitions.** "Buddy system" means a system of organizing employees into work groups in such a manner that each employee of the work group is designated to be observed by at least one other employee in the work group. The purpose of the buddy system is to provide rapid assistance to employees in the event of an emergency.

"Clean-up operation" means an operation where hazardous substances are removed, con-

tained, incinerated, neutralized, stabilized, cleared-up, or in any other manner processed or handled with the ultimate goal of making the site safer for people or the environment.

"Decontamination" means the removal of hazardous substances from employees and their equipment to the extent necessary to preclude the occurrence of foreseeable adverse health affects.

"Emergency response" or "responding to emergencies" means a response effort by employees from outside the immediate release area or by other designated responders (i.e., mutual-aid groups, local fire departments, etc.) to an occurrence which results or is likely to result, in an uncontrolled release of a hazardous substance. Responses to incidental releases of hazardous substances where the substance can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel are not considered to be emergency responses within the scope of this standard. Responses to releases of hazardous substances where there is no potential safety or health hazard (i.e., fire, explosion, or chemical exposure) are not considered to be emergency responses.

"Facility" means (A) any building, structure, installation, equipment, pipe or pipeline (including any pipe into a sewer or publicly owned treatment works), well, pit, pond, lagoon, impoundment, ditch, storage container, motor vehicle, rolling stock, or aircraft, or (B) any site or area where a hazardous substance has been deposited, stored, disposed of, or placed, or otherwise come to be located; but does not include any consumer product in consumer use or any water-borne vessel.

(3) "Hazardous materials response (HAZMAT) team" means an organized group of employees, designated by the employer, who are expected to perform work to handle and control actual or potential leaks or spills of hazardous substances requiring possible close approach to the substance. The team members perform responses to releases or potential releases of hazardous substances for the purpose of control or stabilization of the incident. A HAZMAT team is not a fire brigade nor is a typical fire brigade a HAZMAT team. A HAZMAT team, however, may be a separate component of a fire brigade or fire department.

"Hazardous substance" means any substance designated or listed under paragraphs (A) through (D) of this definition, exposure to which results or may result in adverse affects on the health or safety of employees:

(a) Any substance defined under section 101(14) of CERCLA;

(b) Any biological agent and other disease-causing agent as defined in section 101(33) of CERCLA;

(c) Any substance listed by the U.S. Department of Transportation as hazardous materials under 49 CFR 172.101 and appendices; and

(d) Hazardous waste as herein defined.

"Hazardous waste" means

(a) A waste or combination of wastes as defined in 40 CFR 261.3, or

(b) Those substances defined as hazardous wastes in 49 CFR 171.8.

"Hazardous waste operation" means any operation conducted within the scope of this standard.

"Hazardous waste site" or "Site" means any facility or location within the scope of this standard at which hazardous waste operations take place.

"Health hazard" means a chemical, mixture of chemicals or a pathogen for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. the term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, heptaotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic system, and agents which damage the lungs, skin, eyes, or mucous membranes. It also includes stress due to temperature extremes. Further definition of the terms used above can be found in Appendix A to 29 CFR 1910.1200.

"IDLH" or "Immediately dangerous to life or health" means an atmospheric concentration of any toxic, corrosive or asphyxiant substance that poses an immediate threat to life or would cause irrever-

sible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere.

"Oxygen deficiency" means that concentration of oxygen by volume below which atmosphere supplying respiratory protection must be provided. It exists in atmospheres where the percentage of oxygen by volume is less than 19.5 percent oxygen.

"Permissible exposure limit" means the exposure, inhalation or dermal permissible exposure limit specified in 29 CFR Part 1910, Subparts G and Z.

"Published exposure level" means the exposure limits published in "NIOSH Recommendations for Occupational Health Standards" dated 1986 incorporated by reference, or if none is specified, the exposure limits published in the standards specified by the American Conference of Governmental Industrial Hygienists in their publication "Threshold Limit Values and Biological Exposure Indices for 1987–88" dated 1987 incorporated by reference.

"Post emergency response" means that portion of an emergency response performed after the immediate threat of a release has been stabilized or eliminated and clean-up of the site has begun. If post emergency response is performed by an employer's own employees who were part of the initial emergency response, it is considered to be part of the initial response and not post emergency response. However, if a group of an employer's own employees, separate from the group providing initial response, performs the clean-up operation, then the separate group of employees would be considered to be performing post-emergency response and subject to paragraph (g)(11) of this section.

"Qualified person" means a person with specific training, knowledge and experience in the area for which the person has the responsibility and the authority to control.

"Site safety and health supervisor (or official)" means the individual located on a hazardous waste site who is responsible to the employer and has the authority and knowledge necessary to implement the site safety and health plan and verify compliance with applicable safety and health requirements.

"Small quantity generator" means a generator of hazardous wastes who in any calendar month generates no more than 1,000 kilograms (2,205 pounds) of hazardous waste in that month.

"Uncontrolled hazardous waste site" means an area where an accumulation of hazardous waste creates a threat to the health and safety of individuals or the environment or both. Some sites are found on public lands, such as those created by former municipal, county or state landfills where illegal or poorly managed waste disposal has taken place. Other sites are found on private property, often belonging to generators or former generators of hazardous waste. Examples of such sites include, but are not limited to, surface impoundments, landfills, dumps, and tank or drum farms. Normal operations at TSD sites are not covered by this definition.

(b) Safety and health program.

Note to (b): Safety and health programs developed and implemented to meet other Federal, state, or local regulations are considered acceptable in meeting this requirement if they cover or are modified to cover the topics required in this paragraph. An additional or separate safety and health program is not required by this paragraph.

(1) General.

(i) Employers shall develop and implement a written safety and health program for their employees involved in hazardous waste operations. The program shall be designed to identify, evaluate, and control safety and health hazards, and provide for emergency response for hazardous waste operations.

(ii) The written safety and health program shall incorporate the following:

(a) An organizational structure;

(b) A comprehensive workplan;

(c) A site-specific safety and health plan which need not repeat the employer's standard operating procedures required in paragraph (b)(1)(ii)(F) of this section;

(d) The safety and health training program;

(e) The medical surveillance program;

(f) The employer's standard operating procedures for safety and health; and

(g) Any necessary interface between general program and site specific activities.

(iii) Site excavation. Site excavations created during initial site preparation or during hazardous waste operations shall be shored or sloped as appropriate to prevent accidental collapse in accordance with Subpart P of 29 CFR Part 1926.

(iv) Contractors and sub-contractors. An employer who retains contractor or subcontractor services for work in hazardous waste operations shall inform those contractors, sub-contractors, or their representatives of the site emergency response procedures and any potential fire, explosion, health, safety or other hazards of the hazardous waste operation that have been identified by the employer, including those identified in the employer's information program.

(v) Program availability. The written safety and health program shall be made available to any contractor or subcontractor or their representative who will be involved with the hazardous waste operation; to employees; to employee designated representatives; to OSHA personnel, and to personnel of other Federal, state, or local agencies with regulatory authority over the site.

(2) Organizational structure part of the site program.

(i) The organizational structure part of the program shall establish the specific chain of command and specify the overall responsibilities of supervisors and employees. It shall include, at a minimum, the following elements:

(a) A general supervisor who has the responsibility and authority to direct all hazardous waste operations.

(b) A site safety and health supervisor who has the responsibility and authority to develop and implement the site safety and health plan and verify compliance

(c) All other personnel needed for hazardous waste site operations and emergency response and their general functions and responsibilities.

(d) The lines of authority, responsibility, and communication.

(ii) The organizational structure shall be reviewed and updated as necessary to reflect the current status of waste site operations.

(3) Comprehensive workplan part of the site program. The comprehensive workplan part of the program shall address the tasks and objectives of the site operations and the logistics and resources required to reach those tasks and objectives.

(i) The comprehensive workplan shall address anticipated clean-up activities as well as normal operating procedures which need not repeat the employer's procedures available elsewhere.

(ii) The comprehensive workplan shall define work tasks and objectives and identify the methods for accomplishing those tasks and objectives.

(iii) The comprehensive workplan shall establish personnel requirements for implementing the plan.

(iv) The comprehensive workplan shall provide for the implementation of the training required in paragraph (e) of this section.

(v) The comprehensive workplan shall provide for the implementation of the required informational programs required in paragraph (i) of this section.

(vi) The comprehensive workplan shall provide for the implementation of the medical surveillance program described in paragraph (f) of this section.

(4) Site-specific safety and health plan part of the program.

(i) **General.** The site safety and health plan, which must be kept on site, shall address the safety and health hazards of each phase of site operation and include the requirements and procedures for employee protection

(ii) Elements. The site safety and health plan, as a minimum, shall address the following:

(a) A safety and health risk or hazard analysis for each site task and operation found in the workplan.

(b) Employee training assignments to assure compliance with paragraph (e) of this section.

(c) Personal protective equipment to be used by employees for each of the site tasks and operations being conducted as required by the personal protective equipment program in paragraph (g)(5) of this section.

(d) Medical surveillance requirements in accordance with the program in paragraph (f) of this section.

(e) Frequency and types of air monitoring, personnel monitoring, and environmental sampling techniques and instrumentation to be used, including methods of maintenance and calibration of monitoring and sampling equipment to be used.

(f) Site control measures in accordance with the site control program required in paragraph (d) of this section.

(g) Decontamination procedures in accordance with paragraph (k) of this section.

(h) An emergency response plan meeting the requirements of paragraph (l) of this section for safe and effective responses to emergencies, including the necessary PPE and other equipment.

(i) Confined space entry procedures.

(j) A spill containment program meeting the requirements of paragraph (j) of this section.

(iii) Pre-entry briefing. The site specific safety and health plan shall provide for pre-entry briefings to be held prior to initiating any site activity, and at such other times as necessary to ensure that employees are apprised of the site safety and health plan and that this plan is being followed. The information and data obtained from site characterization and analysis work required in paragraph (c) of this section shall be used to prepare and update the site safety and health plan.

(iv) Effectiveness of site safety and health plan. Inspections shall be conducted by the site safety and health supervisor or, in the absence of that individual, another individual who is knowledgeable in occupational safety and health, acting on behalf of the employer as necessary to determine the effectiveness of the site safety and health plan. Any deficiencies in the effectiveness of the site safety and health plan shall be corrected by the employer.

(c) Site characterization and analysis.

(1) General. Hazardous waste sites shall be evaluated in accordance with this paragraph to identify specific site hazards and to determine the appropriate safety and health control procedures needed to protect employees from the identified hazards.

(2) Preliminary evaluation. A preliminary evaluation of a site's characteristics shall be performed prior to site entry by a qualified person in order to aid in the selection of appropriate employee protection methods prior to site entry. Immediately after initial site entry, a more detailed evaluation of the site's specific characteristics shall be performed by a qualified person in order to further identify existing site hazards and to further aid in the selection of the appropriate engineering controls and personal protective equipment for the tasks to be performed.

(3) Hazard identification. All suspected conditions that may pose inhalation or skin absorption hazards that are immediately dangerous to life or health (IDLH), or other conditions that may cause death or serious harm, shall be identified during the preliminary survey and evaluated during the detailed survey. Examples of such hazards include, but are not limited to, confined space entry, potentially explosive or flammable situations, visible vapor clouds, or areas where biological indicators such as dead animals or vegetation are located.

(4) Required information. The following information to the extent available shall be obtained by the employer prior to allowing employees to enter a site:

(i) Location and approximate size of the site.

(ii) Description of the response activity and/or the job task to be performed.

(iii) Duration of the planned employee activity.

(iv) Site topography and accessibility by air and roads.

(v) Safety and health hazards expected at the site.

(vi) Pathways for hazardous substance dispersion.

(vii) Present status and capabilities of emergency response teams that would provide assistance to hazardous waste clean-up site employees at the time of an emergency.

(viii) Hazardous substances and health hazards involved or expected at the site, and their chemical and physical properties.

(5) Personal protective equipment. Personal protective equipment (PPE) shall be provided and used during initial site entry in accordance with the following requirements:

(i) Based upon the results of the preliminary site evaluation, an ensemble of PPE shall be selected and used during initial site entry which will provide protection to a level of exposure below permissible exposure limits and published exposure levels for known or suspected hazardous substances and health hazards, and which will provide protection against other known and suspected hazards identified during the preliminary site evaluation. If there is no permissible exposure limit or published exposure level, the employer may use other published studies and information as a guide to appropriate personal protective equipment.

(ii) If positive-pressure self-contained breathing apparatus is not used as part of the entry ensemble, and if respiratory protection is warranted by the potential hazards identified during the preliminary site evaluation, an escape self-contained breathing apparatus of at least five minute's duration shall be carried by employees during initial site entry.

(iii) If the preliminary site evaluation does not produce sufficient information to identify the hazards or suspected hazards of the site, an ensemble providing protection equivalent to Level B PPE shall be provided as minimum protection, and direct reading instruments shall be used as appropriate for identifying IDLH conditions. (See Appendix B for a description of Level B hazards and the recommendations for Level B protective equipment.)

(iv) Once the hazards of the site have been identified, the appropriate PPE shall be selected and used in accordance with paragraph (g) of this section.

(6) Monitoring. The following monitoring shall be conducted during initial site entry when the site evaluation produces information that shows the potential for ionizing radiation or IDLH conditions, or when the site information is not sufficient reasonably to eliminate these possible conditions:

(i) Monitoring with direct reading instruments for hazardous levels of ionizing radiation.

(ii) Monitoring the air with appropriate direct reading test equipment (i.e., combustible gas meters, detector tubes) for IDLH and other conditions that may cause death or serious harm (combustible or explosive atmospheres, oxygen deficiency, toxic substances).

(iii) Visually observing for signs of actual or potential IDLH or other dangerous conditions.

(iv) An ongoing air monitoring program in accordance with paragraph (h) of this section shall be implemented after site characterization has determined the site is safe for the startup of operations.

(7) Risk identification. Once the presence and concentrations of specific hazardous substances and health hazards have been established, the risks associated with these substances shall be identified. Employees who will be working on the site shall be informed of any risks that have been identified. In situations covered by the Hazard Communication Standard, 29 CFR 1910.1200, training required by that standard need not be duplicated.

Note to (c)(7).—Risks to consider include, but are not limited to:

(a) Exposures exceeding the permissible exposure limits and published exposure levels.

(b) IDLH concentrations.

(c) Potential skin absorption and irritation sources.

(d) Potential eye irritation sources.

(e) Explosion sensitivity and flammability ranges.

(f) Oxygen deficiency.

(8) Employee notification. Any information concerning the chemical, physical, and toxicologic properties of each substance known or expected to be present on site that is available to the employer and relevant to the duties an employee is expected to perform shall be made available to the affected employees prior to the commencement of their work activities. The employer may utilize information developed for the hazard communication standard for this purpose.

(d) Site control.

(1) General. Appropriate site control procedures shall be implemented to control employee exposure to hazardous substances before clean-up work begins.

(2) Site control program. A site control program for protecting employees which is part of the employer's site safety and health program required in paragraph (b) of this section shall be developed during the planning stages of a hazardous waste clean-up operation and modified as necessary as new information becomes available.

(3) Elements of the site control program. The site control program shall, as a minimum, include: A site map; site work zones; the use of a "buddy system"; site communications including alerting means for emergencies; the standard operating procedures or safe work practices; and, identification of the nearest medical assistance. Where these requirements are covered elsewhere they need not be repeated.

(e) Training.

(1) General.

(i) All employees working on site (such as but not limited to equipment operators, general laborers and others) exposed to hazardous substances, health hazards, or safety hazards and their supervisors and management responsible for the site shall receive training meeting the requirements of this paragraph before they are permitted to engage in hazardous waste operations that could expose them to hazardous substances, safety, or health hazards, and they shall receive review training as specified in this paragraph.

(ii) Employees shall not be permitted to participate in or supervise field activities until they have been trained to a level required by their job function and responsibility.

(2) Elements to be covered. The training shall thoroughly cover the following:

(i) Names of personnel and alternates responsible for site safety and health;

(ii) Safety, health and other hazards present on the site;

(iii) Use of personal protective equipment;

(iv) Work practices by which the employee can minimize risks from hazards;

(v) Safe use of engineering controls and equipment on the site;

(vi) Medical surveillance requirements, including recognition of symptoms and signs which might indicate overexposure to hazards; and

(vii) The contents of paragraphs (g) through (j) of the site safety and health plan set forth in paragraph (b)(4)(ii) of this section.

(3) Initial training.

(i) General site workers (such as equipment operators, general laborers and supervisory personnel) engaged in hazardous substance removal or other activities which expose or potentially expose workers to hazardous substances and health hazards shall receive a minimum of 40 hours of instruction off the site, and a minimum of three days actual field experience under the direct supervision of a trained, experienced supervisor.

(ii) Workers on site only occasionally for a specific limited task (such as, but not limited to, ground water monitoring, land surveying, or geo-physical surveying) and who are unlikely to be exposed over permissible exposure limits and published exposure limits shall receive a minimum of 24 hours of instruction off the site, and the minimum of one day actual field experience under the direct supervision of a trained, experienced supervisor.

(iii) Workers regularly on site who work in areas which have been monitored and fully characterized indicating that exposures are under permissible exposure limits and published exposure limits where respirators are not necessary, and the characterization indicates that there are no health hazards or the possibility of an emergency developing, shall receive a minimum of 24 hours of instruction off the site and the minimum of one day actual field experience under the direct supervision of a trained, experienced supervisor.

(iv) Workers with 24 hours of training who are covered by paragraphs (a)(3)(ii)and (a)(3)(iii) of this section, and who become general site workers or who are required to wear respirators, shall have the additional 16 hours and two days of training necessary to total the training specified in paragraph (e)(3)(i).

(4) Management and supervisor training. On-site management 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) and 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.

(5) Qualifications for trainers. Trainers shall be qualified to instruct employees about the subject matter that is being presented in training. Such trainers shall have satisfactorily completed a training program for teaching the subjects they are expected to teach, or they shall have the academic credentials and instructional experience necessary for teaching the subjects. Instructors shall demonstrate competent instructional skills and knowledge of the applicable subject matter.

(6) 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 successfully completed the necessary training. A written certificate shall be given to each person so certified. Any person who has not been so certified or who does not meet the requirements of paragraph (e)(9) of this section shall be prohibited from engaging in hazardous waste operations.

(7) Emergency response. Employees who are engaged in responding to hazardous emergency situations at hazardous waste clean-up sites that may expose them to hazardous substances shall be trained in how to respond to such expected emergencies.

(8) 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, any critique of incidents that have occurred in the past year that can serve as training examples of related work, and other relevant topics.

(9) Equivalent training. Employers who can show by documentation or certification that an employee's work experience and/or training has resulted in training equivalent to that training required in paragraphs (e)(1) through (e)(4) of this section shall not be required to provide the initial training requirements of those paragraphs to such employees. However, certified employees new to a site shall receive appropriate, site specific training before site entry and have appropriate supervised field experience at the new site. Equivalent training includes any

academic training or the training that existing employees might have already received from actual hazardous waste site work experience.

(f) Medical surveillance.

(1) General. Employers engaged in operations specified in paragraphs (a)(1)(i) through (a)(1)(iv) of this section and not covered by (a)(2)(iii) exceptions and employers of employees specified in paragraph (g)(9) shall institute a medical surveillance program in accordance with this paragraph.

(2) Employees covered. The medical surveillance program shall be instituted by the employer for the following employees:

(i) All employees who are or may be exposed to hazardous substances or health hazards at or above the permissible exposure limits or, if there is no permissible exposure limit, above the published exposure levels for these substances, without regard to the use of respirators, for 30 days or more a year;

(ii) All employees who wear a respirator for 30 days or more a year or as required by § 1910.134;

(iii) All employees who are injured due to overexposure from an emergency incident involving hazardous substances or health hazards; or

(iv) Members of HAZMAT teams.

(3) Frequency of medical examinations and consultations.

Medical examinations and consultations shall be made available by the employer to each employee covered under paragraph (f)(2) of this section on the following schedules:

(i) For employees covered under paragraphs (f)(2)(i), (f)(2)(ii), and (f)(2)(iv):

(a) Prior to assignment;

(b) At least once every twelve months for each employee covered unless the attending physician believes a longer interval (not greater than biennially) is appropriate;

(c) At termination of employment or reassignment to an area where the employee would not be covered if the employee has not had an examination within the last six months;

(d) As soon as possible upon notification by an employee that the employee has developed signs or symptoms indicating possible overexposure to hazardous substances or health hazards, or that the employee has been injured or exposed above the permissible exposure limits or published exposure levels in an emergency situation;

(e) At more frequent times, if the examining physician determines that an increased frequency of examination is medically necessary.

(ii) For employees covered under paragraph (f)(2)(iii) and for all employees including those of employers covered by paragraph (a)(1)(v) who may have been injured, received a health impairment, developed signs or symptoms which may have resulted from exposure to hazardous substances resulting from an emergency incident, or exposed during an emergency incident to hazardous substances at concentrations above the permissible exposure limits or the published exposure levels without the necessary personal protective equipment being used:

(a) As soon as possible following the emergency incident or development of signs or symptoms;

(b) At additional times, if the examining physician determines that follow-up examinations or consultations are medically necessary.

(4) Content of medical examinations and consultations.

(i) Medical examinations required by paragraph (f)(3) of this section shall include a medical and work history (or updated history if one is in the employee's file) with special emphasis on symptoms related to the handling of hazardous substances and health hazards, and to fitness for duty including the ability to wear any required PPE under conditions (i.e., temperature extremes) that may be expected at the work site.

(ii) The content of medical examinations or consultations made available to employees pursuant to paragraph (f) shall be determined by the attending physician. The guidelines in the *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities* (See Appendix D, Reference #10) should be consulted.

(5) Examination by a physician and costs. All medical examinations and procedures shall be performed by or under the supervision of a licensed physician, preferably one knowledgeable in occupational medicine, and shall be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

(6) Information provided to the physician. The employer shall provide one copy of this standard and its appendices to the attending physician, and in addition the following for each employee:

(i) A description of the employee's duties as they relate to the employee's exposures.

(ii) The employee's exposure levels or anticipated exposure levels.

(iii) A description of any personal protective equipment used or to be used.

(iv) Information from previous medical examinations of the employee which is not readily available to the examining physician.

(v) Information required by §1910.134.

(7) Physician's written opinion.

(i) The employer shall obtain and furnish the employee with a copy of a written opinion from the attending physician containing the following:

(a) The physician's opinion as to whether the employee has any detected medical conditions which would place the employee at increased risk of material impairment of the employee's health from work in hazardous waste operations or emergency response, or from respirator use.

(b) The physician's recommended limitations upon the employee's assigned work.

(c) The results of the medical examination and tests if requested by the employee.

(d) A statement that the employee has been informed by the physician of the results of the medical examination and any medical conditions which require further examination or treatment.

(ii) The written opinion obtained by the employer shall not reveal specific findings or diagnoses unrelated to occupational exposures.

(8) Recordkeeping.

(i) An accurate record of the medical surveillance required by paragraph (f) of this section shall be retained. This record shall be retained for the period specified and meet the criteria of 29 CFR 1910.20.

(ii) The record required in paragraph (f)(8)(i) of this section shall include at least the following information:

(a) The name and social security number of the employee;

(b) Physician's written opinions, recommended limitations, and results of examinations and tests;

(c) Any employee medical complaints related to exposure to hazardous substances;

(d) A copy of the information provided to the examining physician by the employer, with the exception of the standard and its appendices.

(g) Engineering controls, work practices, and personal protective equipment for employee protection.

Engineering controls, work practices, personal protective equipment, or a combination of these shall be implemented in accordance with this paragraph to protect employees from exposure to hazardous substances and safety and health hazards.

(1) Engineering controls, work practices and PPE for substances regulated in Subparts G and Z.

(i) Engineering controls and work practices shall be instituted to reduce and maintain employee exposure to or below the permissible exposure limits for substances regulated by 29 CFR Part 1910, to the extent required by Subpart Z, except to the extent that such controls and practices are not feasible.

Note to (g)(1)(i): Engineering controls which may be feasible include the use of pressurized cabs or control booths on equipment, and/or the use of remotely operated material handling equipment. Work practices which may be feasible are removing all non-essential employees from potential exposure during opening of drums, wetting down dusty operations and locating employees upwind of possible hazards.

(ii) Whenever engineering controls and work practices are not feasible, PPE shall be used to reduced and maintain employee exposures to or below the permissible exposure limits or dose limits for substances regulated by 29 CFR Part 1910, Subpart Z.

(iii) The employer shall not implement a schedule of employee rotation as a means of compliance with permissible exposure limits or dose limits except when there is no other feasible way of complying with the airborne or dermal dose limits for ionizing radiation.

(iv) The provisions of 29 CFR, Subpart G, shall be followed.

(2) 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. The employer may use the published literature and MSDS as a guide in making the employer's determination as to what level of protection the employer believes is appropriate for hazardous substances and health hazards for which there is no permissible exposure limit or published exposure limit.

(3) Personal protective equipment selection.

(i) Personal protective equipment (PPE) shall be selected and used which will protect employees from the hazards and potential hazards they are likely to encounter as identified during the site characterization and analysis.

(ii) Personal protective equipment selection shall be based on an evaluation of the performance characteristics of the PPE relative to the requirements and limitations of the site, the task-specific conditions and duration, and the hazards and potential hazards identified at the site.

(iii) Positive pressure self-contained breathing apparatus, or positive pressure air-line respirators equipped with an escape air supply, shall be used when chemical exposure levels present will create a substantial possibility of immediate death, immediate serious illness or injury, or impair the ability to escape.

(iv) Totally-encapsulating chemical protective suits (protection equivalent to Level A protection as recommended in Appendix B) shall be used in conditions where skin absorption of a hazardous substance may result in a substantial possibility of immediate death, immediate serious illness or injury, or impair the ability to escape.

(v) The level of protection provided by PPE selection shall be increased when additional information on site conditions indicates that increased protection is necessary to reduce employee exposures below permissible exposure limits and published exposure levels for hazardous substances and health hazards. (See Appendix B for guidance on selecting PPE ensembles.)

Note to (g)(3): The level of employee protection provided may be decreased when additional information or site conditions show that decreased protection will not result in hazardous exposures to employees.

(vi) Personal protective equipment shall be selected and used to meet the requirements of 29 CFR Part 1910, Subpart I, and additional requirements specified in this section.

(4) Totally-encapsulating chemical protective suits.

(i) Totally-encapsulating suits shall protect employees from the particular hazards which are identified during site characterization and analysis.

(ii) Totally-encapsulating suits shall be capable of maintaining positive air pressure. (See Appendix A for a test method which may be used to evaluate this requirement.)

(iii) Totally-encapsulating suits shall be capable of preventing inward test gas leakage of more than 0.5 percent. (See Appendix A for a test method which may be used to evaluate this requirement.)

(5) Personal protective equipment (PPE) program. A written personal protective equipment program, which is part of the employer's safety and health program required in paragraph (b) of this section or required in paragraph (p)(1) of this section and which is also a part of the site-specific safety and health plan shall be established. The PPE program shall address the elements listed below. When elements, such as donning and doffing procedures, are provided by the manufacturer of a piece of equipment and are attached to the plan, they need not be rewritten into the plan as long as they adequately address the procedure or element.

(i) PPE selection based upon site hazards,

(ii) PPE use and limitations of the equipment,

(iii) Work mission duration,

(iv) PPE maintenance and storage,

(v) PPE decontamination and disposal,

(vi) PPE training and proper fitting,

(vii) PPE donning and doffing procedures,

(viii) PPE inspection procedures prior to, during, and after use,

(ix) Evaluation of the effectiveness of the PPE program, and

(x) Limitations during temperature extremes, heat stress, and other appropriate medical considerations.

(h) Monitoring.

(1) General.

(i) 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 so that employees are not exposed to levels which exceed permissible exposure limits or published exposure levels for hazardous substances.

(ii) 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.

(2) Initial entry. Upon initial entry, representative air monitoring shall be conducted to identify any 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 or oxygen-deficient environments.

(3) 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:

(i) When work begins on a different portion of the site.

(ii) When contaminants other than those previously identified are being handled.

(iii) When a different type of operation is initiated (e.g., drum opening as opposed to exploratory well drilling).

(iv) When employees are handling leaking drums or containers or working in areas with obvious liquid contamination (e.g., a spill or lagoon).

(4) Monitoring of high-risk employees. After the actual clean-up phase of any hazardous waste

operation commences; for example, when soil, surface water or containers are moved or disturbed; the employer shall monitor those employees likely to have the highest exposure to hazardous substances and health hazards likely to be present above permissible exposure limits or published exposure levels by using personal sampling frequently enough to characterize employee exposures. If the employees likely to have the highest exposure are over permissible exposure limits or published exposure limits, then monitoring shall continue to determine all employees likely to be above those limits. The employer may utilize a representative sampling approach by documenting that the employees and chemicals chosen for monitoring are based on the criteria stated above.

Note to (h): It is not required to monitor employees engaged in site characterization operations covered by paragraph (c) of this section.

(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. Employees, contractors and subcontractors working outside of the operations part of a site are not covered by this standard.

(j) Handling drums and containers.

(1) General.

(i) Hazardous substances and contaminated soils, liquids, and other residues shall be handled, transported, labeled, and disposed of in accordance with this paragraph.

(ii) Drums and containers used during the clean-up shall meet the appropriate DOT, OSHA, and EPA regulations for the wastes that they contain.

(iii) When practical, drums and containers shall be inspected and their integrity shall be assured prior to being moved. Drums or containers that cannot be inspected before being moved because of storage conditions (i.e., buried beneath the earth, stacked behind other drums, stacked several tiers high in a pile, etc.) shall be moved to an accessible location and inspected prior to further handling.

(iv) Unlabeled drums and containers shall be considered to contain hazardous substances and handled accordingly until the contents are positively identified and labeled.

(v) Site operations shall be organized to minimize the amount of drum or container movement.

(vi) 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.

(vii) U.S. Department of Transportation specified salvage drums or containers and suitable quantities of proper absorbent shall be kept available and used in areas where spills, leaks, or ruptures may occur.

(viii) Where major spills may occur, a spill containment program, which is part of the employer's safety and health program required in paragraph (b) of this section, shall be implemented to contain and isolate the entire volume of the hazardous substance being transferred.

(ix) Drums and containers that cannot be moved without rupture, leakage, or spillage shall be emptied into a sound container using a device classified for the material being transferred.

(x) A ground-penetrating system or other type of detection system or device shall be used to estimate the location and depth of buried drums or containers.

(xi) Soil or covering material shall be removed with caution to prevent drum or container rupture.

(xii) Fire extinguishing equipment meeting the requirements of 29 CFR Part 1910, Subpart L, shall be on hand and ready for use to control incipient fires.

(2) Opening drums and containers. The following procedures shall be followed in areas where drums or containers are being opened:

(i) Where an airline respirator system is used, connections to the source of air supply shall be protected from contamination and the entire system shall be protected from physical damage.

(ii) Employees not actually involved in opening drums or containers shall be kept a safe distance from the drums or containers being opened.

(iii) If employees must work near or adjacent to drums or containers being opened, a suitable shield that does not interfere with the work operation shall be placed between the employee and the drums or containers being opened to protect the employee in case of accidental explosion.

(iv) Controls for drum or container opening equipment, monitoring equipment, and fire suppression equipment shall be located behind the explosion-resistant barrier.

(v) When there is a reasonable possibility of flammable atmospheres being present, material handling equipment and hand tools shall be of the type to prevent sources of ignition.

(vi) Drums and containers shall be opened in such a manner that excess interior pressure will be safety relieved. If pressure can not be relieved from a remote location, appropriate shielding shall be placed between the employee and the drums or containers to reduce the risk of employee injury.

(vii) Employees shall not stand upon or work from drums or containers.

(3) **Material handling equipment.** Material handling equipment used to transfer drums and containers shall be selected, positioned and operated to minimize sources of ignition related to the equipment from igniting vapors released from ruptured drums or containers.

(4) **Radioactive wastes.** Drums and containers containing radioactive wastes shall not be handled until such time as their hazard to employees is properly assessed.

(5) **Shock sensitive wastes.** As a minimum, the following special precautions shall be taken when drums and containers containing or suspected of containing shock-sensitive wastes are handled:

(i) All non-essential employees shall be evacuated from the area of transfer.

(ii) Material handling equipment shall be provided with explosive containment devices or protective shields to protect equipment operators from exploding containers.

(iii) An employee alarm system capable of being perceived above surrounding light and noise conditions shall be used to signal the commencement and completion of explosive waste handling activities.

(iv) Continuous communications (i.e., portable radios, hand signals, telephones, as appropriate) shall be maintained between the employee-in-charge of the immediate handling area and both the site safety and health supervisor and the command post until such time as the handling operation is completed. Communication equipment or methods that could cause shock sensitive materials to explode shall not be used.

(v) Drums and containers under pressure, as evidenced by bulging or swelling, shall not be moved until such time as the cause for excess pressure is determined and appropriate containment procedures have been implemented to protect employees from explosive relief of the drum.

(vi) Drums and containers containing packaged laboratory wastes shall be considered to contain shock-sensitive or explosive materials until they have been characterized.

Caution: Shipping of shock sensitive wastes may be prohibited under U.S. Department of Transportation regulations. Employers and their shippers should refer to 49 CFR 173.21 and 173.50.

(6) **Laboratory waste packs.** In addition to the requirements of paragraph (j)(5) of this section, the following precautions shall be taken, as a minimum, in handling laboratory waste packs (lab packs):

(i) Lab packs shall be opened only when necessary and then only by an individual knowledgeable in the inspection, classification, and segregation of the containers within the pack according to the hazards of the wastes.

(ii) If crystalline material is noted on any con-

tainer, the contents shall be handled as a shock-sensitive waste until the contents are identified.

(7) Sampling of drum and container contents. Sampling of containers and drums shall be done in accordance with a sampling procedure which is part of the site safety and health plan developed for and available to employees and others at the specific worksite.

(8) Shipping and transport.

(i) Drums and containers shall be identified and classified prior to packaging for shipment.

(ii) Drum or container staging areas shall be kept to the minimum number necessary to identify and classify materials safely and prepare them for transport.

(iii) Staging areas shall be provided with adequate access and egress routes.

(iv) Bulking of hazardous wastes shall be permitted only after a thorough characterization of the materials has been completed.

(9) Tank and vault procedures.

(i) Tanks and vaults containing hazardous substances shall be handled in a manner similar to that for drums and containers, taking into consideration the size of the tank or vault.

(ii) Appropriate tank or vault entry procedures as described in the employer's safety and health plan shall be followed whenever employees must enter a tank or vault.

(k) Decontamination.

(1) General. Procedures for all phases of decontamination shall be developed and implemented in accordance with this paragraph.

(2) Decontamination procedures.

(i) A decontamination procedure shall be developed, communicated to employees and implemented before any employees or equipment may enter areas on site where potential for exposure to hazardous substances exists.

(ii) Standard operating procedures shall be developed to minimize employee contact with hazardous substances or with equipment that has contacted hazardous substances.

(iii) All employees leaving a contaminated area shall be appropriately decontaminated; all contaminated clothing and equipment leaving a contaminated area shall be appropriately disposed of or decontaminated.

(iv) Decontamination procedures shall be monitored by the site safety and health supervisor to determine their effectiveness. When such procedures are found to be ineffective, appropriate steps shall be taken to correct any deficiencies.

(3) Location. Decontamination shall be performed in geographical areas that will minimize the exposure of uncontaminated employees or equipment to contaminated employees or equipment.

(4) Equipment and solvents. All equipment and solvents used for decontamination shall be decontaminated or disposed of properly.

(5) Personal protective clothing and equipment.

(i) Protective clothing and equipment shall be decontaminated, cleaned, laundered, maintained or replaced as needed to maintain their effectiveness.

(ii) Employees whose non-impermeable clothing becomes wetted with hazardous substances shall immediately remove that clothing and proceed to shower. The clothing shall be disposed of or decontaminated before it is removed from the work zone.

(6) Unauthorized employees. Unauthorized employees shall not remove protective clothing or equipment from change rooms.

(7) Commercial laundries or cleaning establishments. Commercial laundries or cleaning establishments that decontaminate protective clothing or equipment shall be informed of the potentially harmful effects of exposures to hazardous substances.

(8) Showers and change rooms. 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. If temperature conditions prevent the effective use of water, then other effective means for cleansing shall be provided and used.

(l) Emergency response by employees at uncontrolled hazardous waste sites.

(1) Emergency response plan.

(i) An emergency response plan shall be developed and implemented by all employers within the scope 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 with relevant responsibilities.

(ii) Employers who will evacuate their employees from the workplace when an emergency occurs, and who do not permit any of their employees to assist in handling the emergency, are exempt from the requirements of this paragraph if they provide an emergency action plan complying with section 1910.38(a) of this part.

(2) Elements of an emergency response plan. The employer shall develop an emergency response plan for emergencies which shall address, as a minimum the following:

(i) Pre-emergency planning.

(ii) Personnel roles, lines of authority, and communication.

(iii) Emergency recognition and prevention.

(iv) Safe distances and places of refuge.

(v) Site security and control.

(vi) Evacuation routes and procedures.

(vii) Decontamination procedures which are not covered by the site safety and health plan.

(viii) Emergency medical treatment and first aid.

(ix) Emergency alerting and response procedures.

(x) Critique of response and follow-up.

(xi) PPE and emergency equipment.

(3) Procedures for handling emergency incidents.

(i) In addition to the elements for the emergency response plan required in paragraph (1)(2) of this section, the following elements shall be included for emergency response plans:

(a) Site topography, layout, and prevailing weather conditions.

(b) Procedures for reporting incidents to local, state, and federal governmental agencies.

(ii) The emergency response plan shall be a separate section of the Site Safety and Health Plan.

(iii) The emergency response plan shall be compatible and integrated with the disaster, fire and/or emergency response plans of local, state, and federal agencies.

(iv) The emergency response plan shall be rehearsed regularly as part of the overall training program for site operations.

(v) The site emergency response plan shall be reviewed periodically and, as necessary, be amended to keep it current with new or changing site conditions or information.

(vi) An employee alarm system shall be installed in accordance with 29 CFR 1910.165 to notify employees of an emergency situation; to stop work activities if necessary; to lower background noise in order to speed communication; and to begin emergency procedures.

(vii) Based upon the information available at time of the emergency, the employer shall evaluate the incident and the site response capabilities and proceed with the appropriate steps to implement the site emergency response plan.

(m) Illumination.

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

TABLE H-120.1—MINIMUM ILLUMINATION INTENSITIES IN FOOT-CANDLES

Foot-candles	Area or operations
5	General site areas.
3	Excavation and waste areas, accessways, active storage areas, loading platforms, refueling, and field maintenance areas.
5	Indoors: Warehouses, corridors, hallways, and exitways.
5	Tunnels, shafts, and general underground work areas. (Exception: Minimum of 10 foot-candles is required at tunnel and shaft heading during drilling mucking, and scaling. Mine Safety and Health Administration approved cap lights shall be acceptable for use in the tunnel heading).
10	General shops (e.g., mechanical and electrical equipment rooms, active storerooms, barracks or living quarters, locker or dressing rooms, dining areas, and indoor toilets and workrooms.)
30	First aid stations, infirmaries, and offices.

(n) Sanitation at temporary workplaces.

(1) Potable water.

(i) An adequate supply of potable water shall be provided on the site.

(ii) Portable containers used to dispense drinking water shall be capable of being tightly closed, and equipped with a tap. Water shall not be dipped from containers.

(iii) Any container used to distribute drinking water shall be clearly marked as to the nature of its contents and not used for any other purpose.

(iv) Where single service cups (to be used but once) are supplied, both a sanitary container for the unused cups and a receptacle for disposing of the used cups shall be provided.

(2) Nonpotable water.

(i) Outlets for nonpotable water, such as water for firefighting purposes, shall be identified to indicate clearly that the water is unsafe and is not to be used for drinking, washing, or cooking purposes.

(ii) There shall be no cross-connection, open or potential, between a system furnishing potable water and a system furnishing nonpotable water.

(3) Toilet facilities.

(i) Toilets shall be provided for employees according to the following Table H-120.2.

TABLE H-120.2—TOILET FACILITIES

Number of employees	Minimum number of facilities
20 or fewer	One.
More than 20, fewer than 200.	One toilet seat and one urinal per 40 employees.
More than 200	One toilet seat and one urinal per 50 employees.

(ii) Under temporary field conditions, provisions shall be made to assure that at least one toilet facility is available.

(iii) Hazardous waste sites not provided with a sanitary sewer shall be provided with the following toilet facilities unless prohibited by local codes:

(a) Chemical toilets;

(b) Recirculating toilets;

(c) Combustion toilets; or

(d) Flush toilets.

(iv) The requirements of this paragraph for sanitation facilities shall not apply to mobile crews having transportation readily available to nearby toilet facilities.

(v) Doors entering toilet facilities shall be provided with entrance locks controlled from inside the facility.

(4) Food handling. All food service facilities and operations for employees shall meet the applicable laws, ordinances, and regulations of the jurisdictions in which they are located.

(5) Temporary sleeping quarters. When temporary sleeping quarters are provided, they shall be heated, ventilated, and lighted.

(6) Washing facilities. The employer shall provide adequate washing facilities for employees engaged in operations where hazardous substances may be harmful to employees. Such facilities shall be in near proximity to the worksite; in areas where exposures are below permissible exposure limits and published exposure levels and which are under the controls of the employer; and shall be so equipped as to enable employees to remove hazardous substances from themselves.

(7) Showers and change rooms. When hazardous waste clean-up or removal operations commence on a site and the duration of the work will require six months or greater time to complete, the employer shall provide showers and change rooms for all employees exposed to hazardous substances and health hazards involved in hazardous waste clean-up or removal operations.

(i) Showers shall be provided and shall be provided and shall meet the requirements of 29 CFR 1910.141(d)(3).

(ii) Change rooms shall be provided and shall meet the requirements of 29 CFR 1910.141(e). Change rooms shall consist of two separate change areas separated by the shower area required in paragraph (n)(7)(i) of this section. One change area, with an exit leading off the worksite, shall provide employees with a clean area where they can remove, store, and put on street clothing. The second area, with an exit to the worksite, shall provide employees with an area where they can put on, remove and store work clothing and personal protective equipment.

(iii) Showers and change rooms shall be located in areas where exposures are below the permissible exposure limits and published exposure levels. If this cannot be accomplished, then a ventilation system shall be provided that will supply air that is below the permissible exposure limits and published exposure levels.

(iv) Employers shall assure that employees shower at the end of their work shift and when leaving the hazardous waste site.

(o) New technology programs.

(1) 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.

(2) New technologies, equipment or control measures available to the industry, such as the use of foams, absorbents, adsorbents, neutralizers, or other means to suppress the level of air contaminants while excavating the site or for spill control, shall be evaluated by employers or their representatives. Such an evaluation shall be done to determine the effectiveness of the new methods, materials, or equipment before implementing their use on a large scale for enhancing employee protection. Information and data from manufacturers or suppliers may be used as part of the employer's evaluation effort. Such evaluations shall be made available to OSHA upon request.

(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 not exempted by paragraph (a)(2)(iii) of this section shall provide and implement the programs specified in this paragraph.

(1) Safety and health program. The employer shall develop and implement a written safety and health program for employees involved in hazardous waste operations that shall be available for inspection by employees, their representatives and OSHA personnel. The program shall be designed to identify, evaluate and control safety and health hazards in their facilities

for the purpose of employee protection, to provide for emergency response meeting the requirements of paragraph (p)(8) of this section and to address as appropriate site analysis, engineering controls, maximum exposure limits, hazardous waste handling procedures and uses of new technologies.

(2) Hazard communication program. The employer shall implement a hazard communication program meeting the requirements of 29 *CFR 1910.1200* as part of the employer's safety and program.

Note to 1910.120.—The exemption for hazardous waste provided in §1910.1200 is applicable to this section.

(3) Medical surveillance program. The employer shall develop and implement a medical surveillance program meeting the requirements of paragraph (f) of this section.

(4) Decontamination program. The employer shall develop and implement a decontamination procedure meeting the requirements of paragraph (k) of this section.

(5) New technology program. The employer shall develop and implement procedures meeting the requirements of paragraph (o) of this section for introducing new and innovative equipment into the workplace.

(6) Material handling program. Where employees will be handling drums or containers, the employer shall develop and implement procedures meeting the requirements of paragraphs (j)(1)(ii) through (viii) and (xi) of this section, as well as (j)(3) and (j)(8) of this section prior to starting such work.

(7) Training program.

(i) New employees. The employer shall develop and implement a training program, which is part of the employer's safety and health program, for employees involved with hazardous waste operations to enable employees to perform their assigned duties and functions in a safe and healthful manner so as not to endanger themselves or other employees. The initial training shall be for 24 hours and refresher training shall be for eight hours annually. Employees who have received the initial training required by this paragraph shall be given a written certificate attesting that they have successfully completed the necessary training.

(ii) Current employees. Employers who can show by an employee's previous work experience and/or training that the employee has had training equivalent to the initial training required by this paragraph, shall be considered as meeting the initial training requirements of this paragraph as to that employee. Equivalent training includes the training that existing employees might have already received from actual site work experience. Current employees shall receive eight hours of refresher training annually.

(iii) Trainers. Trainers who teach initial training shall have satisfactorily completed a training course for teaching the subjects they are expected to teach or they shall have the academic credentials and instruction experience necessary to demonstrate a good command of the subject matter of the courses and competent instructional skills.

(8) Emergency response program.

(i) Emergency response plan. An emergency response plan shall be developed and implemented by all employers. Such plans need not duplicate any of the subjects fully addressed in the employer's contingency planning required by permits, such as those issued by the U.S. Environmental Protection Agency, provided that the contingency plan is made part of the emergency response plan shall be a written portion of the employers safety and health program required in paragraph (p)(1) of this section. Employers who will evacuate their employees from the worksite location when an emergency occurs and who do not permit any of their employees to assist in handling the emergency are exempt from the requirements of paragraph (p)(8) if they provide an emergency action plan complying with §1910.38(a) of this part.

(ii) Elements of an emergency response plan. The employer shall develop an emergency response plan for emergencies which shall address, as a minimum, the following areas to the extent that they are not addressed in any specific program required in this paragraph:

(a) Pre-emergency planning and coordination with outside parties.

(b) Personnel roles, lines of authority, and communication.

(c) Emergency recognition and prevention.

(d) Safe distances and places of refuge.

(e) Site security and control.

(f) Evacuation routes and procedures.

(g) Decontamination procedures.

(h) Emergency medical treatment and first aid.

(i) Emergency alerting and response procedures.

(j) Critique of response and follow-up.

(k) PPE and emergency equipment.

(iii) Training.

(a) 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 equipment to be worn and procedures for handling emergency incidents.

Exception #1: An employer need not train all employees to the degree specified if the employer divides the work force in a manner such that a sufficient number of employees who have responsibility to control emergencies have the training specified, and all other employees, who may first respond to an emergency incident, have sufficient awareness training to recognize that an emergency response situation exists and that they are instructed in that case to summon the fully trained employees and not attempt control activities for which they are not trained.

Exception #2: An employer need not train all employees to the degree specified if arrangements have been made in advance for an outside fully-trained emergency response team to respond in a reasonable period and all employees, who may come to the incident first, have sufficient awareness training to recognize that an emergency response situation exists and they have been instructed to call the designated outside fully-trained emergency response team for assistance.

(b) 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. This would include training in the methods used to minimize the risk from safety and health hazards; in the safe use of control equipment; in the selection and use of appropriate personal protective equipment; in the safe operating procedures to be used at the incident scene; in the techniques of coordination with other employees to minimize risks; in the appropriate response to over exposure from health hazards or injury to themselves and other employees; and in the recognition of subsequent symptoms which may result from over exposures.

(c) The employer shall certify that each covered employee has attended and successfully completed the training required in paragraph (p)(8)(iii) of this section, or shall certify the employee's competency at least yearly. The method used to demonstrate competency for certification of training shall be recorded and maintained by the employer.

(iv) Procedures for handling emergency incidents.

(a) In addition to the elements for the emergency response plan required in paragraph (p)(8)(ii) of this section, the following elements shall be included for emergency response plans to the extent that they do not repeat any information already contained in the emergency response plan:

(1) Site topography, layout, and prevailing weather conditions.

(2) Procedures for reporting incidents to local, state, and federal governmental agencies.

(b) The emergency response plan shall be compatible and integrated with the disas-

ter, fire and/or emergency response plans of local, state, and federal agencies.

(c) The emergency response plan shall be rehearsed regularly as part of the overall training program for site operations.

(d) The site emergency response plan shall be reviewed periodically and, as necessary, be amended to keep it current with new or changing site conditions or information.

(e) An employee alarm system shall be installed in accordance with 29 CFR 1910.165 to notify employees of an emergency situation; to stop work activities if necessary; to lower background noise in order to speed communication; and to begin emergency procedures.

(f) Based upon the information available at time of the emergency, the employer shall evaluate the incident and the site response capabilities and proceed with the appropriate steps to implement the site emergency response plan.

(q) Emergency response to hazardous substance releases.

This paragraph covers employers whose employees are engaged in emergency response no matter where it occurs except that it does not cover employees engaged in operations specified in paragraphs (a)(1)(i) through (a)(1)(iv) of this section. Those emergency response organizations who have developed and implemented programs equivalent to this paragraph for handling releases of hazardous substances pursuant to section 303 of the Superfund Amendments and Reauthorization Act of 1986 (Emergency Planning and Community Right-to-Know Act of 1986, 42 U.S.C. 11003) shall be deemed to have met the requirements of this paragraph.

(1) Emergency response plan. An emergency response plan shall be developed and implemented to handle anticipated emergencies prior to the commencement of emergency response operations. The plan shall be in writing and available for inspection and copying by employees, their representatives and OSHA personnel. Employers who will evacuate their employees from the workplace when an emergency occurs, and who do not permit any of their employees to assist in handling the emergency, are exempt from the requirements of this paragraph if they provide an emergency action plan in accordance with §1910.38(a) of this part.

(2) Elements of an emergency response plan. The employer shall develop an emergency response plan for emergencies which shall address, as a minimum, the following to the extent that they are not addressed elsewhere:

(i) Pre-emergency planning and coordination with outside parties.

(ii) Personnel roles, lines of authority, training, and communication.

(iii) Emergency recognition and prevention.

(iv) Safe distances and places of refuse.

(v) Site security and control.

(vi) Evacuation routes and procedures.

(vii) Decontamination.

(viii) Emergency medical treatment and first aid.

(ix) Emergency alerting and response procedures.

(x) Critique of response and follow-up.

(xi) PPE and Emergency equipment.

(xii) Emergency response organizations may use the local emergency response plan or the state emergency response plan or both, as part of their emergency response plan to avoid duplication. Those items of the emergency response plan that are being properly addressed by the SARA Title III plans may be substituted into their emergency plan or otherwise kept together for the employer and employee's use.

(3) Procedures for handling emergency response.

(i) The senior emergency response official responding to an emergency shall become the individual in charge of a site-specific Incident Command System (ICS). All emergency responders and their communications shall be coordinated and controlled through the individual in charge of the ICS assisted by the senior official present for each employer.

Note to (q)(3)(i).—The "senior official" at an emergency response is the most senior official on the site who has the responsibility for controlling the operations at the site. Initially it is the senior officer on the first-due piece of responding emergency apparatus to arrived on the incident scene. As more senior officers arrive (i.e., battalion chief, fire chief, state law enforcement official, site coordinator, etc.) the position is passed up the line of authority which has been previously established.

(ii) The individual in charge of the ICS shall identify, to the extent possible, all hazardous substances or conditions present and shall address as appropriate site analysis, use of engineering controls, maximum exposure limits, hazardous substance handling procedures, and use of any new technologies.

(iii) Based on the hazardous substances and/or conditions present, the individual in charge of the ICS shall implement appropriate emergency operations, and assure that the personal protective equipment worn is appropriate for the hazards to be encountered. However, personal protective equipment shall meet, at a minimum, the criteria contained in 29 CFR 1910.156(e) when worn while performing fire fighting operations beyond the incipient stage for any incident or site.

(iv) Employees engaged in emergency response and exposed to hazardous substances presenting an inhalation hazard or potential inhalation hazard shall wear positive pressure self-contained breathing apparatus while engaged in emergency response, until such time that the individual in charge of the ICS determines through the use of air monitoring that a decreased level of respiratory protection will not result in hazardous exposures to employees.

(v) The individual in charge of the ICS shall limit the number of emergency response personnel at the emergency site, in those areas of potential or actual exposure to incident or site hazards, to those who are actively performing emergency operations. However, operations in hazardous areas shall be performed using the buddy system in groups of two or more.

(vi) Back-up personnel shall stand by with equipment ready to provide assistance or rescue. Advance first aid support personnel, as a minimum, shall also stand by with medical equipment and transportation capability.

(vii) The individual in charge of the ICS shall designate a safety official, who is knowledgeable in the operations being implemented at the emergency response site, with specific responsibility to identify and evaluate hazards and to provide direction with respect to the safety of operations for the emergency at hand.

(viii) When activities are judged by the safety official to be an IDLH condition and/or to involve an imminent danger condition, the safety official shall have the authority to alter, suspend, or terminate those activities. The safety official shall immediately inform the individual in charge of the ICS of any actions needed to be taken to correct these hazards at an emergency scene.

(ix) After emergency operations have terminated, the individual in charge of the ICS shall implement appropriate decontamination procedures.

(x) When deemed necessary for meeting the tasks at hand, approved self-contained compressed air breathing apparatus may be used with approved cylinders from other approved self-contained compressed air breathing apparatus provided that such cylinders are of the same capacity and pressure rating. All compressed air cylinders used with self-contained breathing apparatus shall meet U.S. Department of Transportation and National Institute for Occupational Safety and Health criteria.

(4) Skilled support personnel. Personnel, not necessarily an employer's own employees, who are skilled in the operation of certain equipment, such as mechanized earth moving or digging equipment or crane and hoisting equipment, and who are needed temporarily to perform immediate emergency support work that cannot reasonably be performed in a timely fashion by an employer's own employees, and who will be or may be exposed to the hazards at an emergency response scene, are not required to meet the training required in this paragraph for the employer's regular employees. However, these personnel shall be given an initial briefing at the site prior to their participation in any emergency response. The initial briefing shall

include instruction in the wearing of appropriate personal protective equipment, what chemical hazards are involved, and what duties are to be performed. All other appropriate safety and health precautions provided to the employer's own employees shall be used to assure the safety and health of these personnel.

(5) Specialist employees. Employees who, in the course of their regular job duties, work with and are trained in the hazards of specific hazardous substances, and who will be called upon to provide technical advice or assistance at a hazardous substance release incident to the individual in charge, shall receive training or demonstrate competency in the area of their specialization annually.

(6) Training. Training shall be based on the duties and function to be performed by each responder of an emergency response organization. The skill and knowledge levels required for all new responders, those hired after the effective date of this standard, shall be conveyed to them through training before they are permitted to take part in actual emergency operations on an incident. Employees who participate, or are expected to participate, in emergency response, shall be given training in accordance with the following paragraphs:

(i) First responder awareness level. 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 awareness level shall have sufficient training to have had sufficient experience to objectively demonstrate competency in the following areas.

(a) An understanding of what hazardous materials are, and the risks associated with them in an incident.

(b) An understanding of the potential outcomes associated with an emergency created when hazardous materials are present.

(c) The ability to recognize the presence of hazardous materials in an emergency.

(d) The ability to identify the hazardous materials, if possible.

(e) An understanding of the role of the first responder awareness individual in the employer's emergency response plan including the site security and control and the U.S. Department of Transportation's Emergency Response Guidebook.

(f) The ability to realize the need for additional resources, and to make appropriate notifications to the communication center.

(ii) First responder operations level. 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 or have had sufficient experience to objectively demonstrate competency in the following areas in addition to those listed for the awareness level and the employer shall so certify:

(a) Knowledge of the basic hazard and risk assessment techniques.

(b) Know how to select and use proper personal protective equipment provided to the first responder operational level.

(c) An understanding of basic hazardous materials terms.

(d) Know how to perform basic control, containment and/or confinement operations within the capabilities of the resources and personal protective equipment available with their unit.

(e) Know how to implement basic decontamination procedures.

(f) An understanding of the relevant standard operating procedures and termination procedures.

(iii) **Hazardous materials technician.** Hazardous materials technicians are individuals who respond to releases or potential releases for the purpose of stopping the release. They assume a more aggressive role than a first responder at the operations level 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 in addition have competency in the following areas and the employer shall so certify:

(a) Know how to implement the employer's emergency response plan.

(b) Know the classification, identification and verification of known and unknown materials by using field survey instruments and equipment.

(c) Be able to function within an assigned role in the Incident Command System.

(d) Know how to select and use proper specialized chemical personal protective equipment provided to the hazardous materials technician.

(e) Understand hazard and risk assessment techniques.

(f) Be able to perform advance control, containment, and/or confinement operations within the capabilities of the resources and personal protective equipment available with the unit.

(g) Understand and implement decontamination procedures.

(h) Understand termination procedures.

(i) Understand basic chemical and toxicological terminology and behavior.

(iv) **Hazardous materials specialist.** 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 called upon 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 competency in the following areas and the employer shall so certify:

(a) Know how to implement the local emergency response plan.

(b) Understand classification, identification and verification of known and unknown materials by using advanced survey instruments and equipment.

(c) Know of the state emergency response plan.

(d) Be able to select and use roper specialized chemical personal protective equipment provided to the hazardous materials specialist.

(e) Understand in-depth hazard and risk techniques.

(f) Be able to perform specialized control, containment, and/or confinement operations within the capabilities of the resources and personal protective equipment available.

(g) Be able to determine and implement decontamination procedures.

(h) Have the ability to develop a site safety and control plan.

(i) Understand chemical, radiological and toxicological terminology and behavior.

(v) **On scene incident commander.** Incident commanders, who will assume control of the incident scene beyond the first responder awareness level, shall receive at least 24 hours of training equal to the first responder operations level and in addition have competency in the following areas and the employer shall so certify:

(a) Know and be able to implement the employer's incident command system.

(b) Know how to implement the employer's emergency response plan.

(c) Know and understand the hazards and risks associated with employees working in chemical protective clothing.

(d) Know how to implement the local emergency response plan.

(e) Know of the state emergency response plan and of the Federal Regional Response Team.

(f) Know and understand the importance of decontamination procedures.

(7) Trainers. Trainers who teach any of the above training subjects shall have satisfactorily completed a training course for teaching the subjects they are expected to teach, such as the courses offered by the U.S. Fire Academy, or they shall have the training and/or academic credentials and instructional experience necessary to demonstrate competent instructional skills and a good command of the subject matter of the courses they are to teach.

(8) Refresher training.

(i) Those employees who are trained in accordance with paragraph (q)(6) of this section shall receive annual refresher training of sufficient content and duration to maintain their competencies, or shall demonstrate competency in those areas at least yearly.

(ii) A statement shall be made of the training or competency, and if a statement of competency is made, the employer shall keep a record of the methodology used to demonstrate competency.

(9) Medical surveillance and consultation.

(i) Members of an organized and designated HAZMAT team and hazardous materials specialists shall receive a baseline physical examination and be provided with medical surveillance as required in paragraph (f) of this section.

(ii) Any emergency response employees who exhibits signs or symptoms which may have resulted from exposure to hazardous substances during the course of an emergency incident, either immediately or subsequently, shall be provided with medical consultation as required in paragraph (f)(3)(ii) of this section.

(10) Chemical protective clothing. Chemical protective clothing and equipment to be used by organized and designated HAZMAT team members, or to be used by hazardous materials specialists, shall meet the requirements of paragraphs (g)(3) through (5) of this section.

(11) Post-emergency response operations. Upon completion of the emergency response, if it is determined that it is necessary to remove hazardous substances, health hazards, and materials contaminated with them (such as contaminated soil or other elements of the natural environment) from the site of the incident, the employer conducting the clean-up shall comply with one of the following:

(i) Meet all of the requirements of paragraphs (b) through (o) of this section; or

(ii) Where the clean-up is done on plant property using plant or workplace employees, such employees shall have completed the training requirements of the following: 29 CFR 1910.38(a); 1910.134; 1910.1200, and other appropriate safety and health training made necessary by the tasks that they are expected to be performed such as personal protective equipment and decontamination procedures. All equipment to be used in the performance of the clean-up work shall be in serviceable condition and shall have been inspected prior to use.

APPENDICES TO 1910.120—HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE

Note: The following appendices serve as non-mandatory guidelines to assist employees and employers in complying with the appropriate requirements of this section. However paragraph 1910.120(g) makes mandatory in certain circumstances the use of Level A and Level B PPE protection.

Appendix A—Personal Protective Equipment Test Methods

This appendix sets forth the nonmandatory examples of tests which may be used to evaluate compliance with § 1910.120 (g)(4)(ii) and (iii). Other tests and other challenge agents may be used to evaluate compliance.

A. Totally-encapsulating chemical protective suit pressure test.

1.0—Scope

1.1 This practice measures the ability of a gas tight totally-

encapsulating chemical protective suit material, seams, and closures to maintain a fixed positive pressure. The results of this practice allow the gas tight integrity of a totally-encapsulating chemical protective suit to be evaluated.

1.2 Resistance of the suit materials to permeation, penetration, and degradation by specific hazardous substances is not determined by this test method.

2.0—Definition of terms

2.1 "Totally-encapsulated chemical protective suit (TECP suit)" means a full body garment which is constructed of protective clothing materials; covers the wearer's torso, head, arms, legs and respirator; may cover the wearer's hands and feet with tightly attached gloves and boots; completely encloses the wearer and respirator by itself or in combination with the wearer's gloves and boots.

2.2 "Protective clothing material" means any material or combination of materials used in an item of clothing for the purpose of isolating parts of the body from direct contact with a potentially hazardous liquid or gaseous chemicals.

2.3 "Gas tight" means, for the purpose of this test method, the limited flow of a gas under pressure from the inside of a TECP suit to atmosphere at a prescribed pressure and time interval.

3.0—Summary of test method

3.1 The TECP suit is visually inspected and modified for the test. The test apparatus is attached to the suit to permit inflation to the pre-test suit expansion pressure for removal of suit wrinkles and creases. The pressure is lowered to the test pressure and monitored for three minutes. If the pressure drop is excessive, the TECP suit fails the test and is removed from service. The test is repeated after leak location and repair.

4.0—Required Supplies

4.1 Source of compressed air.

4.2 Test apparatus for suit testing, including a pressure measurement device with a sensitivity of at least ¼ inch water gauge.

4.3 Vent valve closure plugs or sealing tape.

4.4 Soapy water solution and soft brush.

4.5 Stop watch or appropriate timing device.

5.0—Safety Precautions

5.1 Care shall be taken to provide the correct pressure safety devices required for the source of compressed air used.

6.0—Test Procedure

6.1 Prior to each test, the tester shall perform a visual inspection of the suit. Check the suit for seam integrity by visually examining the seams and gently pulling on the seams. Ensure that all air supply lines, fittings, visor, zippers, and valves are secure and show no signs of deterioration

6.1.1 Seal off the vent valves along with any other normal inlet or exhaust points (such as umbilical air line fittings or face piece opening) with tape or other appropriate means (caps, plugs, fixture, etc.). Care should be exercised in the sealing process not to damage any of the suit components.

6.1.2 Close all closure assemblies.

6.1.3 Prepare the suit for inflation by providing an improvised connection point on the suit for connecting an airline. Attach the pressure test apparatus to the suit to permit suit inflation from a compressed air source equipped with a pressure indicating regulator. The leak tightness of the pressure test apparatus should be tested before and after each test by closing off the end of the tubing attached to the suit and assuring a pressure of three inches water gauge for three minutes can be maintained. If a component is removed for the test, that component shall be replaced and a second test conducted with another component removed to permit a complete test of the ensemble.

6.1.4 The pre-test expansion pressure (A) and the suit test pressure (B) shall be supplied by the suit manufacturer, but in no case shall they be less than: (A) = three inches water gauge; and (B) = two inches water gauge. The ending suit pressure (C) shall be no less than 80 percent of the test pressure (B); i.e., the pressure drop shall not exceed 20 percent of the test pressure (B).

6.1.5 Inflate the suit until the pressure inside is equal to pressure (A), the pre-test expansion suit pressure. Allow at least one minute to fill out the wrinkles in the suit. Release sufficient air to reduce the suit pressure to pressure (B), the suit test pressure. Begin timing. At the end of three minutes, record the suit pressure as pressure (C), the ending suit pressure. The difference between the suit test pressure and the ending suit test pressure (B–C) shall be defined as the suit pressure drop.

6.1.6 If the suit pressure drop is more than 20 percent of the suit test pressure (B) during the three-minute test period, the suit fails the test and shall be removed from service.

7.0—Retest Procedure

7.1 If the suit fails the test check for leaks by inflating the suit to pressure (A) and brushing or wiping the entire suit (including seams, closures, lens gaskets, glove-to-sleeve joints, etc.) with a mild soap and water solution. Observe the suit for the formation of soap bubbles, which is an indication of a leak. Repair all identified leaks.

7.2 Retest the TECP suit as outlined in Test procedure 6.0.

8.0—Report

8.1 Each TECP suit tested by this practice shall have the following information recorded:

8.1.1 Unique identification number, identifying brand name, date of purchase, material of construction, and unique fit features, e.g., special breathing apparatus.

8.1.2 The actual values for test pressures (A), (B), and (C) shall be recorded along with the specific observation times. If the ending pressure (C) is less than 80 percent of the test pres-

sure (B), the suit shall be identified as failing the test. When possible, the specific leak location shall be identified in the test records. Retest pressure data shall be recorded as an additional test.

8.1.3 The source of the test apparatus used shall be identified and the sensitivity of the pressure gauge shall be recorded.

8.1.4 Records shall be kept for each pressure test even if repairs are being made at the test location.

Caution

Visually inspect all parts of the suit to be sure they are positioned correctly and secured tightly before putting the suit back into service. Special care should be taken to examine each exhaust valve to make sure it is not blocked.

Care should also be exercised to assure that the inside and outside of the suit is completely dry before it is put into storage.

B. Totally-encapsulating chemical protective suit qualitative leak test.

1.0—Scope

1.1 This practice semi-qualitatively tests gas tight totally-encapsulating chemical protective suit integrity by detecting inward leakage of ammonia vapor. Since no modifications are made to the suit to carry out this test, the results from this practice provide a realistic test for the integrity of the entire suit.

1.2 Resistance of the suit materials to permeation, penetration, and degradation is not determined by this test method. ASTM test methods are available to test suit materials for these characteristics and the tests are usually conducted by the manufacturers of the suits.

2.0—Definition of terms

2.1 "Totally-encapsulated chemical protective suit (TECP suit) means a full body garment which is constructed of protective clothing materials; covers the wearer's torso, head, arms, legs and respirator; may cover the wearer's hands and feet with tightly attached gloves and boots; completely encloses the wearer and respirator by itself or in combination with the wearer's gloves, and boots.

2.2 "Protective clothing material" means any material or combination of materials used in an item of clothing for the purpose of isolating parts of the body from direct contact with a potentially hazardous liquid or gaseous chemicals.

2.3 "Gas tight" means, for the purpose of this test method, the limited flow of a gas under pressure from the inside of a TECP suit to atmosphere at a prescribed pressure and time interval.

2.4 "Intrusion Coefficient" means a number expressing the level of protection provided by a gas tight totally-encapsulating chemical protective suit. The intrusion coefficient is calculated by dividing the test room challenge agent concentration by the concentration of challenge agent found inside the suit. The accuracy of the intrusion coefficient is dependent on the challenge agent monitoring methods. The larger the intrusion coefficient the greater the protection provided by the TECP suit.

3.0—Summary of recommended practice

3.1 The volume of concentrated aqueous ammonia solution (ammonia hydroxide NH_4OH) required to generate the test atmosphere is determined using the directions outlined in 6.1. The suit is donned by a person wearing the appropriate respiratory equipment (either a positive pressure self-contained breathing apparatus or a positive pressure supplied air respirator) and worn inside the enclosed test room. The concentrated aqueous ammonia solution is taken by the suited individual into the test room and poured into an open plastic pan. A two-minute evaporation period is observed before the test room concentration is measured, using a high range ammonia length of stain detector tube. When the ammonia vapor reaches a concentration of between 1000 and 1200 ppm, the suited individual starts a standardized exercise protocol to stress and flex the suit. After this protocol is completed, the test room concentration is measured again. The suited individual exits the test room and his stand-by person measures the ammonia concentration inside the suit using a low range ammonia length of stain detector tube or other more sensitive ammonia detector. A stand-by person is required to observe the test individual during the test procedure; aid the person in donning and doffing the TECP suit; and monitor the suit interior. The intrusion coefficient of the suit can be calculated by dividing the average test area concentration by the interior suit concentration. A colorimetric ammonia indicator strip of bromophenol blue or equivalent is placed on the inside of the suit face piece lens so that the suited individual is able to detect a color change and know if the suit has a significant leak. If a color change is observed the individual shall leave the test room immediately.

4.0—Required supplies

4.1 A supply of concentrated aqueous (58 percent ammonium hydroxide by weight).

4.2 A supply of bromophenol/blue indicating paper or equivalent, sensitive to 5-10 ppm ammonia or greater over a two-minute period of exposure. [pH 3.0 (yellow) to pH 4.6 (blue)]

4.3 A supply of high range (0.5-10 volume percent) and low range (5-700 ppm) detector tubes for ammonia and the corresponding sampling pump. More sensitive ammonia detectors can be substituted for the low range detector tubes to improve the sensitivity of this practice.

4.4 A shallow plastic pan (PVC) at least 12":14":1" and a half pint plastic container (PVC) with tightly closing lid.

4.5 A graduated cylinder or other volumetric measuring device of at least 50 milliliters in volume with an accuracy of at least ± 1 milliliters.

5.0—Safety precautions

5.1 Concentrated aqueous ammonium hydroxide, NH_4OH, is a corrosive volatile liquid requiring eye, skin, and respiratory protection. The person conducting the test shall review the MSDS for aqueous ammonia.

5.2 Since the established permissible exposure limit for ammonia is 50 ppm, only persons wearing a positive pressure self-contained breathing apparatus or a positive pressure supplied air respirator shall be in the chamber. Normally only the person wearing the totally-encapsulating suit will be inside the chamber. A stand-by person shall have a positive pressure self-contained breathing apparatus, or a positive pressure supplied air respirator available to enter the test area should the suited individual need assistance.

5.3 A method to monitor the suited individual must be used during this test. Visual contact is the simplest but other methods using communication devices are acceptable.

5.4 The test room shall be large enough to allow the exercise protocol to be carried out and then to be ventilated to allow for easy exhaust of the ammonia test atmosphere after the test(s) are completed.

5.5 Individuals shall be medically screened for the use of respiratory protection and checked for allergies to ammonia before participating in this test procedure.

6.0—Test procedure

6.1.1 Measure the test area to the nearest foot and calculate its volume in cubic feet. Multiply the test area volume by 0.2 milliliters of concentrated aqueous ammonia solution per cubic foot of test area volume to determine the approximate volume of concentrated aqueous ammonia required to generate 1000 ppm in the test area.

6.1.2 Measure this volume from the supply of concentrated aqueous ammonia and place it into a closed plastic container.

6.1.3 Place the container, several high range ammonia detector tubes, and the pump in the clean test pan and locate it near the test area entry door so that the suited individual has easy access to these supplies.

6.2.1 In a non-contaminated atmosphere, open a pre-sealed ammonia indicator strip and fasten one end of the strip to the inside of the suit face shield lens where it can be seen by the wearer. Moisten the indicator strip with distilled water. Care shall be taken not to contaminate the detector part of the indicator paper by touching it. A small piece of masking tape or equivalent should be used to attach the indicator strip to the interior of the suit face shield.

6.2.2 If problems are encountered with this method of attachment, the indicator strip can be attached to the outside of the respirator face piece lens being used during the test.

6.3 Don the respiratory protective device normally used with the suit, and then don the TECP suit to be tested. Check to be sure all openings which are intended to be sealed (zippers, gloves, etc.) are completely sealed. DO NOT, however, plug off any venting valves.

6.4 Step into the enclosed test room such as a closet, bathroom, or test booth, equipped with an exhaust fan. No air should be exhausted from the chamber during the test because this will dilute the ammonia challenge concentrations.

6.5 Open the container with the premeasured volume of concentrated aqueous ammonia within the enclosed test room, and pour the liquid into the empty plastic test pan. Wait two minutes to allow for adequate volatilization of the concentrated aqueous ammonia. A small mixing fan can be used near the evaporation pan to increase the evaporation rate of the ammonia solution.

6.6 After two minutes a determination of the ammonia concentration within the chamber should be made using the high range colorimetric detector tube. A concentration of 1000 ppm ammonia or greater shall be generated before the exercises are started.

6.7 To test the integrity of the suit the following four minute exercise protocol should be followed:

6.7.1 Raising the arms above the head with at least 15 raising motions completed in one minute.

6.7.2 Walking in place for one minute with at least 15 raising motions of each leg in a one-minute period.

6.7.3 Touching the toes with at least 10 complete motions of the arms from above the head to touching of the toes in a one-minute period.

6.7.4 Knee bends with at least 10 complete standing and squatting motions in a one-minute period.

6.8 If at any time during the test the colorimetric indicating paper should change colors, the test should be stopped and section 6.10 and 6.12 initiated (See ¶4.2).

6.9 After completion of the test exercise, the test area concentration should be measured again using the high range colorimetric detector tube.

6.10 Exit the test area.

6.11 The opening created by the suit zipper or other appropriate suit penetration should be used to determine the ammonia concentration in the suit with the low range length of stain detector tube or other ammonia monitor. The internal TECP suit air should be sampled far enough from the enclosed test area to prevent a false ammonia reading.

6.12 After completion of the measurement of the suit interior ammonia concentration the test is concluded and the suit is doffed and the respirator removed.

6.13 The ventilating fan for the test room should be turned on and allowed to run for enough time to remove the ammonia gas. The fan shall be vented to the outside of the building.

6.14 Any detectable ammonia in the suit interior (five ppm ammonia (NH_3) or more for the length of stain detector tube) indicates that the suit has failed the test. When other ammonia detectors are used a lower level of detection is possible, and it should be specified as the pass/fail criteria.

6.15 By following this test method, an intrusion coefficient of approximately 200 or more can be measured with the suit in a completely operational condition. If the intrusion coefficient is 200 or more, then the suit is suitable for emergency response and field use.

7.0—Retest procedures

7.1 If the suit fails this test, check for leaks by following the pressure test in test A above.

7.2 Retest the TECP suit as outlined in the test procedure 6.0.

8.0—Report

8.1 Each gas tight totally-encapsulating chemical protective suit tested by this practice shall have the following information recorded.

8.1.1 Unique identification number, identifying brand name, date of purchase, material of construction, and unique suit features; e.g., special breathing apparatus.

8.1.2 General description of test room used for test.

8.1.3 Brand name and purchase date of ammonia detector strips and color change data.

8.1.4 Brand name, sampling range, and expiration date of the length of stain ammonia detector tubes. The brand name and model of the sampling pump should also be recorded. If another type of ammonia detector is used, it should be identified along with its minimum detection limit for ammonia.

8.1.5 Actual test results shall list the two test area concentrations, their average, the interior suit concentration, and the calculated intrusion coefficient. Retest data shall be recorded as an additional test.

8.2 The evaluation of the data shall be specified as "suit passed" or "suit failed," and the date of the test. Any detectable ammonia (five ppm or greater for the length of stain detector tube) in the suit interior indicates the suit has failed this test. When other ammonia detectors are used, a lower level of detection is possible and it should be specified as the pass fail criteria.

Caution

Visually inspect all parts of the suit to be sure they are positioned correctly and secured tightly before putting the suit back into service. Special care should be taken to examine each exhaust valve to make sure it is not blocked.

Care should also be exercised to assure that the inside and outside of the suit is completely dry before it is put into storage.

Appendix B—General Description and Discussion of the Levels of Protection and Protective Gear

This appendix 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.

As required by the standard, PPE must be selected which will protect employees from the specific hazards which they are likely to encounter during their work on-site.

Selection of the appropriate PPE is a complex process which should take into consideration a variety of factors. Key factors involved in this process are identification of the hazards, or suspected hazards; their routes of potential hazard to employees (inhalation, skin absorption, ingestion, and eye or skin contact); and the performance of the PPE *materials* (and seams) in providing a barrier to these hazards. The amount of protection provided by PPE is material-hazard specific. That is, protective equipment materials will protect well against some hazardous substances and poorly, or not at all, against others. In many instances, protective equipment materials cannot be found which will provide continuous protection from the particular hazardous substance. In these cases the breakthrough time of the protective material should exceed the work durations, or the exposure after breakthrough may not pose a hazardous level.

Other factors in this selection process to be considered are matching the PPE to the employee's work requirements and task-specific conditions. The durability of PPE materials, such as tear strength and seam strength, should be considered in relation to the employee's tasks. The effects of PPE in relation to heat stress and task duration are a factor in selecting and using PPE. In some cases layers of PPE may be necessary to provide sufficient protection, or to protect expensive PPE inner garments, suits or equipment.

The more that is known about the hazards at the site, the easier the job of PPE selection becomes. As more information about the hazards and conditions at the site becomes available, the site supervisor can make decisions to up-grade or down-grade the level of PPE protection to match the tasks at hand.

The following are guidelines which an employer can use to begin the selection of the appropriate PPE. As noted above, the site information may suggest the use of combinations of PPE selected from the different protection levels (i.e., A, B, C, or D) as being more suitable to the hazards of the work. It should be cautioned that the listing below does not fully address the performance of the specific PPE material in relation to the specific hazards at the job site, and that PPE selection, evaluation and re-selection is an ongoing process until sufficient information about the hazards and PPE performance is obtained.

Part A. Personal protective equipment is divided into four categories based on the degree of protection afforded. (See Part B of this appendix for further explanation of Levels A, B, C, and D hazards.)

I. Level A—To be selected when the greatest level of skin, respiratory, and eye protection is required.

The following constitute Level A equipment; it may be used as appropriate:

1. Positive pressure, full face-piece self-contained breathing apparatus (SCBA), or positive pressure supplied air respirator with escape SCBA, approved by the National Institute for Occupational Safety and Health (NIOSH).

2. Totally-encapsulating chemical-protective suit.

3. Coveralls.[1]

4. Long underwear.[1]

5. Gloves, outer, chemical-resistant.

6. Gloves, inner, chemical-resistant.

7. Boots, chemical-resistant, steel toe and shank.

8. Hard hat (under suit).[1]

9. Disposable protective suit, gloves and boots (depending on suit construction, may be worn over totally-encapsulating suit).

II. Level B—The highest level of respiratory protection is necessary but a lesser level of skin protection is needed.

The following constitute Level B equipment; it may be used as appropriate.

1. Positive pressure, full-facepiece self-contained breathing apparatus (SCBA), or positive pressure supplied air respirator with escape SCBA (NIOSH approved).

2. Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; one or two-piece chemical-splash suit; disposable chemical-resistant overalls).

3. Coveralls.[1]

4. Gloves, outer, chemical-resistant.

5. Gloves, inner, chemical-resistant.

6. Boots, outer, chemical-resistant steel toe and shank.

7. Boot-covers, outer, chemical-resistant (disposable).[1]

8. Hard hat.[1]

9. [Reserved]

10. Face shield.[1]

III. Level C—The concentration(s) and type(s) of airborne substance(s) is known and the criteria for using air purifying respirators are met.

The following constitute Level C equipment; it may be used as appropriate.

1. Full-face or half-mask, air purifying respirators (NIOSH approved).

2. Hooded chemical-resistant clothing (overalls; two-piece chemical-splash suit; disposable chemical-resistant overalls).

3. Coveralls.[1]

4. Gloves, outer, chemical-resistant.

5. Gloves, inner, chemical-resistant.

6. Boots (outer), chemical-resistant steel toe and shank.[1]

7. Boot-covers, outer, chemical-resistant (disposable).[1]

8. Hard hat.[1]

9. Escape mask.[1]

10. Face shield.[1]

IV. Level D—A work uniform affording minimal protection, used for nuisance contamination only.

The following constitute Level D equipment; it may be used as appropriate:

1. Coveralls.

2. Gloves.[1]

3. Boots/shoes, chemical-resistant steel toe and shank.

4. Boots, outer, chemical-resistant (disposable).[1]

5. Safety glasses or chemical splash goggles*.

6. Hard hat.[1]

7. Escape mask.[1]

8. Face shield.[1]

Part B. The types of hazards for which levels A, B, C, and D protection are appropriate are described below:

I. Level A—Level A protection should be used when:

1. The hazardous substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on either the measured (or potential for) high concentration of atmospheric vapors, gases, or particulates; or the site operations and work functions involve a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates of materials that are harmful to skin or capable of being absorbed through the skin;

2. Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible; or

3. Operations are being conducted in confined, poorly ventilated areas, and the absence of conditions requiring Level A have not yet been determined.

II. Level B—Level B protection should be used when:

1. The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but less skin protection;

2. The atmosphere contains less than 19.5 percent oxygen; or

3. The presence of incompletely identified vapors or gases is indicated by a direct-reading organic vapor detection instrument, but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the skin.

[1]Optional, as applicable.

Note: This involves atmospheres with IDLH concentrations of specific substances that present severe inhalation hazards and that do not represent a severe skin hazard; or that do not meet the criteria for use of air-purifying respirators.

III. Level C—Level C protection should be used when:

1. The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect or be absorbed through any exposed skin;

2. The types of air contaminants have been identified, concentrations measured, and an air-purifying respirator is available that can remove the contaminants; and

3. All criteria for the use of air-purifying respirators are met.

IV. Level D—Level D protection should be used when:

1. The atmosphere contains no known hazard; and

2. Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

Note: As stated before, combinations of personal protective equipment other than those described for Levels A, B, C, and D protection may be more appropriate and may be used to provide the proper level of protection.

As an aid in selecting suitable chemical protective clothing, it should be noted that the National Fire Protection Association is developing standards on chemical protective clothing. These standards are currently undergoing public review prior to adoption, including:

NFPA 1991—Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies (EPA Level A Protective Clothing)

NFPA 1991—Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies (EPA Level B Protective Clothing.)

NFPA 1993—Standard on Liquid Splash-Protective Suits for Non-emergency, Non-flammable Hazardous Chemical Situations (EPA Level B Protective Clothing)

These standards would apply documentation and performance requirements to the manufacture of chemical protective suits. Chemical protective suits meeting these requirements would be labelled as compliant with the appropriate standard. When these standards are adopted by the National Fire Protection Association, it is recommended that chemical protective suits which meet these standards be used.

Appendix C—Compliance Guidelines

1. **Occupational Safety and Health Program.** Each hazardous waste site clean-up effort will require an occupational safety and health program headed by the site coordinator or the employer's representative. The purpose of the program will be the protection of employees at the site and will be an extension of the employer's overall safety and health program. The program will need to be developed before work begins on the site and implemented as work proceeds as stated in paragraph (b). The program is to facilitate coordination and communication of safety and health issues among personnel responsible for the various activities which will take place at the site. It will provide the overall means for planning and implementing the needed safety and health training and job orientation of employees who will be working at the site. The program will provide the means for identifying and controlling worksite hazards and the means for monitoring program effectiveness. The program will need to cover the responsibilities and authority of the site coordinator or the employer's manager on the site for the safety and health of employees at the site, and the relationships with contractors or support services as to what each employer's safety and health responsibilities are for their employees on the site. Each contractor on the site needs to have its own safety and health program so structured that it will smoothly interface with the program of the site coordinator or principal contractor.

Also those employers involved with treating, storing or disposal of hazardous waste as covered in paragraph (p) must have implemented a safety and health program for their employees. This program is to include the hazard communication program required in paragraph (p)(1) and the training required in paragraphs (p)(7) and (p)(8) as parts of the employers comprehensive overall safety and health program. This program is to be in writing.

Each site or workplace safety and health program will need to include the following: (1) Policy statements of the line of authority and accountability for implementing the program, the objectives of the program and the role of the site safety and health supervisor or manager and staff; (2) means or methods for the development of procedures for identifying and controlling workplace hazards at the site; (3) means or methods for the development and communication to employees of the various plans, work rules, standard operating procedures and practices that pertain to individual employees and supervisors; (4) means for the training of supervisors and employees to develop the needed skills and knowledge to perform their work in a safe and healthful manner; (5) means to anticipate and prepare for emergency situations; and (6) means for obtaining information feedback to aid in evaluating the program and for improving the effectiveness of the program. The management and employees should be trying continually to improve the effectiveness of the program thereby enhancing the protection being afforded those working on the site.

Accidents on the site or workplace should be investigated to provide information on how such occurrences can be avoided in the future. When injuries or illnesses occur on the site or workplace, they will need to be investigated to determine what needs to be done to prevent this incident from occurring again. Such information will need to be used as feedback on the effectiveness of the program and the information turned into positive steps to prevent any reoccurrence. Receipt of employee suggestions or complaints relating to safety and health issues involved with site or workplace activities is also a feedback mechanism that can be used effectively to improve the program and may serve in part as an evaluative tool(s).

For the development and implementation of the program to be the most effective, professional safety and health personnel should be used. Certified Safety Professionals, Board Certified Industrial Hygienists or Registered Professional Safety Engineers are good examples of professional stature for safety and health managers who will administer the employer's program

2. **Training.** The training programs for employees subject to the requirements of paragraph (e) of this standard should address: the safety and health hazards employees should expect

to find on hazardous waste clean-up sites; what control measures or techniques are effective for those hazards; what monitoring procedures are effective in characterizing exposure levels; what makes an effective employer's safety and health program; what a site safety and health plan should include; hands on training with personal protective equipment and clothing they may be expected to use; the contents of the OSHA standard relevant to the employee's duties and function; and, employee's responsibilities under OSHA and other regulations. Supervisors will need training in their responsibilities under the safety and health program and its subject areas such as the spill containment program, the personal protective equipment program, the medical surveillance program, the emergency response plan and other areas.

The training programs for employees subject to the requirements of paragraph (p) of this standard should address: the employers safety and health program elements impacting employees; the hazard communication program; the medical surveillance program; the hazards and the controls for such hazards that employees need to know for their job duties and functions. All require annual refresher training.

The training programs for employees covered by the requirements of paragraph (q) of this standard should address those competencies required for the various levels of response such as: the hazards associated with hazardous substances; hazard identification and awareness; notification of appropriate persons; the need for and use of personal protective equipment including respirators; the decontamination procedures to be used; preplanning activities for hazardous substance incidents including the emergency response plan; company standard operating procedures for hazardous substance emergency responses; the use of the incident command system and other subjects. Hands-on training should be stressed whenever possible. Critiques done after an incident which include an evaluation of what worked and what did not and how could the incident be better handled the next time may be counted as training time.

For hazardous materials specialists (usually members of hazardous materials teams), the training should address the care, use and/or testing of chemical protective clothing including totally encapsulating suits, the medical surveillance program, the standard operating procedures for the hazardous materials team including the use of plugging and patching equipment and other subject areas.

Officers and leaders who may be expected to be in charge at an incident should be fully knowledgeable of their company's incident command system. They should know where and how to obtain additional assistance and be familiar with the local district's emergency response plan and the state emergency response plan.

Specialist employees such as technical experts, medical experts or environmental experts that work with hazardous materials in their regular jobs, who may be sent to the incident scene by the shipper, manufacturer or governmental agency to advise and assist the person in charge of the incident should have training on an annual basis. Their training should include the care and use of personal protective equipment including respirators; knowledge of the incident command system and how they are to relate to it; and those areas needed to keep them current in their respective field as it relates to safety and health involving specific hazardous substances.

Those skilled support personnel, such as employees who work for public works departments or equipment operators who operate bulldozers, sand trucks, backhoes, etc., who may be called to the incident scene to provide emergency support assistance, should have at least a safety and health briefing before entering the area of potential or actual exposure. These skilled support personnel, who have not been a part of the emergency response plan and do not meet the training requirements, should be made aware of the hazards they face and should be provided all necessary protective clothing and equipment required for their tasks.

3. Decontamination. Decontamination procedures should be tailored to the specific hazards of the site, and may vary in complexity and number of steps, depending on the level of hazard and the employee's exposure to the hazard. Decontamination procedures and PPE decontamination methods will vary depending upon the specific substance, since one procedure or method may not work for all substances. Evaluation of decontamination methods and procedures should be performed, as necessary, to assure that employees are not exposed to hazards by re-using PPE. References in Appendix F may be used for guidance in establishing an effective decontamination program. In addition, the U.S. Coast Guard's Manual, "Policy Guidance for Response to Hazardous Chemical Releases," U.S. Department of Transportation, Washington, DC (COMDTINST M16465.30) is a good reference for establishing an effective decontamination program.

4. Emergency response plans. States, along with designated districts within the states, will be developing or have developed local emergency response plans. These state and district plans should be utilized in the emergency response plans called for in the standard. Each employer should assure that its emergency response plan is compatible with the local plan. The major reference being used to aid in developing the state and local district plans is the Hazardous Materials Emergency Planning Guide, NRT—1. The current Emergency Response Guidebook from the U.S. Department of Transportation, CMA's CHEMTREC and the Fire Service Emergency Management Handbook may also be used as resources.

Employers involved with treatment, storage, and disposal facilities for hazardous waste, which have the required contingency plan called for by their permit, would not need to duplicate the same planning elements. Those items of the emergency response plan that are properly addressed in the contingency plan may be substituted into the emergency response plan required in 1910.120 or otherwise kept together for employer and employee use.

5. Personal protective equipment programs. The purpose of personal protective clothing and equipment (PPE) is to shield or isolate individuals from the chemical, physical, and biologic hazards that may be encountered at a hazardous substance site.

As discussed in Appendix B, no single combination of protective equipment and clothing is capable of protecting against all hazards. Thus PPE should be used in conjunction with other protective methods and its effectiveness evaluated periodically.

The use of PPE can itself create significant worker hazards, such as heat stress, physical and psychological stress, and impaired vision, mobility, and communication. For any given situation, equipment and clothing should be selected that provide an adequate level of protection. However, overprotection, as well as under-protection, can be hazardous and should be avoided where possible.

Two basic objectives of any PPE program should be to protect the wearer from safety and health hazards, and to prevent

injury to the wearer from incorrect use and/or malfunction of the PPE. To accomplish these goals, a comprehensive PPE program should include hazard identification, medical monitoring, environmental surveillance, selection, use, maintenance, and decontamination of PPE and its associated training.

The written PPE program should include policy statements, procedures, and guidelines. Copies should be made available to all employees, and a reference copy should be made available at the worksite. Technical data on equipment, maintenance manuals, relevant regulations, and other essential information should also be collected and maintained.

6. Incident command system (ICS). Paragraph 1910.120(q)(3)(ii) requires the implementation of an ICS. The ICS is an organized approach to effectively control and manage operations at an emergency incident. The individual in charge of the ICS is the senior official responding to the incident. The ICS is not much different than the "command post" approach used for many years by the fire service. During large complex fires involving several companies and many pieces of apparatus, a command post would be established. This enabled one individual to be in charge of managing the incident, rather than having several officers from different companies making separate, and sometimes conflicting, decisions. The individual in charge of the command post would delegate responsibility for performing various tasks to subordinate officers. Additionally, all communications were routed through the command post to reduce the number of radio transmissions and eliminate confusion. However, strategy, tactics, and all decisions were made by one individual.

The ICS is a very similar system, except it is implemented for emergency response to all incidents, both large and small, that involve hazardous substances.

For a small incident, the individual in charge of the ICS may perform many tasks of the ICS. There may not be any, or little, delegation of tasks to subordinates. For example, in response to a small incident, the individual in charge of the ICS, in addition to normal command activities, may become the safety officer and may designate only one employee (with proper equipment) as a backup to provide assistance if needed. OSHA does recommend, however, that at least two employees be designated as back-up personnel since the assistance needed may include rescue.

To illustrate the operation of the ICS, the following scenario might develop during a small incident, such as an overturned tank truck with a small leak of flammable liquid.

The first responding senior officer would implement and take command of the ICS. That person would size-up the incident and determine if additional personnel and apparatus were necessary; would determine what actions to take to control the leak; and, determine the proper level of personal protective equipment. If additional assistance is not needed, the individual in charge of the ICS would implement actions to stop and control the leak using the fewest number of personnel that can effectively accomplish the tasks. The individual in charge of the ICS then would designate himself as the safety officer and two other employees as a back-up in case rescue may become necessary. In this scenario, decontamination procedures would not be necessary.

A large complex incident may require many employees and difficult, time-consuming efforts to control. In these situations, the individual in charge of the ICS will want to delegate different tasks to subordinates in order to maintain a span of control that will keep the number of subordinates, that are reporting, to a manageable level

Delegation of task at large incidents may be by location, where the incident scene is divided into sectors, and subordinate officers coordinate activities within the sector that they have been assigned.

Delegation of tasks can also be by function. Some of the functions that the individual in charge of the ICS may want to delegate at a large incident are: medical services; evacuation; water supply; resources (equipment, apparatus); media relations; safety; and, site control (integrate activities with police for crowd and traffic control). Also for a large incident, the individual in charge of the ICS will designate several employees as back-up personnel; and a number of safety officers to monitor conditions and recommend safety precautions.

Therefore, no matter what size or complexity an incident may be, by implementing an ICS there will be *one individual in charge* who makes the decisions and gives directions; and, all actions, and communications are coordinated through one central point of command. Such a system should reduce confusion, improve safety, organize and coordinate actions, and should facilitate effective management of the incident.

7. Site Safety and Control Plans. The safety and security of response personnel and others in the area of an emergency response incident site should be of primary concern to the incident commander. The use of a site safety and control plan could greatly assist those in charge of assuring the safety and health of employees on the site.

A comprehensive site safety and control plan should include the following: summary analysis of hazards on the site and a risk analysis of those hazards; site map or sketch; site work zones (clean zone, transition or decontamination zone, work or hot zone); use of the buddy system; site communications; command post or command center; standard operating procedures and safe work practices; medical assistance and triage area; hazard monitoring plan (air contaminate monitoring, etc.); decontamination procedures and area; and other relevant areas. This plan should be a part of the employer's emergency response plan or an extension of it to the specific site.

8. **Medical surveillance programs.** Workers handling hazardous substances may be exposed to toxic chemicals, safety hazards, biologic hazards, and radiation. Therefore, a medical surveillance program is essential to assess and monitor workers' health and fitness for employment in hazardous waste operations and during the course of work; to provide emergency and other treatment as needed; and to keep accurate records for future reference.

The Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities developed by the National Institute for Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), the U.S. Coast Guard (USCG), and the Environmental Protection Agency (EPA); October 1985 provides an excellent example of the types of medical testing that should be done as part of a medical surveillance program.

Appendix D—References

The following references may be consulted for further information on the subject of this standard:

1. OSHA Instruction DFO CPL 2.70—January 29, 1986, *Special Emphasis Program: Hazardous Waste Sites.*

2. OSHA Instruction DFO CPL 2-2.37A—January 29, 1986, *Technical Assistance and Guidelines for Superfund and Other Hazardous Waste Site Activities*

3. OSHA Instruction DTS CPL 2.74—January 29, 1986, *Hazardous Waste Activity Form, OSHA 175.*

4. **Hazardous Waste Inspections Reference Manual**, U.S. Department of Labor, Occupational Safety and Health Administration, 1986.

5. Memorandum of Understanding Among the National Institute for Occupational Safety and Health, the Occupational Safety and Health Administration, the United States Coast Guard, and the United States Environmental Protection Agency, *Guidance for Worker Protection During Hazardous Waste Site Investigations and Clean-up and Hazardous Substance Emergencies.* December 18, 1980.

6. **National Priorities List**, 1st Edition, October 1984; U.S. Environmental Protection Agency, Revised periodically.

7. **The Decontamination of Response Personnel**, Field Standard Operating Procedures (F.S.O.P.) 7; U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Hazardous Response Support Division, December 1984.

8. **Preparation of a Site Safety Plan**, Field Standard Operating Procedures (F.S.O.P.) 9; U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Hazardous Response Support Division, April 1985.

9. **Standard Operating Safety Guidelines**; U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Hazardous Response Support Division, Environmental Response Team; November 1984.

10. **Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities**, National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA), U.S. Coast Guard (USCG), and Environmental Protection Agency (EPA); October 1985.

11. **Protecting Health and Safety at Hazardous Waste Sites**; An Overview, U.S. Environmental Protection Agency, EPA/625/9—85/006; September 1985.

12. **Hazardous Waste Sites and Hazardous Substance Emergencies**, NIOSH Worker Bulletin, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health; December 1982.

13. **Personal Protective Equipment for Hazardous Materials Incidents: A Selection Guide**; U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health; October 1984.

14. **Fire Service Emergency Management Handbook**, International Association of Fire Chiefs Foundation, 101 East Holly Avenue, Unit 10B, Sterling, VA 22170, January 1985.

15. **Emergency Response Guidebook**, U.S. Department of Transportation, Washington, DC, 1987.

16. **Report to the Congress on Hazardous Materials Training, Planning and Preparedness**, Federal Emergency Management Agency, Washington, DC, July 1986.

17. **Workbook for Fire Command**, Alan V. Brunacini and J. David Beageron, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269, 1985.

18. **Fire Command**, Alan V. Brunacini, National Fire Protection, Batterymarch Park, Quincy, MA 02269, 1985.

19. **Incident Command System**, Fire Protection Publications, Oklahoma State University, Stillwater, OK 74078, 1983.

20. **Site Emergency Response Planning**, Chemical Manufacturers Association, Washington, DC 20037, 1986.

21. **Hazardous Materials Emergency Planning Guide**, NRT-1, Environmental Protection Agency, Washington, DC, March 1987.

22. **Community Teamwork: Working Together to Promote Hazardous Materials Transportation Safety.** U.S. Department of Transportation, Washington, DC, May 1983.

23. **Disaster Planning Guide for Business and Industry**, Federal Emergency Management Agency, Publication No. FEMA 141, August 1987.

(The Office of Management and Budget has approved the information collection requirements in this section under control number 1218–0139)

SECTION 1

OCCUPATIONAL SAFETY AND HEALTH REGULATIONS AND STANDARDS

PART 2

EPA ORDER 1440.2 - HEALTH AND SAFETY REQUIREMENTS FOR EMPLOYEES ENGAGED IN FIELD ACTIVITIES

ENVIRONMENTAL

PROTECTION **ORDER** 1440.2

AGENCY July 12, 1981

PROTECTIVE SERVICES - SAFETY

HEALTH AND SAFETY REQUIREMENTS FOR EMPLOYEES ENGAGED IN FIELD ACTIVITIES

1. PURPOSE. This order establishes policy, responsibilities, and mandatory requirements for occupational health and safety training and certification, and occupational medical monitoring of Agency employees engaged in field activities.

2. DEFINITIONS.

a. The term "field activities" as used in this Order means EPA program activities that are conducted by EPA employees outside of EPA administered facilities. These activities include environmental and pesticides sampling, inspection of water and wastewater treatment plants, and hazardous material spills and waste site investigations, inspections, and sampling.

b. The term "health and safety training" means scheduled, formal or informal training courses, approved and sponsored by EPA and conducted by EPA or its contracted agents which is designed to develop, improve and upgrade the health and safety knowledge of EPA employees involved in field activities.

c. The term "occupational medical monitoring" means surveillance over the health status of employees by means of periodic medical examinations or screening in accordance with the Agency's Occupational Medical Monitoring guidelines.

d. The term "certification" as used in this Order means that the employee has successfully completed the minimum classroom and field training requirements for the specified level of training and the Agency has issued a certificate attesting that the employee met those requirements.

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3. REFERENCES.

a. 29 CFR 1910, Parts 16, 94, 96, 106, 109, 111, 134, 151, 1000, Occupational Health and Safety Standards

b. Executive Order 12196, Section 1-201, Sec. (k), Occupational Health and Safety Programs for Federal Employees.

c. 29 CFR 1960.59(a), Occupational Safety and Health for the Federal Employee.

d. EPA Occupational Health and Safety Manual, Chapter 7(1).

e. EPA Training and Development Manual, Chapter 3, Par 7(b).

f. Occupational Health and Safety Act of 1971, P.L. 91-596, Sec. 6.

g. EPA Order on Respiratory Protection (Proposed).

h. 49 CFR, Parts 100-177, Transportation of Hazardous Materials.

i. EPA Order 1000.18, Transportation of Hazardous Materials.

j. EPA Order 3100.1, Change 1, Uniforms, Protective Clothing, and Protective Equipment.

4. BACKGROUND. Field activities are a critical part of most EPA programs. These activities range from routine environmental reconnaissance sampling, inspections, and monitoring, to entering and working in environments with known and unknown hazards. Since protection cannot be engineered into the field working situation, the protection of personnel engaged in field activities involves training employees in safe operational procedures and the proper use of appropriate personal protective clothing and equipment.

5. APPLICABILITY. This Order applies to all ERA organizational units which have employees engaged in field activities.

6. POLICY. It is the policy of the Environmental Protection Agency to carry out its field activities in a manner that assures the protection of its employees.

7. RESPONSIBILITIES.

a. Assistant Administrators, Regional Administrators, Deputy Assistant Administrators, Laboratory Directors, and Division Directors. These officials are responsible within their jurisdictions for implementing the provisions of this Order and for budgeting the necessary funds for employee training and certification, personal protective clothing and equipment, and occupational medical monitoring programs.

b. Supervisors. Supervisors are responsible for complying with the requirements of this Order for employee training and certification, and occupational medical monitoring programs. They will identify those employees who require training and certification, and occupational medical monitoring, and assure they receive it to comply with the provisions of this Order and will insure these requirements are properly contained in position descriptions and job postings.

c. Employees. Employees are responsible for making known upon request from their supervisors the extent of their individual occupational health and safety training and the history of their occupational medical monitoring participation. Employees should notify their supervisor of any hazardous work situation and make suggestions for corrective measures. Employees are responsible for applying the knowledge, skills, and techniques acquired through training in a manner that will help assure their health and safety and that of fellow workers.

d. Occupational Health and Safety Designees. The Occupational Health and Safety Designees are responsible for identifying program areas that require training and certification, and occupational medical monitoring; recommending or providing training and certification resources to meet the requirements of this Order; and maintaining records of persons receiving training and certification.

e. Office of Occupational Health and Safety. The Director, Office of Occupational Health and Safety is responsible for establishing policy and requirements for adequate training and certification programs for field activities, developing and maintaining an occupational medical monitoring program, approving health and safety training and certification programs for employees involved in field activities, and for evaluating the results of these training and certification programs.

8. OBJECTIVES.

a, Training and Certification. The objectives of the health and safety training and certification programs for employees involved in field activities are:

(1) To assure that EPA employees are aware of the potential hazards they amy encounter during the performance of field activities;

(2) To provide the knowledge and skills necessary to perform the work with the least possible risk to personal health and safety;

(3) To assure that Agency program goals are accomplished in as safe and healthful manner as feasible; and

(4) To assure that EPA employees can safely disengage themselves from an actual hazardous situation which may occur during a field activity.

b. Occupational Medical Monitoring. The objectives of the occupational Medical Monitoring program are:

(1) To detect any adverse effects of occupational exposure on the employees health and to initiate prompt corrective actions when indicated; and

(2) To assure that employees assigned arduous or physically taxing jobs or jobs requiring unique skills are able to perform those jobs without impairing their health and safety or the health and safety of others.

9. TRAINING AND CERTIFICATION REQUIREMENTS. Employees shall not be permitted to engage in routine field activities until they have been trained and certified to a level commensurate with the degree of anticipated hazards.

a. Basic Level. All employee shall be provided a minimum of 24 hours of health and safety training prior to their becoming involved in normal, routine field activities. The training shall include but not be limited to classroom instruction in all the following subject areas:

(1) Employee Rights and Responsibilities;
(2) Nature of Anticipated Hazards;
(3) Emergency Help and Self-Rescue;
(4) Vehicles - Mandatory Rules and Regulations;
(5) Safe Use of Field Equipment;
(6) Use, Handling, Storage, and Transportation of Hazardous Materials;
(7) Personal Protective Equipment and Clothing, Use and Care;
(8) Safe Sampling Techniques.

In addition to classroom instruction, the employee shall accompany an employee experienced in field activities and perform actual field tasks for a minimum of three days within a period of three months after classroom instruction. Employees satisfactorily completing these requirements will receive certification at the Basic Level of training from the Occupational Health and Safety Designee at the Reporting Unit.

b. Intermediate Level. All inexperienced employees who are to work with experienced employees in uncontrolled hazardous waste and hazardous spill sites investigations or employees engaged in other activities which at a later date are determined by the Director, Office of Occupational Health and Safety, to present unique hazards requiring additional training, shall be provided a minimum of 8 hours of additional health and safety training. This training shall include (in addition to the Basic Level requirements) but not be limited to the following subject manner:

(1) Site surveillance, observation, and safety plan development;
(2) Use and decontamination of totally enclosed protective clothing and equipment;
(3) Use of field test equipment for radioactivity, explosivity, and other measurements; and
(4) Topics specific to other identified activities.

In addition to classroom instruction, the employee shall accompany another employee experienced in hazardous waste and spill site investigations and/or cleanup operations and perform actual field tasks for a minimum of three days within a period of three months after classroom instruction. The employee should also be able to provide on-the-job training and instructions to inexperienced employees during normal, routine field activities (as required above). Employees satisfactorily completing these requirements will be certified at the Intermediate Level by the Occupational Health and Safety Designee and the Reporting Unit.

c. Advanced Level. All employees who manage uncontrolled hazardous waste site and spill site monitoring, sampling, investigations, and cleanup operations shall be provided a minimum of 8 hours additional health and safety training. The classroom training shall include but not be limited to (in addition to the Basic and Intermediate Level requirements), instruction in the following subject areas:

(1) Management of restricted and safe zones;
(2) Rules of Handling the Press and VIP's; and
(3) Safe Use of Specialized Sampling Equipment.

In addition to classroom instruction, the employee shall accompany another employee with experience in managing hazardous waste and spill site investigations or cleanup operations and perform actual field tasks for a minimum of three days within a three month period after receiving classroom instruction. After satisfactorily completing these requirements, employees will receive Advanced Level certification from the Occupational Health and Safety Designee at the Reporting Unit.

d. General.

(1) An employee may receive certification at the next higher level by completing only the additional training requirements if certified at the next lower level within the previous one-year period.

(2) The Director, Office of Occupational Health and Safety, may certify employees based on an evaluation of previous training, education, and experience. Recommendations for this type certification should be made to the Director by the Occupational Health and Safety Designee at the Reporting Unit.

10. FREQUENCY OF TRAINING. Employees at the Basic, Intermediate and Advanced Levels shall complete a minimum of 8 hours of refresher classroom instruction annually consisting of a review of all subject areas to maintain their certification. In addition to the classroom instruction, employees shall have demonstrated by having performed actual field tasks that they have sufficient practical experience to perform their assigned duties in a sage and healthful manner.

11. RECORD OF TRAINING

a. A record of the level of training and certification shall be maintained in the employee's official personnel file.

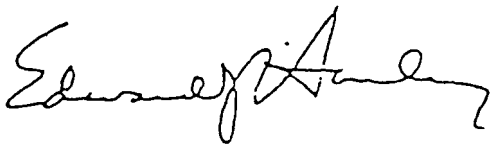
b. The Occupational Health and Safety Designee shall maintain a roster of employee training and certification so that a schedule of annual training can be established.

c. The Occupational Health and Safety Designee shall issue a certificate to the employee showing the level of training and certification.

12. OCCUPATIONAL MEDICAL MONITORING REQUIREMENTS. All employees routinely engaged in field activities which present the probability of exposure to hazardous or toxic substances, which are arduous or physically taxing, or which require the use of respiratory protective equipment shall be included in the Agency's Occupational Medical Monitoring Program. Employees should not be permitted to engage in field activities unless they have undergone a baseline medical examination (as defined in the Agency's Occupational Medical Monitoring Guidelines), which will show physical fitness and provide a base to measure any adverse effects their activities may have on these individuals.

13. SAVINGS PROVISION. Changes in the Act, Executive Order, or EPA and OSHA standards and guidelines which occur after the effective date of this Order will automatically come under the purview of this Order on the effective date of the change.

Full implementation of this Order shall be within one year of its effective date.



Edward J. Hanley
Director, Office of Management
Information and Support Services

SECTION 1

OCCUPATIONAL SAFETY AND HEALTH REGULATIONS AND STANDARDS

PART 3

OTHER OSHA, FEDERAL, AND NFPA REGULATIONS AND STANDARDS RELATED TO HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE WORKER PROTECTION

RELATED OSHA REGULATIONS

GENERAL DUTY CLAUSE OF THE OCCUPATIONAL SAFETY AND HEALTH ACT (OSH Act) OF 1970

The OSH Act, Section 5(a)(1) states that each employer "shall furnish to each of his employees employment and a place of employment which

causing or are likely to cause death or serious physical harm to his employees".

LOG AND SUMMARY OF OCCUPATIONAL INJURIES AND ILLNESSES

29 CFR 1904.24 requires that each employer maintain a log of all recordable occupational injuries and illnesses and that the information be recorded in the log within six working days of the receipt of the information. Form OSHA No. 200 or its equivalent is to be used for this purpose.

ACCESS TO EMPLOYEE EXPOSURE AND MEDICAL RECORDS

29 CFR 1910.20 requires that an employer provide exposure and medical records to an employee or designated representative within fifteen days after the request for access to records. If the employee requests copies of this information, the employer must make the copies available to the employee at no cost. All employee medical records must be maintained by the employer for the duration of employment plus 30 years.

EMPLOYEE EMERGENCY PLANS AND FIRE PREVENTION PLANS

29 CFR 1910.38 applies to all emergency action plans and fire prevention plans required by particular OSHA standards. With the exception of employers with 10 or fewer employees, both the emergency action plan and the fire prevention plan are required in writing. The required elements of each of these plans are provided in the regulation. If the employer has 10 or fewer employees, the elements of both types of plans must be provided orally to employees. The employer shall also perform housekeeping and maintenance of equipment and systems as part of the fire prevention plan.

OCCUPATIONAL NOISE AND EXPOSURE

29 CFR 1910.95 states that it is important that area and personal noise surveys be conducted to categorize noise levels appropriately. A sound level meter that has the capability to integrate and average sound levels over the course of a work day is required. The OSHA-Permissible Exposure Limit for an eight-hour

recorded on a sound level meter on the A weighted scale. An employer shall implement a hearing conservation program if 8-hour time weighted average noise exposures equal or exceed 85 decibels on the A scale. Continuous intermittent and impulsive sound levels of 80 dBA or greater shall be integrated into the time weighted average.

IONIZING RADIATION

29 CFR 1910.96 covers employee protection measures related to the possession, use, or transfer of ionizing radiation. The regulations set limitations on employee exposure to ionizing radiation and provide methods for establishing precautionary procedures and personnel monitoring, including surveys of radiation hazards, monitoring equipment, marking of

radiation areas, emergency evacuation warning signals, and personnel instruction. The regulations require notification of incidents of releases, overexposure, or excessive levels or concentrations of radiation, and specify that employer must keep records of employee exposure and disclose the information upon request from a former employee.

CHEMICAL PROCESS SAFETY

29 CFR 1910.119 establishes procedures for process safety management that will protect employees by preventing or minimizing the consequences of chemical accidents involving highly hazardous chemicals.

PERSONAL PROTECTIVE EQUIPMENT

29 CFR 1910.132-1910.136 requires the provision of personal protective equipment for eye, face, head, and extremities in hazardous environments. This protective equipment must be provided, used, and maintained in sanitary and reliable condition. Specific requirements are described as follows:

Section 133 - Eye and Face Protection

29 CFR 1910.133 requires provision of protective eye and face equipment when there is the potential for on-site injury. Particular information on goggles, spectacles, and face protection is included. Design, construction, testing, and use of such devices must be in accordance with ANSI Z87.1-1968 specifications. The regulation also addresses the proper use, maintenance, and repair of the equipment.

Section 134 - Respiratory Protection

29 CFR 1910.134 presents guidance for respiratory protective equipment. It requires the provision and use of appropriate respirators when engineering controls are not feasible to control atmospheric contamination. Employers must develop atmospheric protection for workers, provide and maintain respiratory equipment, establish operating procedures and employee training for respirator use, and adhere to air quality requirements. Employers must also set up a program of regular inspection of respirators for defects and repair needs. Gas mask canisters must be appropriately identified through use of a color code.

Section 135 - Occupational Head Protection

29 CFR 1910.135 requires head protection for on-site workers in the following situations: presence of overhead objects,f operation of heavy equipment, potential for flying objects in the work area, and possible electrical shock hazard. In addition to protecting workers from falling or flying objects, head protection affords limited protection from electric shock and burn. Head protection must meet ANSI Z89.1 -1969 specifications.

Section 136 - Occupational Foot Protection

29 CFR 1910.136 requires that safety toe footwear for employees meet ANSI Z41.1-1967 standards. In general, workers at hazardous waste sites must wear leather or rubber boots with steel toes and steel shanks.

SANITATION

29 CFR 1910.141 contains specifications conccerning appropriate housekeeping, waste disposal, vermin control, water supply, toilet and washing facilities, showers, change rooms, waste disposal containers, sanitary storage, and food handling for permanent places of employment are provided in this regulation.

MEDICAL SERVICES AND FIRST AID

29 CFR 1910.151 states that if a medical facility is not located in proximity to the workplace, there shall be a person or persons on-site with adequate first-aid training. First aid supplies

approved by a consulting physician shall be available on-site. If there is a potential for corrosive materials on-site, suitable facilities shall be available for drenching of eyes and skin.

FIRE BRIGADES

29 CFR 1910.156 applies to fire brigades, industrial fire departments, and contractual-type fire departments. The requirements cover organization, training, and personal protective equipment (PPE) for fire brigades whenever they are established by the employer.

EMPLOYEE ALARM SYSTEMS

29 CFR 1910.165 states that the employee alarm system shall be recognizable to all on-site employees. The signal from the employee alarm system shall be audible to employees in the event of a need to warn employees of an evacuation from work areas.

TOXIC AND HAZARDOUS SUBSTANCES

In Subpart Z, 29 CFR 1910.1000, there are other applicable OSHA standards that refer to particular air sampling procedures for chemical contaminants, PPE requirements, and record keeping for a variety of compounds.

29 CFR 1910.1001	Asbestos
29 CFR 1910.1002	Coal tar pitch volatiles
29 CFR 1910.1003	4-nitrobiphenyl
29 CFR 1910.1004	Alpha-Naphthylamine
29 CFR 1910.1006	Methyl chloromethyl-ether
29 CFR 1910.1007	3,3'-dichlorobenzidine
29 CFR 1910.1008	bis-chloromethyl ether
29 CFR 1910.1010	Benzidine
29 CFR 1910.1011	4-aminodiphenyl
29 CFR 1910.1012	Ethyleneimine
29 CFR 1910.1013	bata-propiolactone
29 CFR 1910.1014	2-acetylaminofluorene
29 CFR 1910.1015	4-dimethylaminoazo-benzene
29 CFR 1910.1016	N-nitrosodi-methylamine
29 CFR 1910.1017	Vinyl chloride
29 CFR 1910.1018	Inorganic arsenic
29 CFR 1910.1025	Lead
29 CFR 1910.1028	Benzene
29 CFR 1910.1029	Coke oven emissions
29 CFR 1910.1044	1,2-dibromo-3-chloro-propane
29 CFR 1910.1045	Acrylonitrile
29 CFR 1910.1047	Ethylene oxide
29 CFR 1910.1048	Formaldehyde

BLOODBORNE PATHOGENS

29 CFR 1910.1030 requires occupational exposure to blood or other potentially infectious materials be minimized or eliminated using a combination of engineering and work practice controls, personal protective clothing and equipment, training, medical surveillance, Hepatitis B vaccination, signs and labels, and other provisions.

HAZARD COMMUNICATION STANDARD

29 CFR 1910.1200 ensures that produced or imported chemical hazards are evaluated and information concerning these hazards is communicated to affected employers and employees. This is accomplished through hazard communication programs which include container labels and warnings, material safety data sheets, and employee information training. These requirements apply to any chemical which is known to be present in the workplace to which employees may be exposed. Any chemical produced in or imported to the workplace must be evaluated to determine if it is hazardous. If a chemical is identified as hazardous, the employer must develop and implement certain standards (i.e., warnings, labels, data sheets, employee information, and training) to ensure employee safety and protection. Section 1200 also defines health hazards related to chemicals, explains mandatory

hazard determination, lists information sources for hazard determination, and discusses the issue of trade secrets in the context of chemical hazards.

HAZARDOUS CHEMICALS IN LABORATORIES

29 CFR 1910.1450 requires the forrmationand implementation of a Chemical Hygiene Plan (CHP) to maintain employee exposures at or below permissible exposure levels (PELs) in laboratories. The CHP must include necessary work practices, procedures, and policies to ensure that employees are protected from all potentially hazardous chemicals in use in their work area.

SAFETY AND HEALTH REGULATIONS FOR CONSTRUCTION

29 CFR 1926 sets forth safety and health standards under Section 107 of the Contract Work Hours and Safety Standards Act. The regulations state that no contractor or subcontractor can require laborers or mechanics to work under conditions that are unsanitary, hazardous, or dangerous to health and safety. Safety training and education programs concerning recognition and prevention of unsafe conditions will be established by OSHA and used by employers to control or eliminate hazards. Employers must practice proper fire prevention, housekeeping, and sanitation. Part 1926 is divided into twenty-four specific areas including:

- Subpart A — General
- Subpart B — General Interpretations
- Subpart C — General Safety and Health Provisions
- Subpart D — Occupational Health and Environmental Controls
- Subpart E — Personal Protective and Life Saving Equipment
- Subpart F — Fire Protection and Prevention
- Subpart G — Signs, Signals, and Barricades
- Subpart H — Materials Handling, Storage, Use, and Disposal
- Subpart I — Tools - Hand and Power
- Subpart J — Welding and Cutting
- Subpart K — Electrical
- Subpart L — Ladders and Scaffolding
- Subpart M — Floors and Wall Openings, and Stairways
- Subpart N — Cranes, Derricks, Hoists, Elevators, and Conveyors
- Subpart O — Motor Vehicles, Mechanized Equipment and Marine Operations
- Subpart P — Excavations, Trenching, and Shoring
- Subpart Q — Concrete, Concrete Forms, and Shoring
- Subpart R — Steel Erection
- Subpart S — Tunnels and Shafts, Caissons, Cofferdams, and Compressed Air
- Subpart T — Demolition
- Subpart U — Blasting and Use of Explosives
- Subpart V — Power Transmission and Distribution
- Subpart W — Rollover Protective Structures; Overhead Protection
- Subpart X — Effective Dates

FEDERAL REGULATIONS RELATED TO WORKER PROTECTION

RESPIRATORY PROTECTIVE DEVICES

30 CFR Part 11 is the Mine Safety and Health Administration (MSHA) program to certify respiratory protective devices. It requires that NIOSH (National Institute for Occupational Safety and Health) and/or MSHA certify any respiratory protective device before it can be used. Respirators for use in hazardous atmospheres must be approved, used, and maintained in accordance with the provisions of American National Standard Practices for Respiratory Protection. Thirteen subparts outline procedures for the approval process for respirators as well as inspection, examination, and testing requirements:

- Subpart A General Provisions
- Subpart B Application for Approval
- Subpart C Fees
- Subpart D Approval and Disapproval
- Subpart E Quality Control
- Subpart F Classification of Approved Respirators; Scope of Approval; Atmospheric Hazards; Service Time
- Subpart G General Construction and Performance Requirements
- Subpart H Self-Contained Breathing Apparatus
- Subpart I Gas Masks
- Subpart J Supplied-Air Respirators
- Subpart K Dust, Fume, and Mist Respirators
- Subpart L Chemical Cartridge Respirators
- Subpart M Pesticide Respirators
- Subpart N Special Use Respirators

NATIONAL CONTINGENCY PLAN

The National Contingency Plan is required by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by Superfund Amendments and Reauthorization Act of 1986 (SARA). The revised National Oil and Hazardous Substances Pollution Contingency Plan (National Contingency Plan or NCP) was signed by the EPA Administrator on February 2, 1990. The NCP covers discharges of oil into navigable waters and releases of hazardous substances into the environment. It provides for efficient, coordinated, and effective response to discharges of such substances. The NCP consists of the following Subparts:

- Subpart A Introduction
- Subpart B Responsibility and Organization for Response
- Subpart C Planning and Preparedness
- Subpart D Operational Response Phases for Oil Removal
- Subpart E Hazardous Substance Response
- Subpart F State Involvement in Hazardous Substance Response
- Subpart G Trustees for Natural Resources
- Subpart H Participation by Other Persons
- Subpart I Administrative Record for Selection of Response Action
- Subpart J Use of Dispersants and Other Chemicals
- Subpart K Federal Facilities (Reserved)

The NCP requires planning and coordination for response to oil and hazardous substance releases and it requires that the National Response Center (NRC) be notified of a release. The National Response Team (NRT) is responsible for national planning and coordination of response actions and the Regional Response Team (RRT) is responsible for regional planning and preparedness activities. The RRT also provides assistance and advice to the On-Scene Coordinator (OSC) who directs the response to the release.

HAZARDOUS MATERIALS TRANSPORTATION REGULATIONS

49 CFR specifies shipping regulations for a variety of different materials. All parties involved with the shipment of hazardous materials must be cognizant of the restrictions that apply to these materials. These restrictions regulate hazardous materials transport for aircraft, motor carriers, rail carriage, and vessel carriage. 49 CFR provides a hazardous materials table referencing appropriate packaging and labeling requirements. The regulations require notification to Federal authorities in the event of a release of a hazardous material.

THE REPORTABLE QUANTITIES PROGRAM

The purpose of the "reportable quantities" (RQ) program is to alert Federal, State, and local response authorities of releases of hazardous substances that may potentially pose a threat to public health, welfare, or the environment. These government authorities are notified when a certain threshold, or RQ, of the hazardous substance is released into the environment.

Specifically, CERCLA section 103 requires the release of a CERCLA hazardous substance in an RQ or more to be reported immediately to the National Response Center (NRC). If the release is less than an RQ, no report is necessary. RQs serve as a trigger for informing response authorities of a hazardous substance release so that they can evaluate the need for a response action, and undertake any necessary action in a timely fashion. RQs do not reflect a determination that a release of a substance will be hazardous at the RQ level and not hazardous below that level. A Federal On-Scene Coordinator makes the risk determination based on the unique circumstances of the release. Title III of SARA supplements this NRC reporting with additional emergency notification requirements to State and local response officials.

The RQ program is a integral part of Superfund. To control acute threats, Federal, State, and local emergency responnseauthorities need to know about them. The release reporting requirements of Superfund are quite broad. Although several reporting exemptions are provided, thousands of reports are still required each year to the National Response Center, State emergency response commissions, and local emergency planning committees. Because the potential liability for failure to notify is great, and the effort required to comply generally is quite small, it is of interest to all organizations that handle hazardous substances to learn and understand their reporting obligations.

REIMBURSEMENT TO LOCAL GOVERNMENT FOR EMERGENCY RESPONSE TO HAZARDOUS SUBSTANCE RELEASES

40 CFR Part 310 contains regulations, developed under section 123 of CERCLA, concerning procedures for reimbursing local governments for expenses incurred in carrying out temporary emergency measures in response to hazardous substance threats. These measures must be necessary to prevent or mitigate injury to human health and the environment from a release of a hazardous substance or a pollutant or contaminant. Temporary emergency measures may include such activities as erecting security fencing to limit access, responding to fires and explosions and other measures that require immediate response at a local level. The intent of the reimbursement program is to alleviate significant financial burden on a local government resulting from such responses.

SARA TITLE I/TITLE III EMERGENCY RESPONSE PLANNING REQUIREMENTS

TITLE I EMERGENCY RESPONSE PLANNING REQUIREMENTS 29 CFR 1910.120 (q)(2)	TITLE III PLANNING REQUIREMENTS FOR LEPCs
(i) Pre-emergency planning and coordination with outside parties	• Identify facilities and transportation routes of extremely hazardous substances (EHSs)

The LEPC plan must only cover EHSs; the Title I plan will need to include more hazardous chemicals (e.g., CERCLA hazardous substances, RCRA hazardous wastes).

(ii) Personnel roles, lines of authority, training, and communications	• Designate a community coordinator and facility coordinator(s) to implement the LEPC plan

Title III simply requires the identification of community and facility emergency coordinators. Although some explanation of the individuals' responsibilities should be included in the LEPC plan, the plan will not cover the specifics of an Incident Command System (ICS) or the lines of authority below the coordinators that the Title I plan requires. The site security and control requirements under Title I refers to procedures that limit personnel on site to those who are actively performing emergency operations. The LEPC plan would probably not include detailed emergency response information of this type.

(iii) Emergency recognition and prevention	• Describe methods for determining the occurrence of a release and the probable affected area and population

The LEPC plan should contain specific guidelines for approach, recognition, and evaluation of releases. This may include generic types of hazards and guidance. The Title I requirements must include the same type of information. The LEPC requirement includes specifics on determining the probable affected area because the LEPC plan is community oriented. The Title I plan should contain more specifics geared towards the actual responders.

TITLE I EMERGENCY RESPONSE PLANNING REQUIREMENTS 29 CFR 1910.120 (q)(2)	TITLE III PLANNING REQUIREMENTS FOR LEPCs
(iv) Safe distances and places of refuge	• Outline evacuation plans

These planning elements overlap. The plans must identify potential conditions requiring evacuation, an indication of how evacuation distances are determined, the designated authority for ordering evacuations, shelter facilities, means for locating "sensitive populations" (e.g., elderly, handicapped), evacuation routes and procedures, and designated authority to make re-entry decisions.

(v) Site security and control

See paragraph (ii)

(vi) Evacuation routes and procedures

See paragraph (iv)

(vii) Decontamination	• Describe emergency response procedures, on-site and off-site

Overlap may exist to some extent. Both plans must address alternate means of communication and public altering procedures, and should designate a person to be in charge of public information during an incident. The Title I decontamination requirement is a specific emergency response procedure. The LEPC plan requirements are intended to include standard emergency response procedures; LEPC plans may not be sufficiently specific to satisfy the requirements under Title I.

(viii) Emergency medical treatment and first aid	• Describe community and industry emergency equipment and facilities, and the identity of persons responsible for them

Both rules require equipment to be identified for various levels and types of emergencies. References to neighboring jurisdictions' equipment and facility resources should be included and arrangements, either formal or informal, should be made for their use during an emergency. Maintenance schedules may also be included in both plans. PPE is a specific type of equipment that must be addressed in the Title I plan. Emergency medical treatment and first aid must be addressed explicitly in the Title I plan.

TITLE I EMERGENCY RESPONSE PLANNING REQUIIREMENTS 29 CFR 1910.120 (q)(2)	TITLE III PLANNING REQUIREMENTS FOR LEPCs
(ix) Emergency alerting and response	• Outline emergenc notification procedures procedures
See paragraph (vii)	
(x) Critique of response and follow-up	• Present methods and schedules for exercising emergency response plans
These two criteria are different and complementary. The LEPC requirement refers to table-top exercises or simulated accidents to test a variety of local response systems. The Title I requirement specifies that following an actual event, participants critique the response in order to improve capabilities for the next accident. The two requirements together provide an opportunity to test the plan and learn from the results of a response.	
(xi) PPE and emergency requirements	
See paragraph (viii)	
(xii) Emergency response organizations may use the local emergency response plan or the State emergency response plan or both, as part of their emergency response plan to avoid duplication. Those items of the emergency response plan that are being properly addressed by the SARA Title III plans may be substituted into their emergency plan or otherwise kept together for the employer and employee's use.	• The LEPC may develop their plan based on the guidance provided by the National Response Team (Hazardous Materials Emergency Planning Guide, NRT-1). This document provides additional information on the nine general planning requirements and reinforces the importance of the planning process for the community.

SARA TITLE I/TITLE III EMERGENCY RESPONSE TRAINING REQUIREMENTS

TITLE I EMERGENCY RESPONSE TRAINING REQUIREMENTS 29 CFR 1910.120 (q)(6)	TITLE III TRAINING REQUIREMENTS FOR LEPCs
• Training shall be based on duties and functions to be performed by each responder of an emergency response organization	• Describe a training program for emergency response personnel (including schedules)

Title I requires specific training for employees engaged in emergency response, based on 5 categories of responders: first responder awareness level, first responder operations level, hazardous materials technician, hazardous materials specialist, and on-scene incident commander. The Title III planning requirements were developed prior to the OSHA regulations and thus may not specifically address the training programs and schedules necessary to fulfill the OSHA requirements.

SUMMARY OF COMPARISON The primary difference between the Title I and the Title III requirements is the intended audience. Title III has nine very general planning elements that allow a community to develop emergency plans based on their perceived needs. Title I contains the federally-determined, specific criteria for employer plans to protect emergency responders. A good LEPC plan may significantly overlap with the Title I plan; however a good LEPC plan may also be too general for Title I purposes.

RELATED NATIONAL FIRE PROTECTION ASSOCIATION STANDARDS

RESPONDING TO HAZARDOUS MATERIALS INCIDENTS

NFPA 471 recommends procedures and practices for mitigating hazardous materials incidents. Topics include decontamination, methods of mitigation, chemical protective clothing, and safety.

PROFESSIONAL COMPETENCE OF RESPONDERS TO HAZARDOUS MATERIALS INCIDENTS

NFPA 472 deals with training and capabilities that are required at various levels of response to hazardous materials incidents, including First Responder Awareness and Operational levels; the Technician level; and the Specialist level. An appendix deals with management of an incident.

PROFESSIONAL COMPETENCE OF EMERGENCY MEDICAL SERVICES RESPONDERS TO HAZARDOUS MATERIALS INCIDENTS

NFPA 473 identifies the level of competence required of emergency medical services personnel who respond to hazardous materials incidents. The competencies outlined have been prepared to reduce the numbers of accidents, exposure, and injuries resulting from HAZMAT incidents.

IDENTIFICATION OF THE FIRE HAZARDS OF MATERIALS

NFPA 704 presents a system of recognizable markings ("Hazard Diamond") that indicate the relative reactivity, flammability, and health hazards of materials in storage. Includes expanded definitions for the Health and Reactivity Hazard Ratings.

FIRE DEPARTMENT OCCUPATIONAL SAFETY AND HEALTH PROGRAM

NFPA 1500 provides minimum standard requirements for a fire service related occupational safety and health program for all career and volunteer departments. Covers organization, training and education, vehicles and equipment, protective clothing, protective equipment, facilities, safety, medical and member assistance programs.

FIRE DEPARTMENT SAFETY OFFICER

NFPA 1501 outlines the duties of a Fire Department Safety Officer, and requires every department to have a safety officer.

FIRE DEPARTMENT INCIDENT MANAGEMENT SYSTEM

NFPA 1561 provides minimum criteria for emergency incident management. Such incident management systems are intended to provide structure, coordination, and effectiveness of all emergency incidents to enhance safety and health of fire department members and other persons involved.

FIRE DEPARTMENT INFECTION CONTROL PROGRAM

NFPA 1581 specifies minimum requirements for infection control practices for public safety and emergency response personnel providing EMS care and in contact with potentially infectious persons and materials in emergency

settings, and for universal precautions for infection control in routine or non-emergency settings.

PROTECTIVE CLOTHING AND EQUIPMENT FOR STRUCTURAL FIREFIGHTING AND STATION / WORK UNIFORMS

NFPA 1971-Protective Clothing

NFPA 1971 specifies minimum performance, design, and testing requirements for protective coats, trousers and hoods.

NFPA 1972-Helmets

NFPA 1971 specifies performance criteria and test methods for helmets.

NFPA 1973-Gloves

NFPA 1972 specifies minimum performance criteria and test methods for the materials and construction of gloves.

NFPA 1974-Footwear

NFPA 1974 specifies minimum standard design, performance, and testing requirements for protective footwear.

NFPA 1975-Station/Work Uniforms

NFPA 1975 specifies performance criteria and test methods for uniforms worn under protective clothing.

OPEN-CIRCUIT SELF-CONTAINED BREATHING APPARATUS

NFPA 1981 specifies performance criteria and testing methods for open-circuit self-contained breathing apparatus (SCBA) in addition to NIOSH/OSHA certification.

VAPOR-PROTECTIVE SUITS FOR HAZARDOUS CHEMICALS EMERGENCIES

NFPA 1991 specifies minimum design, performance, testing, and documentation requirements for vapor-protective suits for protection from exposure to specified chemicals in vapor and splash environments. Covers technical documentation, chemical permeation resistance, suit pressurization, water permeation, penetration resistance of closures, exhaust valve leaking and cracking pressure; and materials for testing for burst, tear, abrasion, flammability, cold performance and flexural fatigue.

LIQUID SPLASH-PROTECTIVE SUITS FOR HAZARDOUS CHEMICALS EMERGENCIES

NFPA 1992 specifies minimum design, performance, testing, and documentation requirements for liquid splash-protective suits for protection from exposure to specified chemicals in liquid splash environments. Covers technical documentation, chemical permeation resistance, and water permeation; and materials for testing for burst, tear, abrasion, flammability, cold performance and flexural fatigue.

SUPPORT FUNCTION GARMENTS FOR HAZARDOUS CHEMICALS OPERATIONS

NFPA 1993 specifies minimum design, performance, testing, and documentation requirements garments worn by personnel performing support functions in known, controlled atmospheres outside the "hot zone" at a hazardous material incident.

NFPA STANDARDS ARE AVAILABLE FROM:

National Fire Protection Association
1 Batterymarch Park
P.O. Box 9101
Qunicy, MA 02269-9101
(617) 770-3000

SECTION 1

OCCUPATIONAL SAFETY AND HEALTH REGULATIONS AND STANDARDS

PART 4

NIOSH CRITERIA FOR A RECOMMENDED STANDARD FOR WORKING IN CONFINED SPACES

criteria for a recommended standard. . .

WORKING in CONFINED SPACES

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

December 1979

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PREFACE

The Occupational Safety and Health Act of 1970 emphasizes the need for standards to protect the health and safety of workers exposed to an ever-increasing number of potential hazards in their workplace.

The National Institute for Occupational Safety and Health (NIOSH) evaluates all available research data and criteria and recommends standards for safe work practices and occupational exposure to toxic substances. The Secretary of Labor will weigh these recommendations along with other considerations, such as feasibility and means of implementation, in promulgating regulatory standards.

NIOSH will periodically review the recommended standards to ensure continuing protection of workers and will make successive reports as new research and epidemiologic studies are completed and as engineering controls for the workers safety are developed.

The contributions to this document on working in confined spaces by members of the NIOSH staff, other Federal agencies or departments, the review consultants, and Robert B. O'Connor, M.D., NIOSH consultant in occupational medicine, are gratefully acknowledged.

The views and conclusions expressed in this document, together with the recommendations for a standard, are those of NIOSH. They are not necessarily those of the consultants, the reviewers selected by professional and trade associations, or other Federal agencies. However, all comments, whether or not incorporated, were considered carefully and were sent with the criteria document to the Occupational Safety and Health Administration for consideration in setting the standard. The review consultants and the Federal agencies which received the document for review appear on pages v and vi respectively.

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Department of Defense

- Department of the Army
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- Department of the Navy
  - Naval Regional Medical Center

Department of Commerce
- Maritime Administration

Department of Health, Education, and Welfare
- National Institute of Health

Department of Interior
- Bureau of Mines

Department of Labor
- Mine Safety and Health Administration
- Occupational Safety and Health Administration

National Aeronautics and Space Administration

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I. RECOMMENDATIONS FOR A STANDARD FOR WORKING IN CONFINED SPACES

NIOSH recommends the procedures set forth in the following sections as a means of protecting the health, and significantly reducing accidental injury and death associated with entering, working in, and exiting from confined spaces. The standard is designed not only to make the confined space safe for the worker, but also to make the worker cognizant of the hazards associated with this work area and the safe work practices necessary to deal with these hazards. The criteria and standard will be reviewed and revised as necessary.

Section 1 - Definitions - For Purposes of this Document

Atmosphere	Refers to the gases, vapors, mists, fumes, and dusts within a confined space.
Ceiling Level	The maximum airborne concentration of a toxic agent to which an employee may be exposed for a specified period of time.
Combustible Dust	A dust capable of undergoing combustion or of burning when subjected to a source of ignition.
Confined Space	Refers to a space which by design has limited openings for entry and exit; unfavorable natural ventilation which could contain or produce dangerous air contaminants, and which is not intended for continuous employee occupancy. Confined spaces include but are not limited to storage tanks, compartments of ships, process vessels, pits, silos, vats, degreasers, reaction vessels, boilers, ventilation and exhaust ducts, sewers, tunnels, underground utility vaults, and pipelines.
Confined Space, Class "A"	A confined space that presents a situation that is immediately dangerous to life or health (IDLH). These include but are not limited to oxygen deficiency, explosive or flammable atmospheres, and/or concentrations of toxic substances.
Confined Space, Class "B"	A confined space that has the potential for causing injury and illness, if preventive measures are not used, but not immediately dangerous to life and health.
Confined Space, Class "C"	A confined space in which the potential hazard would not require any special modification of the work procedure.

Hot Work	Any work involving burning, welding, riveting, or similar fire producing operations, as well as work which produces a source of ignition, such as drilling, abrasive blasting, and space heating.
Inerting	Displacement of the atmosphere by a non-reactive gas (such as nitrogen) to such an extent that the resulting atmosphere is noncombustible.
Isolation	A process whereby the confined space is removed from service and completely protected against the inadvertent release of material by the following: blanking off (skillet type metal blank between flanges), misaligning sections of all lines and pipes, a double block and bleed system, electrical lockout of all sources of power, and blocking or disconnecting all mechanical linkages.
Lower Flammable Limit (LFL)	The minimum concentration of a combustible gas or vapor in air (usually expressed in percent by volume at sea level), which will ignite if an ignition source (sufficient ignition energy) is present.
Oxygen Deficiency	Refers to an atmosphere with a partial pressure of oxygen (PO_2) less than 132 mm Hg. Normal air at sea level contains approximately 21% oxygen at a PO_2 of 160 mm Hg. At an altitude of 5,280 feet normal air contains approximately 21% O_2 at a PO_2 of 132 mm Hg.
Oxygen Enriched Atmosphere	Any oxygen concentration greater than 25% (PO_2 - 190 mm Hg) at normal atmospheric pressure.
Permissible Exposure Limit (PEL)	The maximum 8-hour time weighted average of any airborne contaminant to which an employee may be exposed. At no time shall the exposure level exceed the ceiling concentration for that contaminant as listed in 29 CFR Part 1910 Sub Part Z.
Purging	The method by which gases, vapors, or other airborne impurities are displaced from a confined space.
Qualified Person	A person designated by the employer, in writing, as capable (by education and/or specialized training) of anticipating, recognizing, and evaluating employee

	exposure to hazardous substances or other unsafe conditions in a confined space. This person shall be capable of specifying necessary control and/or protective action to insure worker safety.
Respirator (Approved)	A device which has met the requirements of 30 CFR Part 11 and is designed to protect the wearer from inhalation of harmful atmospheres and has been approved by the Bureau of Mines and the National Institute for Occupational Safety and Health, and Mine Safety and Health Administration (formerly, Mining Enforcement and Safety Administration).
Standby Person	A person trained in emergency rescue procedures and assigned to remain on the outside of the confined space and to be in communication with those working inside.

Section 2 - Entry and Rescue

The Confined Space Classification Table on page 4 is based on existing or potential hazards relative to the confined space. The classification is based upon the characteristics of the confined space, oxygen level, flammability and toxicity. If any of the hazards present a situation which is immediately dangerous to life or health (IDLH), the confined space shall be designated Class A. The classification shall be determined by the most hazardous condition of entering, working in, and exiting a confined space. Class B confined space has the potential for causing injury and illness but is not immediately dangerous to life and health. A Class C entry would be one in which the hazard potential would not require any special modification of the work procedure.

The Check List of Consideration on page 5 delineates the minimum preparation required for each class of confined space entry. In the recommended standard where specific procedures, activities or requirements are correlated with a classification: the procedure, activity or requirement is mandatory. As an example, Section 3 - Permit System (Class A, B and C) means that a permit is mandatory for Class A, B, and C confined space entry.

CONFINED SPACE CLASSIFICATION TABLE

Parameters	Class A	Class B	Class C
Characteristics	immediately dangerous to life - rescue procedures require the entry of more than one individual fully equipped with life support equipment - maintenance of communication requires an additional standby person stationed within the confined space	dangerous, but not immediately life threatening - rescue procedures require the entry of no more than one individual fully equipped with life support equipment - indirect visual or auditory communication with workers	potential hazard - requires no modification of work procedures - standard rescue procedures - direct communication with workers, from outside the confined space
Oxygen	16% or less *(122 mm Hg) or greater than 25% *(190 mm Hg)	16.1% to 19.4% *(122 - 147 mm Hg) or 21.5% to 25% (163 - 190 mm Hg)	19.5% - 21.4% *(148 - 163 mm Hg)
Flammability Characteristics	20% or greater of LFL	10% - 19% LFL	10% LFL or less
Toxicity	**IDLH	greater than contamination level, referenced in 29 CFR Part 1910 Sub Part Z - less than **IDLH	less than contamination level referenced in 29 CFR Part 1910 Sub Part Z

*Based upon a total atmospheric pressure of 760 mm Hg (sea level)
**Immediately Dangerous to Life or Health - as referenced in NIOSH Registry of Toxic and Chemical Substances, Manufacturing Chemists data sheets, industrial hygiene guides or other recognized authorities.

CHECK LIST OF CONSIDERATIONS FOR ENTRY,
WORKING IN AND EXITING CONFINED SPACES

ITEM	CLASS A	CLASS B	CLASS C
1. Permit	X	X	X
2. Atmospheric Testing	X	X	X
3. Monitoring	X	O	O
4. Medical Surveillance	X	X	O
5. Training of Personnel	X	X	X
6. Labeling and Posting	X	X	X
7. Preparation			
Isolate/lockout/tag	X	X	O
Purge and ventilate	X	X	O
Cleaning Processes	O	O	O
Requirements for special equipment/tools	X	X	O
8. Procedures			
Initial plan	X	X	X
Standby	X	X	O
Communications/observation	X	X	X
Rescue	X	X	X
Work	X	X	X
9. Safety Equipment and Clothing			
Head protection	O	O	O
Hearing protection	O	O	O
Hand protection	O	O	O
Foot protection	O	O	O
Body protection	O	O	O
Respiratory protection	O	O	
Safety belts	X	X	X
Life lines, harness	X	O	
10. Rescue Equipment	X	X	X
11. Recordkeeping/Exposure	X	X	

X - indicates requirement
O - indicates determination by the qualified person

If the work practice involved in the confined space has the potential to increase existing hazards or generate additional ones, it shall be necessary to frequently evaluate the space to determine if a classification change is warranted.

Rescue procedures shall be specifically designed for each entry. If a confined space has an A or B Classification, there shall be a trained standby person assigned to that confined space with a fully charged, positive pressure, self-contained breathing apparatus (SCBA) at hand. Additional duties of the standby person are to maintain unobstructed life lines and communications to all workers within the confined space, and to summon rescue personnel if necessary. Under no circumstances will the standby person enter the confined space until he is relieved and is assured that adequate assistance is present. However, while awaiting rescue personnel the standby person will make rescue attempts utilizing the life lines from outside the confined space. Rescue teams entering a Class A or B confined space shall be equipped with all the aforementioned safety equipment of the standby person and required life lines.

In the event of a Class C confined space rescue, a supplied-air respirator or a self-contained breathing apparatus shall be used. A person summoned or one who recognizes the need for rescue shall summon assistance and await their arrival outside the confined space. Respirators and life lines shall be donned by rescue personnel with necessary equipment for removal of the victim(s).

Section 3 - Permit System (Class A, B, and C)

Entry into a confined space shall be by permit only. The permit is an authorization and approval in writing that specifies the location and type of work to be done, and certifies that all existing hazards have been evaluated by the qualified person, and necessary protective measures have been taken to insure the safety of each worker.

The supervisor or a qualified person shall be responsible for securing the permit and both shall sign off when the following areas and actions have been reviewed and confirmed:

(a) Location and description of the work to be done.
(Class A, B, and C)

(b) Hazards that may be encountered.
(Class A, B, and C)

(c) Complete isolation checklist.
(Class A, B, and C)

(1) Blanking and/or disconnecting.

(2) Electrical lockout.

(3) Mechanical lockout.

(d) Special clothing and equipment.
(Class A and B)

(1) Personal protective equipment and clothing

(2) Safety harness and/or lines.

(3) Tools approved for use in accordance with the Hazardous Location Classification (NEC-1978).

(4) Approved electrical equipment.

(e) Atmospheric test readings.
(Class A, B, and C)

(1) Oxygen level.

(2) Flammability and/or explosive levels.

(3) Toxic substance levels.

(f) Atmospheric monitoring while work is being performed.
(Class A on a continuous basis and Class B as determined by the Qualified Person)

(g) Personnel training and complete understanding of the hazards.
(Class A, B, and C)

(h) Standby person(s) as named on the permit.
(Class A and B)

(i) Emergency procedures and location of first aid equipment.
(Class A, B and C)

(j) Confined space classification A, B, and C.

This permit shall be dated and carry an expiration time that will be valid for one shift only. The permit shall be updated for each shift with the same requirements.

The permit for a Class A or B confined space shall be posted in a conspicuous place, close to the entrance, with a copy on file with the employer.

The sample permit in Appendix III should serve as a guide and not be limited to the areas mentioned. The training requirements of personnel entering and/or working in confined spaces shall be suitable for the nature of the hazard and the work to be performed and will therefore vary with the confined space classification. The permit will vary among different industrial activities. However, it should serve the same purpose for all industries, to insure the safety of the worker.

Section 4 - Medical (Class A, B)

(a) Workers who enter a Class A or B confined space shall have a pre-placement physical examination made available to them. The employer shall provide to the physician performing or responsible for the medical surveillance program information such as the type of confined space the employee may be required to enter, the type of substances the employee may encounter, and a description of any protective devices or equipment the employee may be required to use. The physical examination shall include:

(1) A demonstration of the worker's ability to use negative and positive pressure respirators as cited in 29 CFR 1910.134.

(2) A demonstration of the workers ability to see and hear warnings, such as flashing lights, buzzers or sirens.

(3) The examination should place emphasis on general evaluations of the employee's ability to carry out his assigned duties and the detection of any diseases or abnormalities which may make it difficult to work within confined spaces.

(b) Following completion of the examinations, the physician shall give to the employer a written statement specifying any condition or abnormality found which would increase risk to the employee's health by working in confined spaces.

(c) Periodic medical examinations shall be made available to employees required to work in Class A or B confined spaces.

(d) First Aid Provisions

(1) For Class A and B entry there shall always be someone readily available in the area of the confined space who is currently trained in cardio-pulmonary resuscitation (CPR) and basic first-aid procedures.

(2) Employees shall be aware of the location of the nearest first-aid equipment, and how to obtain emergency assistance and medical attention. An adequate supply of first-aid equipment shall be within easy access of the confined space.

(e) Records of exposure to known health hazards shall be included in that employee's medical record. These records shall be made available to the designated medical representatives of the Secretary of Health, Education and Welfare, of the Secretary of Labor, of the employer and of the employee or former employee.

Section 5 - Training (Class A, B, and C)

The employer shall be responsible for training personnel and for the safety of the entire operation. Personnel who work in the vicinity of confined spaces shall be made aware of the hazards associated with confined spaces during orientation. Personnel who are required to work in a confined space, or in support of those working in a confined space shall have additional training in the following areas:

(a) Emergency entry and exit procedures (Class A, B, and C);

(b) Use of applicable respirators (Class A, B, and C);

(c) First aid (Class A, B);

(d) Lockout procedures (Class A, B, and C);

(e) Safety equipment use (Class A, B, and C);

(f) Rescue and training drills designed to maintain proficiency shall be given initially to new employees, and thereafter, at least annually, or at lesser intervals as determined necessary by the judgment of the employer (Class A, B, and C);

(g) Permit system (Class A, B and C); and

(h) Work practices as recommended in Section 9 of this proposed standard. (Class A, B and C)

Training shall not be considered as complete until the supervisor or other employer-designated official, safety or training officer, judges that the employee has attained an acceptable degree of proficiency for entering and working in confined spaces. The trainee's judgment of the adequacy of his training should be properly considered.

Section 6 - Testing and Monitoring (Class A, B, and C)

Entry into a confined space is prohibited until initial testing of the atmosphere has been done from the outside . Appropriate tests shall be made to insure that the atmosphere is safe. The tests performed shall include those for oxygen content, flammability, and toxic materials. Any necessary additional tests will be selected and performed to the satisfaction of the qualified person. Monitoring of a Class A confined space shall be done on a continuous basis. Class B and C shall be monitored as determined by the qualified person.

Entry into a confined space for any type of hot work shall be prohibited when tests indicate the concentration of flammable gases in the atmosphere is greater than 10% of the lower flammability limit (LFL). It is necessary to determine the oxygen level (by appropriate testing) prior to measuring the range of flammability to make necessary corrections in the flammability measurement. Monitoring of the atmosphere shall be performed in accordance with the permit. Equipment for continuous monitoring of gases and vapors shall be explosion proof and equipped with an audible alarm or danger signaling device that will alert employees when a hazardous condition develops. Instruments used for testing the atmosphere in a confined space shall be selected for their functional ability to measure hazardous concentrations. Instruments shall be calibrated in accordance with the manufacturer's guidelines or manuals. Each calibration shall be recorded, filed by the employer, and available for inspection for 1 year after the last calibration date.

In any confined space classified as a Class II or Class III hazardous location according to the 1978 National Electrical Code, Article 500 Sections 5 and 6, a fire watch shall be established as part of the entry procedure. In such areas surface dust and fibers shall be removed and no hot work shall be initiated until the airborne particulate level is below 10% of the LFL for the material. When combustible dusts or ignitable fibers/flyings are present, all equipment and ventilation systems used in the confined space shall comply with Articles 502 and 503 of the National Electrical Code.

The percentage of oxygen for entry into a confined space shall be no less than 19.5% nor greater than 25% at 760 mm Hg. At sea level the normal atmospheric pressure for air (20.9% O_2 + 78.1% N_2 + 1% Ar + trace amounts of various inert gases) is 14.7 psi or 760 mm Hg absolute. The partial pressure of oxygen (PO_2) at sea level will be approximately 160 mm Hg. PO_2 can be reduced by reducing the O_2 level in air at a given elevation or through increasing altitude. If tests indicate the oxygen level to be greater than 25% hot work is prohibited until ventilating techniques have reduced the oxygen level to approximately 21%. If the percentage of oxygen falls below 19.5% approved respiratory equipment shall be used in accordance with Section 8 and Appendix II.

When the contaminants in the atmosphere cannot be kept within permissible exposure levels as set down in 29 CFR Part 1910 Sub Part Z, then the employee shall wear an approved respirator.

Section 7 - Labeling and Posting (Class A, B, and C)

(a) All warning signs shall be printed both in English and in the predominant language of non-English reading workers. Where established symbols exist, they shall also be used. Workers unable to read labels and posted signs shall receive information regarding hazardous areas and shall be informed of the instructions printed on the signs.

(b) All entrances to any confined space shall be posted. Signs shall include but not necessarily be limited to the following information:

DANGER

CONFINED SPACE

ENTRY BY PERMIT
ONLY

(c) When a specific work practice is performed or specific safety equipment is necessary, the following statement shall be added, in large letters, to the warning sign:

RESPIRATOR REQUIRED
FOR ENTRY

LIFELINE REQUIRED
FOR ENTRY

HOT WORK PERMITTED
OR
NO HOT WORK

(d) Emergency procedures, including phone numbers of fire departments and emergency medical services shall be posted conspicuously within the immediate area of the confined space, or at the telephone from which help would be summoned.

Section 8 - Safety Equipment and Clothing (Class A, B, and C)

The entry permit shall include a list of necessary protective equipment to be used in the confined space as determined by the qualified person. The employer shall be responsible for the proper use of the safety equipment, and the inspection and maintenance procedures performed on the safety equipment. The type of protective equipment required, will be determined by the qualified person.

Those items normally used to protect against traumatic injury include: safety glasses, hardhats, footwear and protective clothing.

(a) Eye and Face Protection - For persons who wear corrective spectacles, either prescription ground safety glasses or plano-goggles shall be provided. Additionally if eye-irritating chemicals, vapors, or dusts are present, safety goggles shall be required, and if both the face and eyes are exposed to a hazard, as during scrapping scale or cutting rivets, a full coverage face shield with goggles shall be used. During welding operations the special goggles or shields required shall be in accordance with 29 CFR 1910.252.

(b) Head Protection - Hard hats shall meet the requirements cited in 29 CFR 1910.135.

(c) Foot Protection - All foot protection shall meet or exceed the requirements cited in 29 CFR 1910.136 and shall provide, in addition to protection from falling objects, protection from any other hazard identified by the qualified person.

(d) Body Protection - All personnel entering a confined space shall wear full coverage work clothing as specified by the qualified person. Gloves and clothing made of impervious rubber or similar material are to be worn to protect against toxic or irritating materials. If the hazards of heat or cold stress exist in the confined space, clothing which has been tested to provide protection from over-exposure to these hazards shall be worn. Other body protection required in specific operations such as welding (flame proofed), riveting (heat resistant) and abrasive blasting (abrasion resistant) shall be provided to insure worker safety.

(e) Hearing Protection - Shall be required when engineering technology is insufficient to control the noise level, and the ambient exposure limit exceeds those allowed in Table G-16 of 29 CFR 1910.95. Emergency alarms shall be distinguishable when hearing protection is worn. The sound level meters used to measure noise levels shall be certified by NIOSH in accordance with 24 CFR 82. Where the potential for explosion exists, the sound level meters shall be of an explosion proof design.

(f) Respiratory Protection - Shall be determined by the qualified person based upon conditions and test results of the confined space, and the work activity to be performed. Halfmask respirators are not recommended for use in any atmosphere greater than 10 x PEL because of the probability of accidently breaking the facepiece to face seal due to the work condition in a confined space. Also, gas masks designed for the same respiratory protection may be substituted for chemical cartridge respirators in the table (see Appendix II), but they are more cumbersome and restrictive to movement. The minimum service time of self-contained breathing apparatus shall be calculated on the entry time, plus the maximum work period, plus twice the estimated escape time for safety margin.

The respirators used shall be NIOSH and MSHA approved devices and shall be fitted and maintained in accordance with 29 CFR 1910.134. However, supplied-air respirators purchased before 1975 and bearing Bureau of Mines approval may be used until March 31, 1980. Self-contained breathing apparatus, with audible alarms and all gas masks, approved by the Bureau of Mines may be used until further notice.

(g) Hand Protection - If hands are exposed to rough surfaces or sharp edges, the degree of protection can range from canvas to metal mesh gloves, depending on the material handled. Gloves made of impervious rubber or similar material are to be worn to protect against toxic or irritating materials. Heat protective gloves are required when employees handle objects with temperatures greater than 60 C (140 F). Where a current flow through the body of more than 5 milliamperes may result from contact with energized electrical equipment, employees shall wear insulating gloves that have been visually inspected before each use. Above 5,000 volts, rubber gloves in accordance with 29 CFR 1910.137 shall be worn.

Additional safety equipment that is necessary to protect the worker in the environment of a confined space: a safety belt with "D" rings for attaching a life line shall be worn at all times; the combination of a body harness and/or safety belt with life line shall be used when an employee is required to enter to complete the gas analysis; when an employee is working in an area where entry for purposes of rescue would be contraindicated (special limitations or fire hazard); when any failure of ventilation would allow the build-up of toxic or explosive gases within the time necessary to evacuate the area, or when the atmosphere is immediately dangerous to life and health. Safety belts may be used as the primary means of suspension for the life line only when rescue may be made by keeping the disabled body in a position that will maintain easy passage through exit openings. If the exit opening is less than 18 inches (45 cm) in diameter, then a wrist type harness shall be used. When it is determined by the qualified person that none of the special hazards associated with confined spaces pose an immediate threat to life, as in a Class C entry, then life lines shall be readily available but not used during entry and work procedures.

Other protective measures shall include: safety nets used to protect employees working 10 feet (3 m) above ground or grade level when other protective devices are impractical; life jackets worn if the workers are exposed to falls into liquid over 4 feet (1.2 m) in depth; and insulated floor mats when hot work requires use of electrical energy.

When employees enter a confined space, a barricade shall be erected if inadvertent entry poses a problem. The barricade shall have a mechanism to prevent closure of the escapeway, signs warning of the danger present, a physical barrier (fence) to keep the area clear, and an adequate platform (3 feet x 3 feet as a minimum) for entry or exit. Such added features as a tripod with block and tackle for safety lines and communication equipment should be considered when the entry plan is formulated. The employer shall be responsible for maintenance of the barricade system.

Section 9 - Work Practices (Class A, B, and C)

Before entering a confined space, employees shall review the specific guidelines appropriate for safe entry and emergency exit. These guidelines or standards shall be compiled by the qualified person and be definitive on all the possible hazards. Areas covered by such guidelines shall follow this recommended standard.

(a) Purging and Ventilating (Class A, B)

Environmental control within a confined space is accomplished by purging and ventilating. The method used will be determined by the potential hazards that arise due to the product stored or produced, suspected contaminants, the work to be performed, and the design of the confined space. When ventilating and/or purging operations are to be performed, the blower controls shall be at a safe distance from the confined space. In a Class A entry, an audible warning device shall be installed in all equipment to signal when there is a ventilation failure. When a ventilation system is operational, air flow measurements shall be made before each workshift to ensure that a safe environmental level is maintained. Initial testing of the atmosphere shall be performed from outside the confined space before ventilation begins to determine what precautions are necessary in purging and ventilating. Testing of more remote regions within the confined space may be performed once the immediate area within the confined space has been made safe. Exhaust systems shall be designed to protect workers in the surrounding area from contaminated air. If flammable concentrations are present all electrical equipment shall comply with the requirements of NEC (NFPA no. 70) hazardous locations, and the bonding requirements of Article 250 of NEC, 1978. Where continuous ventilation is not a part of the operating procedure, the atmosphere shall be tested until continuous acceptable levels of oxygen and contaminants are maintained for three tests at 5-minute intervals. Care shall be taken to prevent recirculation of contaminated air and interaction of airborne contaminants.

Continuous general ventilation shall be maintained where toxic atmospheres are produced as part of a work procedure, such as welding or painting, or where a toxic atmosphere may develop due to the nature of the confined space, as in the case of desorption from walls, or evaporation of residual chemicals. General ventilation is an effective procedure for distributing contaminants

from a local generation point throughout the work space to obtain maximum dilution. However, special precautions shall be taken if the ventilating system partially blocks the exit opening. These precautions include a method for providing respirable air to each worker for the time necessary for exit, and a method of maintaining communications.

Local exhaust ventilation shall be provided when general ventilation is not effective due to restrictions in the confined space or when high concentrations of contaminants occur in the breathing zone of the worker. Local high concentrations of contaminants may occur during work activities such as welding, painting, and chemical cleaning. The worker shall not be exposed to concentrations of contaminants in excess of those specified in 29 CFR Part 1910 Sub Part Z. Therefore, respiratory protection, as recommended in Section 8, may be needed in addition to engineering controls. The use of respiratory protection will be determined by the qualified person. However, when fumes may be generated that contain highly toxic or other airborne metal contaminants, the provisions of 29 CFR 1910.252 shall be observed. When freely moving exhaust hoods are used to provide control of fumes generated during welding, such hoods shall maintain a velocity of 100 feet per/minute in the zone of the welding. The effective force of freely moving exhaust hoods is decreased by approximately 90% at a distance of one duct diameter from the plane of the exhaust opening. Therefore, to obtain maximum effectiveness the welder shall re-position the exhaust hood as he changes welding locations to keep the hood in close proximity to the fume source.

Special precautions shall be taken when outgassing or vaporization of toxic and/or flammable substances are likely. If the vapor-generating rate can be determined, the exhaust rate required can be calculated to dilute the atmosphere below the PEL and/or 10% of the LFL, whichever is the lower. This shall be the lowest acceptable ventilation rate. If the area of concern is relatively small, diffusion of the contaminants may be controlled by enclosure with a relatively low volume exhaust for control, or by exhaust hoods located as close as possible to the area of vaporization or outgassing. If the area to be ventilated is too extensive to be controlled by local exhaust, then general ventilation procedures shall be used to control the contaminant level. When the problem of outgassing is due to the application of protective coatings or paint, ventilation shall be continued until the build-up of a flammable and/or toxic atmosphere is no longer possible.

There are three components necessary for combustion: fuel, oxygen, and a source of ignition. If work with fire becomes necessary in a confined space and the source of fuel cannot be controlled, then the atmosphere shall be inerted. This is a highly hazardous work situation, and continuous monitoring of the inert make-up ventilation is mandatory. Monitoring shall include flow measurement as well as gas analysis. The inerting operation shall be continuously monitored and supervised by the qualified person. Since every confined space will have its own infiltration rate, inerting shall continue for the entire duration of the work at a rate that will prevent air from entering the confined space.

(b) Isolation/Lockout/Tagging (Class A, B)

The isolation procedures shall be specific for each type of confined space. Safety equipment required during this procedure shall be designated by the qualified person and be dependent upon the potential hazards involved. A

Class A or B confined space shall be completely isolated from all other systems by physical disconnection, double block and bleed, or blanking off all lines. In continuous systems, where complete isolation is not possible, such as sewers or utility tunnels, specific written safety procedures that are approved and enforced by the employer shall be used. Blanks used to seal off lines shall be capable of withstanding the maximum working pressure or load of the line (with a minimum safety factor of 4), be provided with a gasket on the pressure side to insure a leakproof seal, and be made of chemically non-reactive material. Shutoff valves serving the confined space, shall be locked in the closed position and tagged for identification. In addition to blanking, pumps and compressors serving these lines entering the confined space shall be locked out to prevent accidental activation.

All blanks for that specific confined space shall be recorded on the entry permit and recorded in the employer's file, which shall be available for inspection.

If a drain line is located within the confined space, provision shall be made when necessary to tag it and leave it open. This shall also be recorded on the entry permit.

Additional procedures, which are necessary when the confined space is of a double wall type construction, eg, water jacketed or similar type, shall be determined by the qualified person and noted on the entry permit.

Electrical isolation of the confined space to prevent accidental activation of moving parts that would be hazardous to the worker is achieved by locking circuit breakers and/or disconnects in the open (off) position with a key-type padlock. The only key is to remain with the person working inside the confined space. If more than one person is inside the confined space, each person shall place his own lock on the circuit breaker. In addition to the lockout system, there must be an accompanying tag that identifies the operation and prohibits use.

Mechanical isolation of moving parts can be achieved by disconnecting linkages, or removing drive belts or chains. Equipment with moving mechanical parts shall also be blocked in such a manner that there can be no accidental rotation.

(c) Cleaning (Class A, B, and C)

Procedures and processes used to clean the inside of a confined space shall be reviewed and authorized by the qualified person. The method to be prescribed shall be dependent upon the product in the space. If the confined space contains a flammable atmosphere above the upper flammable limit, it shall be purged with an inert gas to remove the flammable substance before ventilating with air. Initial cleaning shall be done from outside the tank if at all possible.

Special procedures should be adopted to handle the hazards created by the cleaning process itself. For example: if the tank is steamed, (1) it shall be allowed to cool prior to entry; (2) ventilation shall be maintained during neutralization procedures to prevent build-up of toxic materials; (3) steaming shall not be used as a cleaning method when the product stored was a liquid with an autoignition temperature 120% or less of the steam temperature, and

(4) the pipe or nozzle of the steam hose shall be bonded to the tank to decrease the generation of static electricity that could accumulate in tanks during steaming procedures. These and other hazards and controls shall be evaluated by the qualified person.

(d) Equipment and Tools (Class A, B, and C)

Equipment and tools to be used in a confined space shall be carefully inspected and shall meet the following requirements:

(1) Hand tools shall be kept clean and in good repair.

(2) Portable electric tools, equipment, and lighting shall be approved in accordance with 29 CFR Part 1910 Sub Part S and be equipped with a ground fault circuit interrupter that meets the requirements of 29 CFR 1910.309. All grounds shall be checked before electrical equipment is used in a confined space.

(3) All electrical cords, tools, and equipment shall be of heavy duty type with heavy duty insulation and inspected for visually detectable defects before use in a confined space.

(4) Air driven power tools shall be used when flammable liquids are present. The use of air driven power tools will reduce the risk of explosion, not eliminate it. Explosions can arise by tools overheating (drilling), sparks produced by striking (percussion), grinding or discharge of accumulated electrostatic charges developed from the flow of compressed air.

(5) Lighting used in Class A and B confined spaces shall be of explosion proof design and where necessary, equipped with guards. Only equipment listed by the Underwriters Laboratories for use in Division 1, atmospheres of the appropriate class and group, or approved by U.S. Bureau of Mines or Mining Enforcement and Safety Administration or Mine Safety and Health Administration, or the US Coast Guard shall be used. Lighting shall not be hung by electric cords, unless specifically designed for that purpose. The illumination of the work area shall be sufficient to provide for safe work conditions as referenced in the ANSI standard A11-1-1965, or the revision, 1970. Under no circumstances will matches or open flames be used in a confined space for illumination.

(6) Cylinders of compressed gases shall never be taken into a confined space, and shall be turned off at the cylinder valve when not in use. Exempt from this rule are cylinders that are part of self-contained breathing apparatus or resuscitation equipment.

(7) Ladders shall be adequately secured, or of a permanent type which provides the same degree of safety as cited in 29 CFR Part 1910 Sub Part D.

(8) Scaffolding and staging shall be properly designed to carry maximum expected load (safety factor of 4), be equipped with traction type planking, and meet the requirements of 29 CFR 1910.28.

(9) Electrical lines, junctions and appurtenances will be in accordance with National Electrical Code (NEC) and National Fire code (NFC) as cited in 29 CFR 1910.309.

(10) Only hose lines and components designed specially for the compressed gas and working pressure shall be used, and such systems shall have a pressure relief valve outside the confined space.

(11) All equipment that may be used in a flammable atmosphere shall be approved as explosion proof or intrinsically safe for the atmosphere involved by a recognized testing laboratory such as the US Bureau of Mines, MESA, or MSHA for methane and by the Underwriters Laboratories or by Factory Mutual for all cases.

(e) Recordkeeping (Class A, B)

The employer shall maintain a written record of training including safety drills, inspections, tests, and maintenance. The records shall be retained 1 year after the last date of training, inspection, test, or maintenance. In the event of separation of the employee, disposal of equipment or appliance, records may be disposed of after 1 year.

Where atmospheric testing indicates the presence of a toxic substance, records shall be maintained in accordance with the existing Federal regulation(s). These records shall include the dates and times of measurements, duties and location of the employees within the confined space, sampling and analytical methods used, number, duration, and results of the samples taken, PEL concentrations estimated from these samples, type of personal protective equipment used, if any, and employees' names. These records shall be made available to the designated representatives of the Secretary of Labor, of the Secretary of Health, Education, and Welfare, of the employer, and of the employee or former employee.

II. INTRODUCTION

This document presents the criteria and the recommended standard based thereon that were prepared to meet the need for preventing occupational injuries and deaths associated with persons entering, working in, and exiting confined spaces. This document does not address the specialized areas of radiation, inert atmospheres or hyperbaric atmospheres; except to recognize they do exist and represent a potential hazard. The criteria document fulfills the responsibility of the Secretary of Health, Education, and Welfare, under Section 20(a)(2) of the Occupational Safety and Health Act of 1970 to "...develop and establish recommended occupational safety and health standards."

After reviewing data and consulting with others, NIOSH developed criteria upon which standards can be established to protect the health and to provide for the safety of workers exposed to occupational hazards. It should be noted that criteria for a recommended standard should enable management and labor to develop better work practices and more appropriate training programs that will result in safer work environments. Simply complying with the recommended standard should not be the final goal.

The worker who enters a confined space may be, or often is exposed to multiple hazards due primarily either to ignorance of the potential hazards or negligence in the enforcement of safety regulations. Ignorance and negligence have led to deaths by asphyxiation, by fire and explosion, and by fatal exposure to toxic materials. NIOSH is aware that a number of deaths occur each year when workers must enter and work in a confined space, and it recognizes that due to current data collection methods, an estimate of the injuries and deaths which do occur will be inaccurate. Also, since there is no specific Standard Industrial Classification where these injuries and deaths are recorded for confined spaces, they are recorded in several different categories, thereby giving the appearance of a limited exposure to the hazard.

These criteria for a standard are a part of a continuing series of documents published by NIOSH. The proposed standard applies only to entering into, working in, and exiting from confined spaces as applicable under the Occupational Safety and Health Act of 1970.

The method used in this study consisted of developing, evaluating, and recording information from extensive literature searches, site visits to various industries, and consultation with reviewers knowledgeable on the subject of confined spaces.

Standards covering issues of occupational safety and health that are of general application without regard to any specific industry are intended to be applicable to this recommended standard even though no specific reference is made to them. Examples of these general areas are: exposure to toxic chemicals, noise, temperature extremes, and general duty requirements.

III. CONFINED SPACE HAZARDS

Overview and Magnitude of the Problem

(a) Overview

The hazards encountered and associated with entering and working in confined spaces are capable of causing bodily injury, illness, and death to the worker. Accidents occur among workers because of failure to recognize that a confined space is a potential hazard. It should therefore be considered that the most unfavorable situation exists in every case and that the danger of explosion, poisoning, and asphyxiation will be present at the onset of entry.

Before forced ventilation is initiated, information such as restricted areas within the confined space, voids, the nature of the contaminants present, the size of the space, the type of work to be performed, and the number of people involved should be considered. The ventilation air should not create an additional hazard due to recirculation of contaminants, improper arrangement of the inlet duct, or by the substitution of anything other than fresh (normal) air (approximately 20.9% oxygen, 79.1% nitrogen by volume). The terms air and oxygen are sometimes considered synonymous. However, this is a dangerous assumption, since the use of oxygen in place of fresh (normal) air for ventilation will expand the limits of flammability and increase the hazards of fire and explosion.

Hazardous conditions to be discussed in this Chapter include: Hazardous Atmospheres (flammable, toxic, irritant, and asphyxiating), and General Safety Hazards (mechanical, communications, entry and exit, and physical).

An estimation of the number of workers potentially exposed to confined spaces would be difficult to produce. A report prepared under contract for NIOSH [1] shows that the rate of confined space related injuries in the shipbuilding and repair industry is 4.8%. Projected on a national level, 2,448 accidents per year may be attributed to the hazards of working in confined spaces in this single industry. The Bureau of Labor Statistics shows that the Standard Industrial Classification (SIC) 373, Shipbuilding and Repair Industry, has a 23.9% injury rate. Based on this injury rate 5% of all accidents in the Shipbuilding and Repair Industry occur while working in and around confined spaces. Because of the lack of data it is not possible at this time to project this proportion of confined space related injuries to other industries [2]. Based on the total working population of selected specific SIC codes, and a rough estimate of the percentage of each category who may work in confined spaces at some time, NIOSH estimates that millions of workers may be exposed to hazards in confined spaces each year.

(b) Types of Confined Spaces

Confined spaces can be categorized generally as those with open tops and with a depth that will restrict the natural movement of air, and enclosed spaces with very limited openings for entry [3]. In either of these cases the space may contain mechanical equipment with moving parts. Any combination of these parameters will change the nature of the hazards encountered. Degreasers, pits, and certain types of storage tanks may be classified as open

topped confined spaces that usually contain no moving parts. However, gases that are heavier than air (butane, propane, and other hydrocarbons) remain in depressions and will flow to low points where they are difficult to remove [4]. Open topped water tanks that appear harmless may develop toxic atmospheres such as hydrogen sulfide from the vaporization of contaminated water [5]. Therefore, these gases (heavier than air) are a primary concern when entry into such a confined space is being planned. Other hazards may develop due to the work performed in the confined space or because of corrosive residues that accelerate the decomposition of scaffolding supports and electrical components.

Confined spaces such as sewers, casings, tanks, silos, vaults, and compartments of ships usually have limited access. The problems arising in these areas are similar to those that occur in open topped confined spaces. However, the limited access increases the risk of injury. Gases which are heavier than air such as carbon dioxide and propane, may lie in a tank or vault for hours or even days after the containers have been opened [6]. Because some gases are odorless, the hazard may be overlooked with fatal results. Gases that are lighter than air may also be trapped within an enclosed type confined space, especially those with access from the bottom or side.

Hazards specific to a confined space are dictated by: (1) the material stored or used in the confined space; as an example, damp activated carbon in a filtration tank will absorb oxygen thus creating an oxygen deficient atmosphere [7]; (2) the activity carried out, such as the fermentation of molasses that creates ethyl alcohol vapors and decreases the oxygen content of the atmosphere [8]; or (3) the external environment, as in the case of sewer systems that may be affected by high tides, heavier than air gases, or flash floods [9].

The most hazardous kind of confined space is the type that combines limited access and mechanical devices. All the hazards of open top and limited access confined spaces may be present together with the additional hazard of moving parts. Digesters and boilers usually contain power-driven equipment which, unless properly isolated, may be inadvertently activated after entry. Such equipment may also contain physical hazards that further complicate the work environment and the entry and exit process.

(c) Reasons for Entering Confined Spaces

Entering a confined space as part of the industrial activity may be done for various reasons. It is done usually to perform a necessary function, such as inspection, repair, maintenance (cleaning or painting), or similar operations which would be an infrequent or irregular function of the total industrial activity [10].

Entry may also be made during new construction. Potential hazards should be easier to recognize during construction since the confined space has not been used. The types of hazards involved will be limited by the specific work practices. When the area meets the criteria for a confined space, all ventilation and other requirements should be enforced.

One of the most difficult entries to control is that of unauthorized entry, especially when there are large numbers of workers and trades involved, such as welders, painters, electricians, and safety monitors.

A final and most important reason for entry would be emergency rescue. This, and all other reasons for entry, must be well planned before initial entry is made and the hazards must be thoroughly reviewed. The standby person and all rescue personnel should be aware of the structural design of the space, emergency exit procedures, and life support systems required.

Hazardous Atmospheres

Hazardous atmospheres encountered in confined spaces can be divided into four distinct categories: (a) Flammable, (b) Toxic, (c) Irritant and/or Corrosive, and (d) Asphyxiating.

(a) Flammable Atmosphere

A flammable atmosphere generally arises from enriched oxygen atmospheres, vaporization of flammable liquids, byproducts of work, chemical reactions, concentrations of combustible dusts, and desorption of chemicals from inner surfaces of the confined space.

Alther [11] reported on a case involving workers in an enriched oxygen atmosphere. Two men entered a newly constructed tank to repair a bulge which had formed after the flange of the manhole was welded to the tank. The planned repair procedure was to have two men enter the tank with a jack to force the flange of the manhole into place while a third worker heated the bulge from the outside. To accomplish this procedure the men had to close the manhole. To improve the air within the tank, oxygen used for welding was blown in through an opening. A worker on the outside noticed through the opening that the hair of one of the workmen inside was on fire. The cover was immediately removed and one of the workers managed to escape, his clothing was burning rapidly, the second worker had collapsed and remained unconscious inside. It became necessary to invert the tank to remove the unconscious workman. Both workmen who were doing the work inside suffered serious burns. One died a short time later; the second was hospitalized for several months. A rescuer in the operation was burned on the hands.

Investigation of the accident revealed the use of oxygen in place of normal air increased the flammability range of combustibles. Enrichment of the atmosphere with only a few percent of oxygen above 21% will cause an increase in the range of flammability, hair as well as clothing will absorb the oxygen and burn violently. Enriched oxygen atmospheres which expand the region of flammability could be the result of improper blanking off of oxygen lines, chemical reactions which liberate oxygen, or inadvertently purging the space with oxygen in place of air [11].

An atmosphere becomes flammable when the ratio of oxygen to combustible material in the air is neither too rich nor too lean for combustion to occur. Combustible gases or vapors will accumulate when there is inadequate ventilation in areas such as a confined space. Flammable gases such as acetylene, butane, propane, hydrogen, methane, natural or manufactured gases or vapors from liquid hydrocarbons can be trapped in confined spaces, and

since many gases are heavier than air, they will seek lower levels as in pits, sewers, and various types of storage tanks and vessels [12,13]. In a closed top tank, it should also be noted that lighter than air gases may rise and develop a flammable concentration if trapped above the opening.

The byproducts of work procedures can generate flammable or explosive conditions within a confined space. Specific kinds of work such as spray painting can result in the release of explosive gases or vapors [14]. Table III-3 shows that approximately one-third of the events identified as "atmospheric condition" were the result of the victims performing activities that generated fumes or depleted the oxygen supply. The most common of these activities was welding in a confined space. Welding in a confined space was a major cause for explosions in areas that contained combustible gas [1].

Chemical reactions forming flammable atmospheres occur when surfaces are initially exposed to the atmosphere, or when chemicals combine to form flammable gases. This condition arises when dilute sulfuric acid reacts with iron to form hydrogen or when calcium carbide makes contact with water to form acetylene. Other examples of spontaneous chemical reactions that may produce explosions from small amounts of unstable compounds are acetylene-metal compounds, peroxides, and nitrates. In a dry state these compounds have the potential to explode upon percussion or exposure to increased temperature. Another class of chemical reactions that form flammable atmospheres arise from deposits of pyrophoric substances (carbon, ferrous oxide, ferrous sulfate, iron, etc) that can be found in tanks used by the chemical and petroleum industry. These tanks containing flammable deposits, will spontaneously ignite upon exposure to air [15].

Combustible dust concentrations are usually found during the process of loading, unloading, and conveying grain products, nitrated fertilizers, finely ground chemical products, and any other combustible material. It has been reported that high charges of static electricity, which rapidly accumulate during periods of relatively low humidity (below 50%), can cause certain substances to accumulate electrostatic charges of sufficient energy to produce sparks and ignite a flammable atmosphere [14]. These sparks may also cause explosions when the right air or oxygen to dust or gas mixture is present.

Desorption of chemicals from the inner surfaces of a confined space is another process that may produce a flammable atmosphere. This is often a natural phenomenon in which the partial pressure at the interface between the surfaces and the stored chemical is radically reduced. For example, after liquid propane is removed from a storage tank the walls of the vessel may desorb the remaining gas from the porous surface of the confined space.

Dorias [16] reported on an explosive gas-air mixture in a horizontal cylindrical container (1000 m3), which had contained liquid propane. The cylinder was emptied to check for stress cracking. The space was to be filled with water to expell the gas, and drained so it could automatically fill with normal air. The container was presumably filled full of water and drained. The gas analysis of the resulting space showed an explosive gas-air mixture. The procedure of filling with water and draining was repeated and the test results were the same, an explosive gas-air mixture. To speed up the process, a man climbed into the cylinder and sprayed the interior with water for 3 hours, and allowed the interior to air dry. On the 4th day, a mechanic entered the tank and prepared the areas to be inspected for stress. Following

this, a man entered the tank with a test device and a Katel lamp (220 volts not of an explosion-proof design). There was a sudden explosion and flame streamed out of the entry manhole. The man who was testing the atmosphere suffered severe injuries from which he died 6 days later. Investigation of the events revealed that the tanks were filled only 50% full the first time and only 80-90% full the second time. Therefore, it was concluded the space was never thoroughly emptied of all gas. Reconstruction of the operation showed that the spraying operation did not remove all the propane, and left a gas-air mixture of approximately 5% propane by volume, an extremely explosive condition [16].

(b) Toxic Atmospheres

The substances to be regarded as toxic in a confined space can cover the entire spectrum of gases, vapors, and finely-divided airborne dust in industry [17]. The sources of toxic atmospheres encountered may arise from the following:

(1) The manufacturing process (for example, in producing polyvinyl chloride, hydrogen chloride is used as well as vinyl chloride monomer which is carcinogenic).

(2) The product stored (removing decomposed organic material from a tank can liberate toxic substances such as H_2S).

(3) The operation performed in the confined space (for example, welding or brazing with metals capable of producing toxic fumes).

Zavon [18] reported, in 1970, that four employees of a local utility were repairing a water meter in an underground vault 18 feet x 6 feet x 5 feet with an opening 24 inches in diameter. To make the repairs, it was necessary to cut 26 cadmium plated bolts with an oxygen propane torch. Two men worked in the vault with one man cutting and the other standing beside him. Neither man wore a respirator and no ventilation was provided. Two other men remained on the surface. During the cutting of the bolts with the oxygen propane torch, a "heavy blue smoke" filled the vault. This smoke was exhausted after the cutting was completed.

The 56-year-old man who had cut the bolts died 17 days after exposure. He became nauseated shortly after the job and was seen by his family physician the next day for fever (102-103 F), chest pain, cough, and sore throat. On the 4th day following the incident he was in greater distress and was hospitalized. Death occurred in 2 weeks and was attributed to massive coronary infarction and corpulmonale. The 29-year-old assistant complained of chills, nausea, cough and difficulty in breathing. He was treated for pneumonia and made a slow recovery. A reenactment of the work demonstrated that the exposure to cadmium was well above the threshold limit value of "0.1 mg/m3" [18]. Symptoms attributed to cadmium poisoning include: severe labored breathing and wheezing, chest pain, persistent cough, weakness and malaise, and loss of appetite. The clinical course is similar in most cases. The injured frequently are well enough to work the day after exposure, but their conditions deteriorate until approximately the 5th day. At this point, the exposed worker will either get much worse or begin to improve [19].

Toxic gases may be evolved when acids are used for cleaning. Hydrochloric acid can react chemically with iron sulfide to produce hydrogen sulfide [20]. Iron sulfide is formed on the walls of cooling jackets when only several parts per million sulfide are in the water used in the cooling process. As an example, 5 men were overcome while cleaning a heat exchanger using a hydrochloric acid solution [20].

Another area where the hydrogen sulfide hazard exists is in the tanning industry. Lime pits used in the process of removing hair from the hides contain in addition to lime, a 1% solution of sodium sulfate (Na_2SO_4). Acid dichromate solution is also used in the tanning process. If these two solutions (sodium sulfate and acid dichromate) are combined accidentally, hydrogen sulfide (H_2S) will be produced. One such incident occurred when several unused pits at a tannery were being cleaned. Sludge had formed on the bottom of the pit due to drainage from the hides when they had been treated with lime and acid dichromate. When men entered the pit to clear the drain line, they were overcome. Because of the high specific gravity of hydrogen sulfide, the gas formed by the sodium sulfide-dichromate reaction had settled in the pit, and when the sludge was stirred the released gas overcame the workers. In this instance, 5 men became unconscious and two died [21]. The particular hazard associated with hydrogen sulfide at higher concentrations is due to its physiological effect of anesthetizing the olfactory nerves and can also cause a loss of reasoning, paralysis of the respiratory system, unconsciousness, and death [22,23].

During loading, unloading, formulation, and production, mechanical and/or human error may also produce toxic gases which are not part of the planned operation.

Toxic solvents, which present problems [24], such as trichloroethylene, methyl chloroform, and dichloromethane, are used in industry for cleaning and degreasing. Acrylonitrile, infrequently used, has been encountered as an ingredient in a protective coating applied to tank interiors [17].

Trichloroethane and dichloroethane are widely used in industry as cleaning solvents because they are among the least toxic of the chlorinated aliphatic hydrocarbons. These solvents have been used as a replacement for carbon tetrachloride and trichloroethylene [25-27].

In a case report by Hatfield and Maykoski [28] trichloroethane, also known as methyl chloroform was substituted for trichloroethylene because of the high toxicity of the latter. A radiator and metal tank repairman was involved in an aircraft tip tank cleaning and assembly operation. The technique of cleaning the interior of the tanks varied among workers. Some workmen would moisten a pad with solvent and would hand wipe the metal surfaces by reaching through an opening on the end of the tank; some would use pads on the end of a shaft, while others would climb inside and clean. One particular worker would saturate a pad with solvent and lower himself head first into the down-tilted tip of the tank and clean as fast as possible. This worker was found with his legs protruding from the upper end of the 450 gallon tank and was unresponsive. He was removed immediately and was given artificial respiration until a physician arrived and pronounced him dead.

Reconstruction of the fatal accident revealed the concentration of methyl chloroform in the tank had reached 62,000 ppm. The workers assumed that since

the new cleaning solvent was less toxic than the one previously used, there was less danger. However, the new cleaning solvent, methyl chloroform, is a potent anesthetic at 30,000 ppm, which was less than half the concentration level in the worker's breathing zone.

The compatibility of materials must be considered when structural members and equipment are introduced in confined spaces. The previous history of the confined space must be carefully evaluated to avoid reactions with residual chemicals, wall scale, and sludge which can be highly reactive. One such case was reported in May of 1968, when an aluminum ladder was used for entry into a chemical evaporating tank which had contained aqueous sodium arsenite ($Na\ AsO_2\ H_2O$) and sodium hydroxide (NaOH). The aluminum reacted with the $NaAsO_2$ and the NaOH to liberate hydrogen, which in turn reacted with the arsenic to form arsine [29]. Other cases of incompatability arise from the use of chemical cleaning agents. The initial step in chemical cleaning usually is the conversion of the scale or sludge into a liquid state which may cause poisonous gases to be liberated. In 1974, several employees who were cleaning a boiler tank prior to repairing a leak used a cleaning fluid, Vestan 675. The cleaning action caused the release of ammonia fumes that were not properly exhausted. The men were hospitalized with severe chest pains, but recovered [29].

Another hazardous gas that may build up in a confined space is carbon monoxide (CO). This odorless colorless gas that has approximately the same density of air is formed from incomplete combustion of organic materials such as wood, coal, gas, oil, and gasoline [30]; it can be formed from microbial decomposition of organic matter in sewers, silos, and fermentation tanks. Carbon monoxide is an insidious toxic gas because of its poor warning properties. Early stages of carbon monoxide intoxication are nausea and headache. Carbon monoxide may be fatal at 1000 ppm in air, and is considered dangerous at 200 ppm, because it forms carboxyhemoglobin in the blood which prevents the distribution of oxygen in the body.

Carbon monoxide (CO) is a relatively abundant colorless, odorless gas, therefore, any untested atmosphere must be suspect. It must also be noted that a safe reading on a combustible gas indicator does not ensure that CO is not present [14]. Carbon monoxide must be tested for specifically. The formation of CO may result from chemical reactions or work activities, therefore, fatalities due to CO poisoning are not confined to any particular industry. There have been fatal accidents in sewage treatment plants [8] due to decomposition products and lack of ventilation in confined spaces. Another area where CO results as a product of decomposition is in the formation of silo gas in grain storage elevators [8]. In another area, the paint industry, varnish is manufactured by introducing the various ingredients into a kettle, and heating them in an inert atmosphere, usually town gas, which is a mixture of carbon dioxide and nitrogen. In one accident report, a maintenance engineer entered a kettle that had been vented for 12-24 hours to check a blocked sampling tube. He was found dead some time later. Death was due to carbon monoxide poisoning. Investigation into the inert gas supply system revealed that the CO content of the town gas was over 1% (10,000 ppm), and that there were minor faults in the protective valves into the kettle so that a small leak was occurring. The employee had entered an atmosphere of reduced oxygen partial pressure containing CO and had succumbed before he could save himself [21]. In many cases CO poisoning occurs because of poor work practices.

In welding operations, oxides of nitrogen and ozone are gases of major toxicologic importance, and incomplete oxidation may occur and carbon monoxide can form as a byproduct [31]. One such case, documented in the Pennsylvania Occupational Injury Files of 1975, involved an employee who was overcome by carbon monoxide while welding inside a copper heat-treating oven with the door partially closed.

Another poor work practice, which has led to fatalities, is the recirculation of diesel exhaust emissions [32]. Tests have shown that although the initial hazard due to exhaust toxicants may be from increased CO_2 levels (or depleted O_2), the most immediate hazard to life processes is CO [33]. Increased CO levels can only be prevented by strict control of the ventilation or the use of catalytic convertors.

(c) Irritant (Corrosive) Atmosphere

Irritant or corrosive atmospheres can be divided into primary and secondary groups. The primary irritants exert no systemic toxic effects because the products formed by them on tissues of the respiratory tract are non-irritant, and other irritant effects are so violent as to obscure any systemic toxic action. Examples of primary irritants are chlorine (Cl_2), ozone (O_3), hydrochloric acid (HCl), hydrofluoric acid (HF), sulfuric acid (H_2SO_4), nitrogen dioxide (NO_2), ammonia (NH_3), and sulfur dioxide (SO_2). A secondary irritant is one that may produce systemic toxic effects in addition to surface irritation. Examples of secondary irritants include benzene (C_6H_6), carbon tetrachloride (CCl_4), ethyl chloride (CH_3CH_2Cl), trichloroethane (CH_3CCL_3), trichloroethylene ($CHClCCl_2$), and chloropropene (allyl chloride-CH_2CHCH_2Cl) [34].

Irritant gases vary widely among all areas of industrial activity. They can be found in plastics plants, chemical plants, the petroleum industry, tanneries, refrigeration industries, paint manufacturing, and mining operations [17].

Prolonged exposure at irritant or corrosive concentrations in a confined space may produce little or no evidence of irritation. This has been interpreted to mean that the worker has become adapted to the harmful agent involved. In reality, it means there has been a general weakening of the defense reflexes from changes in sensitivity, due to damage of the nerve endings in the mucous membranes of the conjunctivae and upper respiratory tract. The danger in this situation is that the worker is usually not aware of any increase in his exposure to toxic substances [17].

(d) Asphyxiating Atmosphere

The normal atmosphere is composed approximately of 20.9% oxygen and 78.1% nitrogen, and 1% argon with small amounts of various other gases. Reduction of oxygen (O_2) in a confined space may be the result of either consumption or displacement [35].

The consumption of oxygen takes place during combustion of flammable substances, as in welding, heating, cutting, and brazing. A more subtle consumption of oxygen occurs during bacterial action, as in the fermentation process. Oxygen may also be consumed during chemical reactions as in the formation of rust on the exposed surface of the confined space (iron oxide).

The number of people working in a confined space and the amount of their physical activity will also influence the oxygen consumption rate.

A second factor in oxygen deficiency is displacement by another gas. Examples of gases that are used to displace air, and therefore reduce the oxygen level are helium, argon, and nitrogen. Carbon dioxide may also be used to displace air and can occur naturally in sewers, storage bins, wells, tunnels, wine vats, and grain elevators. Aside from the natural development of these gases, or their use in the chemical process, certain gases are also used as inerting agents to displace flammable substances and retard pyrophoric reactions. Gases such as nitrogen, argon, helium, and carbon dioxide, are frequently referred to as non-toxic inert gases but have claimed many lives [36]. The use of nitrogen to inert a confined space has claimed more lives than carbon dioxide. The total displacement of oxygen by nitrogen will cause immediate collapse and death. Carbon dioxide and argon, with specific gravities of 1.53 and 1.38, respectively, (air = 1) may lie in a tank or manhole for hours or days after opening [36]. Since these gases are colorless and odorless, they pose an immediate hazard to health unless appropriate oxygen measurements and ventilation are adequately carried out.

In a report by the Ontario (Canada) Health Department, an underground oil storage tank which required cleaning, had been blanketed with nitrogen to prevent oxidation of the oil. The man assigned to clean the tank dropped an air hose into the tank before entering. As he reached the bottom of the ladder, he passed out. His helper outside the tank went in to help and feeling faint, left without getting the man out. He went to get assistance from a nearby maintenance shop. Three men came to the tank and climbed down and all were overcome. Finally, after about 20 minutes, all four men were recovered with the help of the fire department. The only reason that there were no fatalities was that an airline in the tank was blowing air into the vicinity of the fallen workers [37].

Oxygen deprivation is one form of asphyxiation. While it is desirable to maintain the atmospheric oxygen level at 21% by volume, the body can tolerate deviation from this ideal. When the oxygen level falls to 17%, the first sign of hypoxia is a deterioration to night vision which is not noticeable until a normal oxygen concentration is restored. Physiologic effects are increased breathing volume and accelerated heartbeat. Between 14-16% physiologic effects are increased breathing volume, accelerated heartbeat, very poor muscular coordination, rapid fatigue, and intermittent respiration. Between 6-10% the effects are nausea, vomiting, inability to perform, and unconsciousness. Less than 6%, spasmatic breathing, convulsive movements, and death in minutes [12,38].

In discussing oxygen and what constitutes an oxygen deficient atmosphere from a physiologic view, one must address the concept of partial pressures. At sea level the normal atmospheric pressure for air (20.9% O_2 + 78.1% N_2 + 1% Ar + trace amounts of various inert gases) is 14.7 psi or 760 mm Hg absolute. The partial pressure of O_2 (PO_2) at sea level will be approximately 160 mm Hg. The concept of partial pressures is that in any mixture of gases, the total gas pressure is the sum of the partial pressures of all the gases [39].

The PO_2 in ambient air can be decreased by a reduction in the O_2 level at constant pressure or by maintaining the percentage of O_2 constant and decreasing the total atmospheric pressure as in the case at high altitudes.

It is important not only to know the O_2 percent by volume, but to understand the relationship of O_2 to altitude and the concept of partial pressure. For example, 20.9% O_2 in air at sea level constitutes a greater PO_2 than 20.9% O_2 at 5,000 feet because the total atmospheric pressure at 5,000 feet is less. As the PO_2 in the atmosphere drops, the volume of air required to maintain a PO_2 of 60 mm Hg in the alveolar space of the lungs increases. A PO_2 below 60 mm Hg in the alveolar space is considered oxygen deficient [39].

Absorption of oxygen by the vessel or the product stored therein is another mechanism by which the PO_2 may be reduced and result in an oxygen deficient atmosphere. For example, activated carbon, usually considered as an innocuous material free of occupational hazard and toxicity, was responsible for two fatalities in a carbon filtration tank. Damp activated carbon absorbs oxygen and has been known to decrease the oxygen level from 21% to 4% in a closed vessel [7].

Montgomery et al [7] reported on two fatalities caused by the use of activated carbon in a water filtration vessel, (12.5 feet in diameter and 17 feet high). The space was newly constructed, filled halfway with granular carbon in a slurry form (water medium), the water was drained off through a bottom drain, and the tank was closed off to protect it from the weather. The next morning two workers entered the filtration vessel to perform necessary adjustments to the carbon bed and the interior sprinkler mechanism. When the workmen failed to appear at lunch time, they were found dead on the carbon bed. However, a rescuer entered the tank without any type of respiratory protection and with no ill affects. Tests of the atmosphere revealed no cause of death, the oxygen level was 21%, hydrocarbon and hydrogen sulfide tests were negative.

The investigation of the fatalities revealed the following: the tank was re-closed and re-opened the following day. No toxic gases were found; however, the oxygen level had dropped from 21% to 12% by volume. Other vessels checked at this location which had been closed for several weeks revealed the oxygen level was down to 2%.

In summary, it was discovered that dry carbon would not reduce the oxygen level significantly. Damp activated carbon, however, supposedly an innocuous material and free from toxicity, contributed to the death of two workers as a result of selective absorption of oxygen in a confined space with no ventilation.

General Safety Hazards

(a) Mechanical

If activation of electrical or mechanical equipment would cause injury, each piece of equipment should be manually isolated to prevent inadvertent activation before workers enter or while they work in a confined space. [12,40]. The interplay of hazards associated with a confined space, such as the potential of flammable vapors or gases being present, and the build-up of static charge due to mechanical cleaning, such as abrasive blasting, all influence the precautions which must be taken.

To prevent vapor leaks, flashbacks, and other hazards, workers should completely isolate the space [41]. To completely isolate a confined space the closing of valves is not sufficient. All pipes must be physically disconnected or isolation blanks bolted in place [5]. Other special precautions must be taken in cases where flammable liquids or vapors may re-contaminate the confined space. The pipes blanked or disconnected should be inspected and tested for leakage to check the effectiveness of the procedure. Other areas of concern are steam valves, pressure lines, and chemical transfer pipes. A less apparent hazard is the space referred to as a void, such as double walled vessels, which must be given special consideration in blanking off and inerting.

(b) Communication Problems

Communication between the worker inside and the standby person outside is of utmost importance. If the worker should suddenly feel distressed and not be able to summon help, an injury could become a fatality. Frequently, the body positions that are assumed in a confined space make it difficult for the standby person to detect an unconscious worker [10]. When visual monitoring of the worker is not possible because of the design of the confined space or location of the entry hatch, a voice or alarm-activated explosion proof type of communication system will be necessary [15].

Suitable illumination of an approved type is required to provide sufficient visibility for work in accordance with the recommendations made in the Illuminating Engineering Society Lighting Handbook.

(c) Entry and Exit

Entry and exit time is of major significance as a physical limitation and is directly related to the potential hazard of the confined space. The extent of precautions taken and the standby equipment needed to maintain a safe work area will be determined by the means of access and rescue. The following should be considered: type of confined space to be entered, access to the entrance, number and size of openings, barriers within the space, the occupancy load, and the time requirement for exiting in event of fire, or vapor incursion, and the time required to rescue injured workers [41].

(d) Physical

The hazards described in this section include non-chemical, physiologic stressors. These include thermal effects (heat and cold), noise, vibration, radiation, and fatigue while working in a confined space.

(1) Thermal Effects

Four factors influence the interchange of heat between man and his environment. They are: (1) air temperature, (2) air velocity, (3) moisture contained in the air, and (4) radiant heat [42,43]. Because of the nature and design of most confined spaces, moisture content and radiant heat are difficult to control. As the body temperature rises progressively, workers will continue to function until the body temperature reaches 38.3 - 39.4 C. When this body temperature is exceeded, the workers are less efficient, and are prone to heat exhaustion, heat cramps, or heat stroke [44]. In a cold environment certain physiologic mechanisms come into play, which

tend to limit heat loss and increase heat production. The most severe strain in cold conditions is chilling of the extremities so that activity is restricted [42]. Special precautions must be taken in cold environments to prevent frostbite, trench foot, and general hypothermia.

Protective insulated clothing for both hot and cold environments will add additional bulk to the worker and must be considered in allowing for movement in the confined space and exit time. Therefore, air temperature of the environment becomes an important consideration when evaluating working conditions in confined spaces.

(2) Noise

Noise problems are usually intensified in confined spaces because the interior tends to cause sound to reverberate and thus expose the worker to higher sound levels than those found in an open environment. This intensified noise increases the risk of hearing damage to workers which could result in temporary or permanent loss of hearing. Noise in a confined space which may not be intense enough to cause hearing damage may still disrupt verbal communication with the emergency standby person on the exterior of the confined space. If the workers inside are not able to hear commands or danger signals due to excessive noise, the probability of severe accidents can increase [42].

(3) Vibration

Wholebody vibration may be regarded as a "generalized stressor" and may affect multiple body parts and organs depending upon the vibration characteristics. Segmental vibration, unlike wholebody vibration, appears to be more localized in creating injury to the fingers and hands of workers using tools, such as pneumatic hammers, rotary grinders or other hand tools which cause vibration [42].

(4) General/Physical

Some physical hazards cannot be eliminated because of the nature of the confined space or the work to be performed. These hazards include such items as scaffolding, surface residues, and structural hazards. The use of scaffolding in confined spaces has contributed to many accidents caused by workers or materials falling, improper use of guard rails, and lack of maintenance to insure worker safety. The choice of material used for scaffolding depends upon the type of work to be performed, the calculated weight to be supported, the surface on which the scaffolding is placed, and the substance previously stored in the confined space.

Surface residues in confined spaces can increase the already hazardous conditions of electrical shock, reaction of incompatible materials, liberation of toxic substances, and bodily injury due to slips and falls. Without protective clothing, additional hazards to health may arise due to surface residues.

Structural hazards within a confined space such as baffles in horizontal tanks, trays in vertical towers, bends in tunnels, overhead structural members, or scaffolding installed for maintenance constitute physical hazards, which are exacerbated by the physical surroundings. In dealing with

structural hazards, workers must review and enforce safety precautions to assure safety.

Rescue procedures may require withdrawal of an injured or unconscious person. Careful planning must be given to the relationship between the internal structure, the exit opening, and the worker. If the worker is above the opening, the system must include a rescue arrangement operated from outside the confined space, if possible, by which the employee can be lowered and removed without injury

Statistical Data

Accidents in confined spaces, like all others, are required by Federal regulations to be reported only if medical attention or loss of time from work, or death is involved. Some states and workers' compensation carriers have slightly more stringent requirements, but none require the reporting of incidents which can be considered near misses. The report by Safety Sciences prepared under contract for NIOSH [1] tended to show that fatalities occurred more frequently in confined spaces. For example, death by asphyxiation would be reported; however, if an employee experienced shortness of breath or dizziness, but managed to escape the confined space, and was not treated by a physican, this would probably not be a reported case.

The criteria used in selecting cases was based on the definition published in the Federal Register 42:213, November 4, 1977 and specific circumstances likely to be found on injury and fatality records.

Table III-1 shows the number of "events", injuries, and fatalities from each data source. "Events" refers to the number of separate occasions in which one or more confined space-related injuries or illnesses occurred [1].

Table III-2 shows the number of events, injuries and fatalities obtained for each of the 15 basic accident and illness types which are described in Appendix 4 of this document. A total of 276 confined space related events were identified, which resulted in a total of 234 injuries and 193 fatalities. The table shows that the most hazardous conditions in a confined space are a result of atmospheric related events [1].

Table III-3 shows the number of events by SIC code for each of the 15 confined space-related accident and illness types [1].

TABLE III-1

NUMBER OF CONFINED SPACE-RELATED CASES OBTAINED BY DATA SOURCE

Data Source	Approx. No. of Cases Reviewed	No. of Events	No. of Injuries	No. of Fatalities
1. First Reports from Previous NIOSH Study 1974-75	20,000	67	66	1
2. OSHA 36's 1976-77	6,000	132	130	143
3. Equifax, Inc. "Occupational Death Reports" 8/76-12/76	1,700	41	2	49
4. Shipbuilding and Repair Cases 1976-77	750	36	36	0
Totals	28,450	276	234	193

Safety Sciences, San Diego, California - 1977 [1]

TABLE III-2

ACCIDENT AND ILLNESS TYPE
CONFINED SPACE (CS)

Ref. No.	Accident and Illness Type	Events	Injuries	Fatalities
1	Atmospheric Condition in CS	80	72	78
2	Explosion or Fire in CS	15	49	15
3	Explosion or Fire at Point-of-Entry to CS	23	20	32
4	Electrocution or Electrical Shock	11	2	9
5	Caught In/Crushing of CS	10	3	10
6	Trapped in Unstable Materials in CS	16	0	16
7	Struck by Falling Objects in CS	15	1	14
8	Falls (while in CS; not into CS)	27	26	1
9	Ingress/Egress of CS	33	30	3
10	Insufficient Maneuverability in CS	15	15	0
11	Eye Injury in CS	10	10	0
12	Contact with Temperature Extreme in CS	7	4	3
13	Noise in CS	1	1	0
14	Vibration in CS	1	1	0
15	Stress from Excess Exertion in CS	12	0	12
Totals		276	234	193

Safety Sciences, San Diego, California - 1977 [1]

TABLE III-3

CONFINED SPACE EVENTS BY SIC CODE AND ACCIDENT/ILLNESS TYPE

SIC	Name of Industry	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10	*11	*12	*13	*14	*15
01	Agricultural Products - Crops	4			1		1	1								1
02	Agricultural Products - Livestock						1									
07	Agricultural Services						1									
09	Fishing, Hunting, and Trapping		1													
13	Oil and Gas Extraction	6	1					1		1						
15	Building Construction	2		2	2			1			3					1
16	Construction Other Than Building Construction	6		3				1		2			1			3
17	Construction - Special Trade Contractors	8	4		1			1		1	3					2
20	Food and Kindred Products	1	1	1	1	2	2	1	3	1						1
23	Apparel			3												
24	Lumber and Wood Products, Except Furniture	1		3						1						
25	Furniture and Fixtures	1														
26	Paper and Allied Products	1							3	1	1	2	1			
28	Chemicals and Allied Products	8	2	2	2				1		1					1
29	Petroleum Refining and Related Industries		1													
30	Rubber and Misc. Plastic Products	1								2						
31	Leather and Leather Products	1			1											
32	Stone, Clay, Glass, and Concrete Products					1	3		1	2						
33	Primary Metal Industries	1		1		1		1	3	1	1	2	1			
34	Fabricated Metal Products, Ex. Machinery and Transportation Equip.	4			1		1	1			1					1

TABLE III-3 (CONTINUED)

CONFINED SPACE EVENTS BY SIC CODE AND ACCIDENT/ILLNESS TYPE

SIC	Name of Industry	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10	*11	*12	*13	*14	*15
35	Machinery, Except Electrical	2	1	1				2	2		1	1				
36	Electrical and Electronic Equip.	1			1				1	1						
37	Transportation Equip.	3	2	1					2	4	1		1		1	1
3731	Shipbuilding	4			1	1			8	13	7	1		1		
38	Measuring, Analyzing, and Controlling Instruments; Photographic, Medical, and Optical Goods; Watches and Clocks					1		1								
42	Motor Freight Transportation and Warehousing	3	1				3	1								
44	Water Transportation	3						1					1			
45	Transportation by Air	1						1								
47	Transportation Services	1		1												
48	Communication	3														
49	Electric, Gas, and Sanitary Services	3		1			1									
50	Wholesale Trade - Durable Goods	1		2		4			1							
51	Wholesale Trade - Nondurable Goods	1		2			1	1								1
54	Food Stores								1				2			
55	Auto Dealers and Gas Stations								1							
58	Eating and Drinking Places									1						
59	Misc. Retail						1									
65	Real Estate	1														

TABLE III-3 (CONTINUED)

CONFINED SPACE EVENTS BY SIC CODE AND ACCIDENT/ILLNESS TYPE

SIC	Name of Industry	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10	*11	*12	*13	*14	*15
70	Hotels, Camps, and Other Lodging Places	1														
73	Business Services	1														
75	Automotive Repair		1	1												
76	Misc. Repair Services	1		2												
82	Educational Services	1														
91	Executive, Legislative, and General Government	1														
93	Public Finance, Taxation, and Monetary Policy	1														
	Unknown	1														

*1 - Atmospheric Condition
*2 - Explosion or Fire
*3 - Explosion or Fire at Point-of-Entry
*4 - Electrocution or Electrical Shock
*5 - Caught In/Crushing
*6 - Trapped in Unstable Materials
*7 - Struck by Falling Objects
*8 - Falls
*9 - Ingress/Egress
*10 - Insufficient Maneuverability
*11 - Eye Injury
*12 - Contact with Temperature Extreme
*13 - Noise
*14 - Vibration
*15 - Stress from Excess Exertion

Safety Sciences, San Diego, California - 1977 [1]

IV. DEVELOPMENT OF THE STANDARD

Previous Standards

The basis for most of the previous standards were safety codes designed for specific industrial activities, and dealt with areas such as open surface tanks, welding and cutting, and the pulp and paper, and shipping industries.

The most recent standard published on confined spaces is the 12-year effort compiled by the American National Standards Institute, Z117.1-1977. Despite the effort, the ANSI standard does not address the vitally important areas of training of personnel and specific recommendations for the safety equipment required in a confined space. All personal protective equipment is referenced to different ANSI Standards, which are broad based and do not address the specific problems of confined spaces.

The ANSI Standard also accepts the use of tagging as a reliable method of locking out a potentially hazardous situation. The tagging system as a substitute for locking out all lines or pipes, or de-energizing systems of a confined space does not provide sufficient protection to the worker against accidental activation.

The ANSI Standard does mention the use of life lines; however, the only recommendation is for their use in an oxygen deficient atmosphere.

The General Industry Safety and Health Standards of the Occupational Safety and Health Administration (OSHA) address safety in confined spaces in over 50 different sections of 29 CFR 1910. The defining parameters of a confined space as given in the OSHA regulations are: (1) limited means of exit, (2) a space subject to accumulation of toxic or flammable contaminants or, (3) one where an oxygen deficient atmosphere may develop. It includes but is not limited to such spaces as storage tanks, process vessels, bins, boilers and open top spaces more than 4 feet in depth. This is essentially the same definition used to establish the scope of this recommended criteria. However the "Classification of open-surface tank operation" (1910.94(d) (2) (i-ii)) differs from the classification system proposed in this document. This proposed classification system is intended to apply to all confined spaces and is based upon the evaluation of several additional parameters. Such a classification will allow the application of a wider range of safety measures and ease the enforcement of the OSHA regulation. The confined space classification system was designed to create a focal point by drawing together over 140 references in the OSHA standards. For example, the use of life lines in all confined spaces, has been addressed in this document and a solution to their excessive use has been proposed. The two documents agree on many areas of good work practices, such as the use of standby personnel, blanked-off lines, and main shutoff valves. Another area of agreement is the acceptance of 19.5% as the minimal oxygen level for safe work practice. There are some areas of the OSHA regulations that appear to accept tagging as a sufficient measure to ensure against opening of valves or energizing equipment during entry or while working in confined spaces. The proposed standard is more stringent in that only locking-out, blanking-off or disconnection are acceptable.

Canadian [45] and Australian [46,47] regulations and standards on confined space entry were reviewed. The Canadian Standard uses a hazard evaluation report, which appears to be a condensed form of the recommended permit system. The Canadian Standard also relies on the qualified person to make decisions for entry and necessary precautions for working in and for making emergency escape. A minimum safe level of oxygen for entry is not stated, only what is considered an oxygen deficient atmosphere (less than 17% by volume). The Australian Standard, which comes under the Factories' Regulations, states the confined space shall be emptied and flushed of hazardous substances and be ventilated with fresh air before entry. The Australian Standard is concerned primarily with entry and exit, not with isolation or safe oxygen level. The Australian Standard does; however, refer to a competent person similar to the qualified person for testing the atmosphere for flammable level. Other countries [14,48-50] published guidelines or standards for entering and working in confined spaces. Many of those reviewed follow recommendations similar to the Australian and Candadian standards. Therefore, it would be redundant to make a lengthy comparative list of standards. The state standards reviewed [8,12,51-54] and those from industry [40,55-68] were also closely evaluated. The number of references involved prohibits the citing of each one, although valuable concepts were obtained.

Basis for the Recommended Standard

Workers who enter and work in confined spaces are confronted with many potentially hazardous conditions. The hazards can range from an oxygen deficient atmosphere or liberation of a toxic agent, to mechanical equipment accidentally energized. The hazardous atmospheres that can be encountered in a confined space are; flammable, toxic, irritant and/or corrosive, and asphyxiation. These atmospheric conditions are discussed in Chapter III, along with cited accident cases to emphasize the hazards involved with confined space entry.

The limited statistical data available on accidents and injuries directly related to confined spaces indicate a very high mortality level. This disproportionately high mortality level for the number of reported accidents and injuries could be the result of inadequate reporting methods, as not reporting a near miss with death, or data collection systems failing to list a confined space as a causative or other factor in traumatic accidents. In the accident and injury cases tabulated for this document, atmospheric conditions in confined spaces were responsible for the most frequent accident type in terms of events and number of persons killed or injured [1].

The work practices section in Chapter I of the recommended standard was developed after extensive review of published literature, [2,11,15-17,31,33,36,55-92] the current Federal, State, and local applicable codes, [8,12,51-54,93-101], international codes or recommendations [3,45-50,102], and site visits to facilities where working in confined spaces is part of the industrial activity.

(a) Testing and Monitoring

Prior to entry into a confined space, workers should know the space's potential hazards. Deaths have occurred because a presumably safe space was not tested prior to initial entry [7,13]. The various tests to be performed

prior to entry shall include tests for flammability, toxic agents, oxygen deficiency, and harmful physical agents. Specific instruments are required for testing the atmosphere for flammability, oxygen deficiency, carbon monoxide, and physical agents. For example, combustible gas indicators are designed for the purpose of measuring the concentration of flammable gases, and will not measure or indicate the presence of carbon monoxide at toxic levels, conversely a carbon monoxide detector is designed for the measurement of carbon monoxide only. It should be noted that combustible gas indicators respond differently to different flammable hydrocarbons and should be calibrated for the specific contaminant if known. The flammability measurement may be erroneous if the oxygen level is less or greater than normal atmospheric concentrations. Therefore, it is recommended that the oxygen level be determined prior to flammability testing to make any necessary corrections in the flammability measurement.

When the materials may form a combustible dust mixture, special precautions must be taken to prevent an explosive atmosphere from developing. There are numerous instruments available for measuring airborne dust concentrations; however, none appear to have automatic alarm systems and would require constant personal monitoring. The only practical approach to the control of combustible dusts is to eliminate the hazard by preventive measures, such as, (1) engineering controls, (2) good housekeeping, (3) elimination of ignition sources, (4) isolation of dust producing operations and, (5) training and education of the employees.

The oxygen deficiency measuring instrument is designed to measure the volume of oxygen present, usually scaled with a range of 0.0-25%. If the percentage of oxygen in a confined space atmosphere is less than 19.5% or greater than 25%, special precautions, as determined by the qualified person, shall be taken. In accordance with OSHA Safety and Health Standard 29 CFR Part 1910 and other references [12,33,51,76,87], a minimum oxygen level of 19.5% has been adopted for worker safety. The upper oxygen limit has been set at 25% because an increase above this level will greatly increase the rate of combustion of flammable materials [11].

Continuous and/or frequent monitoring becomes necessary in cases where the work being performed within the confined space has the potential of generating toxic agents [4,5,14,54,58,64,74,81,83,84,86,87]. Data collected for NIOSH by Safety Sciences [1] shows that in 28 out of 80 accident events, the toxic gas or oxygen deficiency was not in the confined space at the time of entry, but was either generated by the work occurring in the space, or by gas being unexpectedly admitted into the confined space after the worker had entered. In these cases, only continuous and/or frequent monitoring would be a possible countermeasure.

(b) Medical

Medical requirements for workers who might enter a confined space should take into consideration the increased hazard potential of confined spaces. In this setting, the workers must rely more heavily upon their physical, mental, and sensory attributes, especially under emergency conditions. Workers should be evaluated by competent medical personnel to insure that they are physically and mentally able to wear respirators under simulated and actual working conditions. Because of the additional stress placed on the cardiopulmonary system, some pathologic conditions, such as cardiovascular diseases or those

associated with hypoxemia, should preclude the use of respiratory protective devices [101].

In areas where the hazard potential is high, a person certified in CPR and first aid should be in attendance. Since irreversible brain damage can occur in approximately 4 minutes in an oxygen deficient atmosphere, it is essential that resuscitation attempts occur within that time [102].

(c) Safety Equipment and Clothing

Many cases of accidental dermal exposure, respiratory distress, and traumatic injury due to falling objects have occurred in confined spaces; therefore, a general safety standard should address the problem of whole body protection [3]. Another area of concern is the use of life lines in all confined spaces. Part of the recommended standard should be an evaluation of the confined space to define when life lines shall be used and when a safety belt with D rings for attaching life lines would be sufficient [12,14,17,53,58,61,73,93,97,103,104].

(d) Training

Training of employees for entering and working in confined spaces is essential because of the potential hazards and the use of life saving equipment. To insure worker safety, the training program should be especially designed for the type of confined space involved and the problems associated with entry and exit. If different types of confined spaces are involved, this will require additional training. Areas that should be covered in an effective training program are:

1. Emergency entry and exit procedures
2. Use of applicable respiratory equipment
3. First Aid and Cardio-Pulmonary Resuscitation (CPR)
4. Lockout procedures
5. Safety equipment use
6. Rescue drills
7. Fire protection
8. Communications

Training of employees should be done by the qualified person or someone knowledgeable in all relevant aspects of confined space entry, hazard recognition, use of safety equipment, and rescue [3,33,53,58,63,68,84,90,97].

For training to be effective, classroom sessions, on-the-job training, or simulated conditions, appear to be the most satisfactory methods. Classroom sessions should include all applicable Federal, state, and local regulations that govern the specific industrial activity in which the employee will be working, as well as the hazards of a confined space (physical and chemical). The training guidelines in Chapter V can be used as a format for additional classroom activity. On-the-job training should be closely supervised until the employee has a complete understanding of all potential hazards. Testing of the employee should take place to evaluate the person's competency and determine if retraining is necessary.

(é) Work Practices

(1) Purging and ventilation - poor natural ventilation is one of the defining parameters of a confined space, therefore purging and mechanical ventilation must be closely evaluated when safe work practices are developed for entering and working in confined spaces. Purging is the initial step in adjusting the atmosphere in a confined space to acceptable standards (PEL's, LEL's, and LFL's). This is accomplished either by displacing the atmosphere in the confined space with fluid or vapor (inert gas, water, steam and/or cleaning solution), or by forced air ventilation. According to the literature [11] 20 air changes should bring the atmosphere in the confined space into equilibrium with the external environment.

After purging, one establishes general and/or local exhaust ventilation to maintain a safe uncontaminated level. Guidelines for establishing ventilation rates are referenced in the ANSI Standard Z9.2-1972 [105] and NIOSH Recommended Industrial Ventilation Guidelines [106]. In addition, other information applicable to the special problems of confined spaces must be considered such as the Occupational Safety and Health Standard 29 CFR 1915.31(b) [31,45,69,107-109]. Entering into an inert atmosphere is one of the most hazardous activities associated with working in a confined space. Work in an inert atmosphere is usually performed by employees of companies who specialize in this because of the high degree of training and expertise needed to perform inert entry operations safely. The scope of this document deals with the necessary precautions but does not cover the specialized training for entry into a confined space containing an inert atmosphere [11,106].

(2) Isolation/Lockout/Tagging - a review of the statistical data provided to NIOSH [1] demonstrated an obvious need for lockout procedures. The use of tags, while valuable for identification and/or information purposes, appears to have been inadequate in preventing accidents. A review of the literature has shown that proper isolation and lockout procedures are more effective than tagging [5,6,12,45,55,57,61,64,88,103].

(3) Cleaning - decontaminating a space by cleaning is necessary to provide for worker safety. However, it must be recognized that the cleaning process itself can generate additional hazards. Continuous and/or frequent monitoring is required during this process to determine that flammable mixtures and hazardous concentrations of contaminants are adequately diluted before safe entry can be made [3,5,15,20,48,49,59,61,79,80,91].

(4) Equipment and tools - the literature reviewed [15,58,63,64,109], has shown the potential for explosion is greatly increased when explosion proof equipped tools and equipment are not used or improperly maintained. Also the potential for electrocution is increased when low voltage or ground fault circuit interrupters are not used.

(5) Permit System - the inherent dangers associated with a confined space clearly indicate the need for strict control measures of employees and equipment. The literature has shown [50,52,55,56,63,69,77,86,88,90] that the use of a permit system is a very effective method of attaining control. The permit provides written authorization for entering and working in confined spaces, clearly states all known or potential hazards, and identifies the safety equipment required to insure the safety of the worker.

(6) Entry and Rescue - the potential hazards associated with a confined space must be evaluated prior to entry. These hazards would include the following: oxygen level, flammability characteristics, toxic agents, and physical hazards ie, limited openings and communications. To simplify entry and rescue it would appear logical to set up a classification table for easy reference. The literature reviewed [5,12,51,63,69,76] has provided necessary information to set up an entry classification table and allow for flexibility in the selection of personal protective equipment.

It is essential that well planned rescue procedures and the proper use of personal protective equipment be followed. The literature and data reviewed have shown a very poor record in successful rescue efforts. Spontaneous reaction instead of well planned and executed rescue procedures has led to multiple fatalities in confined spaces. In 19 of the 25 cases in which rescue was attempted, the rescuers were injured or killed. These cases resulted in 13 deaths and 30 injuries to rescuers, even though only 5 victims were successfully saved. One particular case resulted in injury to 15 rescuers; however, they were successful in saving 3 lives [1]. Therefore, the standby and/or rescue team shall be properly equipped and trained in all aspects of rescue.

(7) Recordkeeping - from a review of the limited data available (no SIC code for confined spaces) and the information collected from the plant site visits on accidents in confined spaces, it is apparent that recordkeeping systems must be changed to identify areas where accidents occur, so that underlying causes can be determined. The records to be kept by the employer should contain such information as employee name, age, training, job description, number of years on the job, accident location and severity, underlying causes, and action taken to insure future worker safety.

V. TRAINING GUIDELINES

The very nature of the hazards encountered in a confined space is of paramount importance in structuring an effective training program which will provide for safe work practices and techniques. The training program should be based on the specific hazards to be encountered, approved by a trained safety person and given to all individuals who will perform the work or may be assigned as standby or rescue persons.

(a) Qualifications of Training Personnel

It is essential that the person in charge of training know the relevant aspects of safety as they relate to confined spaces. The instructor(s) must have a thorough working knowledge of the following:

(1) Type(s) of confined spaces associated with the industrial activity.

(2) Hazards involved

(A) Chemical

(B) Physical

(3) Work practices and techniques

(4) Testing requirements, PEL's, etc.

(5) Safety equipment

(A) Respirators

(B) Clothing

(C) Other protection (shields, helmets, etc)

(6) Rescue procedures

(7) Knowledge of applicable Federal, state, and local regulations

(8) Evaluation and test methods

(b) Training methods

The method and approach of training will be determined by the previous experience and skills of the employee, with the exception of a newly hired person who should receive a complete and thorough safety orientation. Basic types of training prescribed are:

(1) Orientation of all new employees. This type of training would consist of classroom sessions along with a walk-through of the physical plant layout to give the trainee a basic understanding of the industrial activity.

(2) On-the-job training. This would be a second phase of training. After classroom sessions and after the trainee has gained a basic understanding of the operation and hazards involved, on-the-job instruction should include observation and closely supervised participation in actual work practices or simulated conditions.

(3) Retraining. This should be performed periodically and as frequently as needed. Many industrial activities are quite complex and operations are frequently updated to keep up with modern innovations. It is necessary, therefore, for a formal retraining program to be planned so that all personnel concerned may be kept abreast of changes. Retraining should also be considered necessary if a supervisor notices a weakness in employee performance.

(c) Training Evaluation

The effectiveness of the training program can be determined by observation of the employee by the qualified person to see if safe work practices are being followed, testing the employee for knowledge of the operations and hazards, and a reduction in the accident rate due to safe work practices and techniques which have been learned and are being practiced.

(d) Training Program

The work practices section presented in Chapter I was designed to set a formalized standard that could, when complied with, eliminate or minimize accidents and injuries occurring in confined spaces. The standard would not be sufficient without a formal written training program and job planning to convey safe work practices and their relationship to the entire operation.

The employer is responsible for ensuring that each employee is adequately trained and given refresher courses in assigned duties, and that the employee understands and applies safe work practices. The following are recommended areas that should be covered thoroughly in training:

(1) The types of confined spaces that are found in the industrial complex. This should cover physical location, size, and any pertinent information that would inform the worker of its function.

(2) Physical and chemical hazards involved. The physical hazards would include structural members within a confined space, equipment that will be used, eg, scaffolding or ladders, size of openings, flooring, and other. Chemical hazards discussed will cover the product which has been stored, chemical cleaners used, and air contaminants which can be liberated due to the work practices.

(3) Atmospheric testing of the confined space. This phase of the instruction should emphasize the contaminants which should be tested for and the safe levels for entry.

(4) Cleaning and purging. Cleaning methods to be discussed should include steaming, water rinses, chemical cleaners, or other specific processes used.

(5) Ventilation of the space by mechanical methods to reduce or eliminate toxic airborne contaminants. This category should be covered sufficiently to alert the employee of potential hazards, and the need for warning devices to signal when there is a ventilation failure.

(6) Isolation and lockout of the confined space. The worker should be able to recognize a hazard by visual observation of the connecting lines to a confined space. The lockout of electrical circuits and mechanical disconnects to complete confined space isolation should be explained as should the employees' responsibilities in this area.

(7) Safety equipment and clothing. The worker should be aware of the proper use and care required for his personal protective equipment. This should include the type of protective shoes, gloves, face protection, protective clothing, head protection, and safety belts and harnesses that are to be worn as well as the rationale for their use. A major area in this section will be the use of respirators: the types required, their use, quantitative fit (test), respirator cleaning procedures, and proper storage. It should be emphasized that different type respirators are required for different atmospheres and the dangers involved when the wrong type is used [39]. The mandatory wearing of safety belts should be stressed. The use of safety belts and harnesses should be demonstrated so that each individual understands the importance of having the rescue system available, and operative, and is constantly aware of the necessity of keeping life lines clear to the point of exit.

(8) Buddy system and use of a standby person.

(9) Communication systems and emergency signals.

(10) Rescue procedures. All employees working in or around a confined space should be fully trained in emergency entry and exit procedures and be trained in first aid and CPR. This should include on-site entry and rescue drills.

(11) Permit system used by the employer. Information covered on the permit should include: purpose of the permit; location where permit will be posted; responsible persons; emergency information, and hazards to be encountered.

(12) Documentation of Training. Satisfactory completion of this safety training, and refresher courses, should be entered into the employee's permanent record.

VI. RESEARCH NEEDS

The primary research need in the area of confined spaces is the development of a data system that would have the capability of recording injury and mortality information specific to the causative factor eg, confined space and be readily accessible. It is now impossible to retrieve data directly related to confined space injuries and mortality, since data are currently collected by general classifications, such as SIC codes. Feasibility studies are being done by NIOSH on a system that could correct this weakness in data recording and retrieval and provide a more accurate picture in areas such as confined space hazards. These data are essential to the proper evaluation of the causes of injuries and deaths. Specific data will provide a base for establishing training programs and standards aimed toward the more hazardous areas and permit the evaluation of current standards. These data would also provide a background for analyzing unusual accidents to establish causal factors and prevent recurrence.

A final step that would be accomplished by an approved data base on confined spaces would be to standardize the degree of hazards throughout industry and provide justification for a uniform standard. This uniform standard would serve as the basis for a training program, which could be tailored to meet the needs of large as well as small industries.

The second area of research needed is development of more adequate methods for preventing and detecting gas leaks into confined spaces. Many accidents have occurred because the atmosphere in a confined space, which was presumed to be safe by the nature of the contents or obvious safe history of the confined space, had suddenly become lethal. Historical cases reported have shown that faulty seals in storage or processing vessels may allow seepage from an external source, which could be naturally lethal or could form a lethal substance when combined with residual material in the tank.

A third area for research is the analytical devices used in confined spaces, such as intrinsically safe continuous monitors for gases as well as explosive dusts, personal dosimeters, and test meters designed to withstand rugged field use and maintain their integrity. It becomes difficult to calibrate a gas detection meter after continued field use and to be sure of its accuracy. The instrument, for field use, should be of the internal calibration type that will allow for more accurate testing.

A fourth area of research is the need to define and evaluate the stresses on employees who are required to work in confined spaces. This evaluation should include physical stressors (eg heat stress, cold stress) and sensory deprivation with respect to the work practice and length of work period.

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VIII. APPENDIX I

CROSS REFERENCE - NIOSH RECOMMENDED STANDARD FOR WORKING IN CONFINED SPACES TO THE OSHA STANDARD

NIOSH Recommended Standard	OSHA Standard
Confined Space Definition	1926.21(b)(6)(ii) 1915.2(n) 1916.2(n) 1917.2(n) Standards Notice 20
Training of Personnel	1926.21(b)(6)(i)
Isolation, Lockout, and Tagging	1910.252(d)(3)(i) 1910.261(b)(5) 1910.261(e)(12)(iii) 1910.261(f)(6)(i) 1910.261(g)(4)(ii) 1910.261(g)(15) 1910.261(j)(5)(iii) 1910.261(j)(6)(i) 1910.262(p) and (g) 1910.263(d)(6)(ii) 1910.263(l)(3)(iii)
Cleaning	1910.252(d)(2)(vi)(c) 1910.261(g)(4)(i)
Testing	1910.94(d)(11)(iii) 1915.11 1917.11 1915.33(c) 1916.33(c) 1917.33(c) 1915.33(d) 1916.33(d) 1915.33(e) 1916.33(e) 1926.651(v) 1926.850(e) 1926.956(a)(3)(i) 1926.956(a)(3)(ii) 1926.956(b)(3)

APPENDIX I (CONTINUED)
CROSS REFERENCE - NIOSH RECOMMENDED STANDARD FOR WORKING IN CONFINED SPACES TO THE OSHA STANDARD

NIOSH Recommended Standard	OSHA Standard
Ventilation and Purging	1910.94(d)(11)(iv)
	1910.252(e)(4)(ii)
	1910.252(f)(2)(i)
	1910.252(f)(2)(ii)
	1910.252(f)(3)(i)
	1910.252(f)(3)(ii)
	1910.252(f)(4)(i)
	1910.252(f)(4)(ii)
	1910.252(f)(5)(ii)
	1910.261(g)(4)(i)
	1910.261(g)(6)
	1910.261(g)(15)
	1910.261(g)(22)
	1910.265(f)(4)
	1915.31(b)
	1916.31(b)
	1917.31(b)
	1918.93
	1926.154(a)(2)
	1926.353(b)(1)
	1926.353(b)(2)
	1926.353(c)(1)
	1926.353(c)(2)
	1926.651 (v)
	1926.850 (e)
	1926.956(a)(3)(i)
	1926.956(a)(3)(ii)
	1926.956(a)(3)(iii)
	1926.956(b)(2)
Equipment and Tools	1910.252(a)(1)(ii)
	1910.252(e)(4)(iii)
	1910.261(g)(15)
	1910.261(j)(6)(iii)
	1910.263(d)(6)(iii)
	1910.265(f)(4)
	1915.35(b)(4)
	1916.35(b)(4)
	1917.35(b)(4)
	1915.32(g)
	1916.32(g)
	1917.32(a)
	1926.350(b)(4)
	1926.352(g)

APPENDIX I (CONTINUED)
CROSS REFERENCE - NIOSH RECOMMENDED STANDARD FOR WORKING IN CONFINED SPACES TO THE OSHA STANDARD

NIOSH Recommended Standard	OSHA Standard
Personal Protective Equipment	1910.94(a)(5) 1910.94(d)(9)(vi) 1910.94(d)(11)(v) 1910.134(e)(3) 1910.134(e)(3)(iii) 1910.252(e)(4)(iv) 1910.252(f)(4)(ii) 1910.252(f)(4)(iii) 1910.252(f)(4)(iv) 1910.261(b)(5) 1910.261(g)(2)(iii) 1910.261(g)(4)(i) 1910.261(g)(6) 1910.261(g)(8) 1910.261(g)(15) 1910.261(j)(5)(ii) 1915.23(a)(4) 1916.23(a)(4) 1915.23(b) 1916.23(b) 1917.23(b) 1915.24(a) 1916.24(a) 1916.82 1917.82 1918.82 1926.21(b)(6)(i) 1926.103(b)(3) 1926.104(a) 1926.104(b) 1926.104(d) 1926.104(f) 1926.250(b)(2) 1926.353(b)(2) 1926.353(c)(2) 1926.354(c) 1926.651(v) 1926.957(h)(2)
Standby Person and Rescue	1910.134(e)(3) 1910.134(e)(3)(i) 1910.134(e)(3)(ii) 1910.134(e)(3)(iii) 1910.252(e)(4)(iv) 1910.252(f)(4)(iv) 1910.261(b)(5) 1910.261(f)(6)(ii)

APPENDIX I (CONTINUED)
CROSS REFERENCE - NIOSH RECOMMENDED STANDARD FOR WORKING IN CONFINED SPACES TO THE OSHA STANDARD

NIOSH Recommended Standard	OSHA Standard
Standby Person and Rescue	1910.261(g)(4)(ii)
	1910.261(g)(8)
	1910.261(j)(5)(ii)
	1910.268(O)(1)(i)
	1910.268(O)(1)(ii)
	1910.268(O)(2)(i)
	1910.268(O)(2)(ii)
	1910.268(O)(2)(iii)
	1910.268(O)(3)
	1910.268(O)(4)
	1910.268(O)(5)(i)
	1910.268(O)(5)(ii)
	1915.46(b)
	1916.46(b)
	1917.46(b)
	1915.54
	1916.54
	1917.54
	1926.353(b)(2)
	1926.956(b)(1)

IX. APPENDIX II

RECOMMENDED RESPIRATORY SELECTION GUIDE

Hazard	Concentration* Less Than or Equal To	Respirator**
particulate	5 x PEL	single use respirator***
particulate	10 x PEL	any dust respirator***
particulate	50 x PEL	full facepiece respirator with high efficiency filter(s) or self-contained breathing apparatus with full facepiece operated in the demand mode
particulate	2000 x PEL	supplied-air respirator with full facepiece operated in any positive pressure mode
particulate	greater than 2000 x PEL	self-contained breathing apparatus with full facepiece operated in the pressure demand mode or a supplied-air respirator with full facepiece operated in any positive pressure mode with an auxiliary self-contained breathing apparatus
known gas or vapor contaminant****	50 x PEL	chemical cartridge respirator with full facepiece and cartridges approved for the specific contaminant(s) or a full face-piece self-contained breathing apparatus operated in the demand mode

APPENDIX II (CONTINUED)

Hazard	Concentration* Less Than or Equal To	Respirator**
known gas or vapor contaminant***	2000 x PEL	Supplied-air respirator with full facepiece operated in any positive pressure mode
	greater than 2000 x PEL	Self-contained breathing apparatus with full facepiece operated in the pressure-demand mode or combination supplied-air respirator with full facepiece operated in any positive pressure mode with an auxillary self-contained breathing apparatus
combination of particulates and gases or vapors****	50 x PEL	a full facepiece combination respirator approved for dusts and mists and the specific contaminant(s) (gases or vapors)
	1000 x PEL	powered air-purifying full facepiece combination respirator with high efficiency filter and chemical cartridge approved for the specific gas or vapor
	2000 x PEL	supplied-air respirator with full facepiece operated in any positive pressure mode
	greater than 2000 x PEL	self contained breathing apparatus with full facepiece operated in the pressure-demand mode or combination supplied-air respirator with full facepiece operated in any positive pressure mode with an auxilary self-contained breathing apparatus

APPENDIX II (CONTINUED)

Hazard	Concentration* Less Than or Equal To	Respirator**
unknown contaminant	undetermined	self-contained breathing apparatus with full facepiece operated in the positive pressure mode or a supplied-air respirator with full facepiece operated in any positive pressure mode with an auxilary self-contained breathing apparatus
inert and other atmospheres where the oxygen level is below 17%		self-contained breathing apparatus with full facepiece operated in the pressure demand mode or a combination supplied air respirator with full facepiece operated in any positive pressure mode with an auxillary self-contained breathing apparatus
emergency entry	unknown	self-contained breathing apparatus with full facepiece operated in the pressure demand mode or a combination supplied-air respirator with full facepiece operated in any positive pressure mode with an auxilary self-contained breathing apparatus

*If the concentration forms a flammable atmosphere only the self-contained breathing apparatus with full facepiece operated in the pressure-demand mode may be used.
**Any respirator recommended for a higher concentration may be used at a lower concentration.
***These respirators may not be used if the toxic material is carcinogenic.
****If the concentration forms an atmosphere which is immediately dangerous to life then only the self-contained breathing apparatus operated in the pressure mode or the combination supplied-air respirator with full facepiece operated in any positive mode with an auxilary self-contained breathing apparatus may be used.

X. APPENDIX III

SAMPLE PERMIT

CONFINED SPACE ENTRY

CLASS ____

Location of Work: _____
Description of Work (Trades): _____
Employees Assigned: _____
Entry Date: _____ Entry Time: _____
Outside Contractors: _____

Isolation Checklist:

- Blanking and/or Disconnecting
- Electrical
- Mechanical
- Other

Hazardous Work:

- Burning
- Welding
- Brazing
- Open Flame
- Other

Hazards Expected:

- Corrosive Materials
- Hot Equipment
- Flammable Materials
- Toxic Materials
- Drains Open
- Cleaning (Ex: chemical or water lance)
- Spark Producing Operations
- Spilled Liquids
- Pressure Systems
- Other

Vessel Cleaned:

- Deposits _____
- Method _____
- Inspection _____
- Neutralized with _____

Fire Safety Precautions: _____

_____

Personal Safety:

Ventilation Requirements
Respirators
Clothing
Head, Hand, and Foot Protection
Shields
Life Lines and Harness
Lighting
Communications
Employee Qualified
Buddy System
Standby Person
Emergency Egress Procedures
Training Sign Off (Supervisor or Qualified Person)_____
Remarks: _____

Atmospheric Gas Tests

	Tests Performed	Location	Reading
Example:	(Oxygen)		(19.5%)
Example:	(Flammability)		(Less than 10% LFL)

Remarks: _____

Test Performed By: _____
Signature

Time: _____

Authorizations:

Supervisor: _____
Prod Supervisor: _____
Line Supervisor: _____
Safety Supervisor: _____
Etc.: _____

Entry and Emergency Procedures Understood:

Standby Person _____
Rescue _____
Telephone _____

Permit Expires: _____

Classification: _____

XI. APPENDIX IV

CHARACTERISTICS OF CASES INCLUDED AS "CONFINED SPACE RELATED"

Ref. No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
1	Atmospheric Condition in CS	Toxic levels in CS of substances: - contained in CS - from decomposition of substances in CS - from mixture of substances in CS - substances being used in CS, eg, cleaning solvents - catalytic heaters - vapors left from previously emptied CS - welding fumes Oxygen deficiency, due to: - fermentation - rust - use of other gases, eg, nitrogen to clear combustible gases - welding in CS Includes cases in which the employee was at the point of entry to the CS (eg, leaning into CS to measure) and was overcome. Includes allergic reactions to substances inhaled.	Falls or other types which are not the result of hazardous atmospheric conditions, eg, due to surface condition of CS, are covered under other Accident Types such as Ref. No. 8.

(*Note: all cases involving mining, tunneling are excluded.)

APPENDIX IV (CONTINUED)

CHARACTERISTICS OF CASES INCLUDED AS "CONFINED SPACE RELATED"

Ref. No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
		Includes falls and other accident types even if the employee was outside the CS before he fell, <u>if, and only if, they were the result of being overcome by atmospheric substances</u>. Examples: employee was sitting on top of silo and was overcome by gas from fermenting corn and fell into silo; employee fell from ladder, when he was overcome by gas in CS; employee drowned when he was overcome by gas and fell into 12" deep water in CS.	
2	Explosion or Fire in CS	Only includes cases in which one or more victims were in the CS at the time. May be able to identify a spark - generating activity that occurred in CS, eg, - dip testing tank - welding - electrical tools - light bulbs - matches Usually the result of a combination of combustible gases in CS and spark from activity of employee in CS.	Cases in which a CS exploded but no victim was inside. Cases in which the CS exploded for "no apparent reason" or a reason not connected with the activities of those in the CS.

APPENDIX IV (CONTINUED)

CHARACTERISTICS OF CASES INCLUDED AS "CONFINED SPACE RELATED"

Ref. No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
3	Explosion or Fire at Point-of-Entry of CS	Cases in which an employee was welding, using a power tool, or some other spark generating activity at the entry point to the CS.	Cases in which a CS exploded for "no apparent reason" or for a reason unconnected with the activity of the employee near the CS, eg, "just walking by and it blew up."
		Driving an automobile near to a CS containing combustible materials.	Cases in which the employee was welding (or performing some other spark-generating activity) on a CS which is too small for, and would almost certainly never be used to contain an employee, eg, 55 gal oil drums. Welding drums containing flammable liquids or left over vapors is an extremely common cause of fatalities, and has causal factors similar to CS-related cases were not typical of the problem NIOSH is addressing.
	Electrocution or Electrical Shock	Must appear to be result, at least in part, of the CS.	Cases in which an electrically "hot" source just happened to be in a CS eg, "I picked up a cable with a frayed wire".
		Frequently the result of the conductive walls of the CS.	

APPENDIX IV (CONTINUED)

CHARACTERISTICS OF CASES INCLUDED AS "CONFINED SPACE RELATED"

Ref. No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
5	Caught In/ Crushing of CS	Cases in which an employee entered a machine and failed to "lock-out". The machine is activated and the employee is crushed inside the machine. The victim must be inside a machine which it was intended that he should enter and he must have entered deliberately. Elevator shafts, or cases in which the employee was on top of an elevator and crushed in the "CS" when it was elevated. Examples of such machines include rock crushers.	Cases in which the machine is too small for the employee to ever place his entire body inside eg, caught in conveyor gear's. Cases in which the employee was under (not in) a machine or machine part. In particular, being trapped under a vehicle eg, when the jack slips or under a falling bed of a dump truck are not included. Cases in which the employee is drawn into the machine. Elevator injuries if person is inside the elevator. Falls into machines.
6	Trapped in Unstable Materials in CS	"Quicksand" effect of standing in silos containing fine grain or beans. Employee must have been in the CS before the surface gave way eg, unjamming blockage or intentionally stepped into CS with the unstable surface material.	Falls into CS containing such the result of atmospheric conditions (Ref. No. 1).

APPENDIX IV (CONTINUED)

CHARACTERISTICS OF CASES INCLUDED AS "CONFINED SPACE RELATED"

Ref. No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
7	Struck by Falling Objects in CS	Employee is struck by objects falling from walls of CS or through point of entry of CS.	(Eye injuries are covered in Ref. No. 11.)
		Related in that employee is unable to maneuver to safety in a CS.	Does not include cave-ins of trenches as these have not been considered to be CS's.
		Includes being suffocated when a CS is accidentally filled while the employee is in it.	
8	Falls (while in CS)	Only to employees in CS due to surface condition eg, wet, oil; configuration eg, a rolling barrel; or other characteristics of the CS.	Falls into a CS eg, uncovered manhole. Atmospheric condition of CS
			Falls in CS where no characteristic of the CS was involved.
		Falls through holes in or breaking part of CS, eg, employee goes through weak part of ventilation duct as he crawls through it.	(Falls while leaving or entering the CS are covered in Ref. No. 9.)
		Falls over objects or tools, eg, holes, on floor of CS when it is not possible to locate elsewhere.	
		Falls due to poor lighting in CS.	
		Falls due to uneven surface of CS.	

APPENDIX IV (CONTINUED)

CHARACTERISTICS OF CASES INCLUDED AS "CONFINED SPACE RELATED"

Ref. No.	Accident Type or Illness	Characteristics of Included Cases	Related, but Excluded, Cases
9	Ingress/Egress	Strains, bodily reactions, abrasions, or falls as the result of entering or leaving a cramped, sharp-edged, high-level, or otherwise hazardous point-of-entry to a CS.	(Must be a bonafide CS, eg, ingress/egress of vehicle cabs, though subject to similar hazards, are not included because they are not a CS.)
10	Insufficient Maneuver	Strains, bodily reactions, abrasions, contact with caustic substances, etc. when they are in part the result of attempting to maneuver in a CS. Includes striking self or being struck by fellow employee as the result of a CS. Low head room eg, striking head.	Cases of insufficient space when the employee is working under a machine (even though cramped), because these are not considered a CS.
11	Eye Injury in CS	From dust falling from walls of CS, generated by activity in CS, or from materials in CS. Welding arc when unable to use face shield because of CS.	
12	Contact with Temperature	Burns or scalds from hot steam discharged into CS. Heat exhaustion or frost bite from temperature of CS.	

Safety Sciences, San Diego, California - 1977 [1]

SECTION 1

OCCUPATIONAL SAFETY AND HEALTH REGULATIONS AND STANDARDS

PART 5

OSHA 29 CFR 1910.1200 HAZARD COMMUNICATION STANDARD

1910.1200—HAZARD COMMUNICATION

Note: The Office of Management and Budget has disapproved, under the Paperwork Reduction Act, three applications of the Hazard Communication Standard:

(1) The requirement that material safety data sheets be provided on multi-employer worksites;

(2) Coverage of any consumer product excluded from the definition of "hazardous chemical" under section 311(e)(3) of the Superfund Amendments and Reauthorization Act of 1986; and

(3) Coverage of any drugs regulated by the U.S. Food and Drug Administration in the non-manufacturing sector.

(a) Purpose.

(1) The purpose of this section is to ensure that the hazards of all chemicals produced or imported are evaluated, and that information concerning their hazards is transmitted to employers and employees. This transmittal of information is to be accomplished by means of comprehensive hazard communication programs, which are to include container labeling and other forms of warning, material safety data sheets and employee training.

(2) This occupational safety and health standard is intended to address comprehensively the issue of evaluating the potential hazards of chemicals, and communicating information concerning hazards and appropriate protective measures to employees, and to preempt any legal requirements of a state, or political subdivision of a state, pertaining to the subject. Evaluating the potential hazards of chemicals, and communicating information concerning hazards and appropriate protective measures to employees, may include, for example, but is not limited to, provisions for: developing and maintaining a written hazard communication program for the workplace, including lists of hazardous chemicals present; labeling of containers of chemicals in the workplace, as well as of containers of chemicals being shipped to other workplaces; preparation and distribution of material safety data sheets to employees and downstream employers; and development and implementation of employee training programs regarding hazards of chemicals and protective measures. Under section 18 of the Act, no state or political subdivision of a state may adopt or enforce, through any court or agency, any requirement relating to the issue addressed by this Federal standard, except pursuant to a Federally-approved state plan.

(b) Scope and application.

(1) This section requires chemical manufacturers or importers to assess the hazards of chemicals which they produce or import, and all employers to provide information to their employees about the hazardous chemicals to which they are exposed, by means of a hazard communication program, labels and other forms of warning, material safety data sheets, and information and training. In addition, this section requires distributors to transmit the required information to employers.

(2) This section applies to any chemical which is known to be present in the workplace in such a manner that employees may be exposed under normal conditions of use or in a foreseeable emergency.

(3) This section applies to laboratories only as follows:

(i) Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced;

(ii) Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees; and,

(iii) Employers shall ensure that laboratory employees are apprised of the hazards of the chemicals in their workplaces in accordance with paragraph (h) of this section.

(4) In work operations where employees only handle chemicals in sealed containers which are not opened under normal conditions of use (such as are found in marine cargo handling, ware-

housing, or retail sales), this section applies to these operations only as follows:

(i) Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced;

(ii) Employers shall maintain copies of any material safety data sheets that are received with incoming shipments of the sealed containers of hazardous chemicals, shall obtain a material safety data sheet for sealed containers of hazardous chemicals received without a material safety data sheet if an employee requests the material safety data sheet, and shall ensure that the material safety data sheets are readily accessible dur-

ing each work shift to employees when they are in their work area(s); and,

(iii) Employers shall ensure that employees are provided with information and training in accordance with paragraph (h) of this section (except for the location and availability of the written hazard communication program under paragraph (h)(1)(iii)), to the extent necessary to protect them in the event of a spill or leak of a hazardous chemical from a sealed container.

(5) This section does not require labeling of the following chemicals:

(i) Any pesticide as such term is defined in the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 136 et seq.), when subject to the labeling requirements of that Act and labeling regulations issued under that Act by the Environmental Protection Agency;

(ii) Any food, food additive, color additive, drug, cosmetic, or medical or veterinary device, including materials intended for use as ingredients in such products (e.g. flavors and fragrances), as such terms are defined in the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 301 *et seq.*) and regulations issued under that Act, when they are subject to the labeling requirements under that Act by the Food and Drug Administration;

(iii) Any distilled spirits (beverage alcohols), wine, or malt beverage intended for nonindustrial use, as such terms are defined in the Federal Alcohol Administration Act (27 U.S.C. 201 *et seq.*) and regulations issued under that Act, when subject to the labeling requirements of that Act and labeling regulations issued under that Act by the Bureau of Alcohol Tobacco, and Firearms; and,

(iv) Any consumer product or hazardous substance as those terms are defined in the Consumer Product Safety Act (15 U.S.C. 2051 et seq.) and Federal Hazardous Substances Act (15 U.S.C. 1261 et seq.) respectively, when subject to a consumer product safety standard or labeling requirement of those Acts, or regulations issued under those Acts by the Consumer Product Safety Commission.

(6) This section does not apply to:

(i) Any hazardous waste as such term is defined by the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976, as amended (42 U.S.C. 6901 et seq.), when subject to regulations issued under that Act by the Environmental Protection Agency;

(ii) Tobacco or tobacco products;

(iii) Wood or wood products;

(iv) Articles;

(v) Food, drugs, cosmetics, or alcoholic beverages in a retail establishment which are packaged for sale to consumers;

(vi) Foods, drugs, or cosmetics intended for personal consumption by employees while in the workplace;

(vii) Any consumer product or hazardous substance, as those terms are defined in the Consumer Product Safety Act (15 U.S.C. 2051 *et seq.*) and Federal Hazardous Substances Act (15 U.S.C. 1261 *et seq.*) respectively, where the employer can demonstrate it is used in the workplace in the same manner as normal consumer use, and which use results in a duration and frequency of exposure which is not greater than exposures experienced by consumers; and,

(viii) Any drug, as that term is defined in the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 301 *et seq.*), when it is in solid, final form for direct administration to the patient (i.e. tablets or pills).

(c) **Definitions.**

"Article" means a manufactured item:

(i) Which is formed to a specific shape or design during manufacture;

(ii) which has end use function(s) dependent in whole or in part upon its shape or design during end use; and

(iii) which does not release, or otherwise result in exposure to, a hazardous chemical, under normal conditions of use.

"Assistant Secretary" means the Assistant Sec-

retary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"Chemical" means any element, chemical compound or mixture of elements and/or compounds.

"Chemical manufacturer" means an employer with a workplace where chemical(s) are produced for use or distribution.

"Chemical name" means the scientific designation of a chemical in accordance with the nomenclature system developed by the International Union of Pure and Applied Chemistry (IUPAC) or the Chemical Abstracts Service (CAS) rules of nomenclature, or a name which will clearly identify the chemical for the purpose of conducting a hazard evaluation.

"Combustible liquid" means any liquid having a flashpoint at or above 100 °F (37.8 °C), but below 200 °F (93.3 °C), except any mixture having components with flashpoints of 200 °F (93.3 °C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

"Common name" means any designation or identification such as code name, code number, trade name, brand name or generic name used to identify a chemical other than by its chemical name.

"Compressed gas" means:

(i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 °F (21.1 °C); or

(ii) a gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 °F (54.4 °C) regardless of the pressure of 70 °F (21.1 °C); or

(iii) A liquid having a vapor pressure exceeding 40 psi at 100 °F (37.8 °C) as determined by ASTM D-323-72.

"Container" means any bag, barrel, bottle, box, can, cylinder, drum, reaction vessel, storage tank, or the like that contains a hazardous chemical. For purposes of this section, pipes or piping systems, and engines, fuel tanks, or other operating systems in a vehicle, are not considered to be containers.

"Designated representative" means any individual or organization to whom an employee gives written authorization to exercise such employee's rights under this section. A recognized or certified collective bargaining agent shall be treated automatically as a designated representative without regard to written employee authorization.

"Director" means the Director, National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, or designee.

"Distributor" means a business, other than a chemical manufacturer or importer, which supplies hazardous chemicals to other distributors or to employers.

"Employee" means a worker who may be exposed to hazardous chemicals under normal operating conditions or in foreseeable emergencies. Workers such as office workers or bank tellers who encounter hazardous chemicals only in non-routine, isolated instances are not covered.

"Employer" means a person engaged in a business where chemicals are either used, distributed, or are produced for use or distribution, including a contractor or subcontractor.

"Explosive" means a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

"Exposure" or "exposed" means that an employee is subjected to a hazardous chemical in the course of employment through any route of entry (inhalation, ingestion, skin contact or absorption, etc.), and includes potential (e.g. accidental or possible) exposure.

"Flammable" means a chemical that falls into one of the following categories:

(i) "Aerosol, flammable" means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame projection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;

(ii) "Gas, flammable" means:

(a) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of thirteen (13) percent by volume or less; or

(b) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than twelve (12) percent by volume, regardless of the lower limit;

(iii) "Liquid, flammable" means any liquid having a flashpoint below 100 °F (37.8 °C), except any mixture having components with flashpoints of 100 °F (37.8 °C) or higher, the total of which make up 99 percent or more of the total volume of the mixture;

(iv) "Solid, flammable" means a solid, other than a blasting agent or explosive as defined in § 190.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

"Flashpoint" means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

(i) Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tested, Z11.24–1979 (ASTM D 56–79)) for liquids with a viscosity of less than 45 Saybolt University Seconds (SUS) at 100 °F (37.8 °C), that do not contain suspended solids and do not have a tendency to form a surface film under test; or

(ii) Pensky-Martens Closed Tester (See American National Standard Method of Test for Flash Point by Pensky-Martens Closed Tester, Z11.7–1979 (ASTM D 93–79)) for liquids with a viscosity equal to or greater than 45 SUS at 100 °F (37.8 °C), or that contain suspended solids, or that have a tendency to form a surface film under test; or

(iii) Setaflash Closed Tester (see American National Standard Method of Test for Flash Point by Setaflash Closed Tester (ASTMD 3278–78))

Organic peroxides, which undergo autoaccelerating thermal decomposition, are excluded from any of the flashpoint determination methods specified above.

"Foreseeable emergency" means any potential occurrence such as, but not limited to, equipment failure, rupture of containers, or failure of control equipment which could result in an uncontrolled release of a hazardous chemical into the workplace.

"Hazardous chemical" means any chemical which is a physical hazard or a health hazard.

"Hazard warning" means any words, pictures, symbols, or combination thereof appearing on a label or other appropriate form of warning which convey the hazard(s) of the chemical(s) in the container(s).

"Health hazard" means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic system, and agents which damage the lungs, skin, eyes, or mucous membranes. Appendix A provides further definitions and explanations of the scope of health hazards covered by this section, and Appendix B describes the criteria to be used to determine whether or not a chemical is to be considered hazardous for purposes of this standard.

"Identity" means any chemical or common name which is indicated on the material safety data sheet (MSDS) for the chemical. The identity used shall permit cross-references to be made among the required list of hazardous chemicals, the label and the MSDS.

"Immediate use" means that the hazardous chemical will be under the control of and used only by the person who transfers it from a labeled container and only within the work shift in which it is transferred.

"Importer" means the first business with employees within the Customs Territory of the United States which receives hazardous chemicals produced in other countries for the purpose of sup-

plying them to distributors or employers within the United States.

"Label" means any written, printed, or graphic material, displayed on or affixed to containers of hazardous chemicals.

"Material safety data sheet (MSDS)" means written or printed material concerning a hazardous chemical which is prepared in accordance with paragraph (g) of this section.

"Mixture" means any combination of two or more chemicals if the combination is not, in whole or in part, the result of a chemical reaction.

"Organic peroxide" means an organic compound that contains the bivalent -O- O-structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

"Oxidizer" means a chemical other than a blasting agent or explosive as defined in § 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

"Physical hazard" means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive.

"Produce" means to manufacture, process, formulate, or repackage.

"Pyrophoric" means a chemical that will ignite spontaneously in air at a temperature of 130 °F (54.4 °C) or below.

"Responsible party" means someone who can provide additional information on the hazardous chemical and appropriate emergency procedures, if necessary.

"Specific chemical identity" means the chemical name, Chemical Abstracts Service (CAS) Registry Number, or any other information that reveals the precise chemical designation of the substance.

"Trade secret" means any confidential formula, pattern, process, device, information or compilation of information that is used in an employer's business, and that gives the employer an opportunity to obtain an advantage over competitors who do not know or use it. Appendix D sets out the criteria to be used in evaluating trade secrets.

"Unstable (reactive)" means a chemical which in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature.

"Use" means to package, handle, react, or transfer.

"Water-reactive" means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

"Work area" means a room or defined space in a workplace where hazardous chemicals are produced or used, and where employees are present.

"Workplace" means an establishment, job site, or project, at one geographical location containing one or more work areas.

(d) Hazard determination.

(1) Chemical manufacturers and importers shall evaluate chemicals produced in their workplaces or imported by them to determine if they are hazardous. Employers are not required to evaluate chemicals unless they choose not to rely on the evaluation performed by the chemical manufacturer or importer for the chemical to satisfy this requirement.

(2) Chemical manufacturers, importers or employers evaluating chemicals shall identify and consider the available scientific evidence concerning such hazards. For health hazards, evidence which is statistically significant and which is based on at least one positive study conducted in accordance with established scientific principles is considered to be sufficient to establish a hazardous effect if the results of the study meet the definitions of health hazards in this section. Appendix A shall be consulted for the scope of health hazards covered, and Appendix B shall be consulted for the criteria to be followed with respect to the completeness of the evaluation, and the data to be reported.

(3) The chemical manufacturer, importer or employer evaluating chemicals shall treat the

following sources as establishing that the chemicals listed in them are hazardous:

(i) 29 CFR Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA); or,

(ii) *Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment*, American Conference of Government Industrial Hygienists (ACGIH) (latest edition).

The chemical manufacturer, importer, or employer is still responsible for evaluating the hazards associated with the chemicals in these source lists in accordance with the requirements of this standard.

(4) Chemical manufacturers, importers and employers evaluating chemicals shall treat the following sources as establishing that a chemical is a carcinogen or potential carcinogen for hazard communication purposes:

(i) National Toxicology Program (NTP), *Annual Report on Carcinogens* (latest edition);

(ii) International Agency for Research on Cancer (IARC) *Monographs* (latest editions); or

(iii) 29 CFR Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration.

Note—The *Registry of Toxic Effects of Chemical Substances* published by the National Institute for Occupational Safety and Health indicates whether a chemical has been found by NTP or IARC to be a potential carcinogen.

(5) The chemical manufacturer, importer or employer shall determine the hazards of mixtures of chemicals as follows:

(i) If a mixture has been tested as a whole to determine its hazards, the results of such testing shall be used to determine whether the mixture is hazardous;

(ii) If a mixture has not been tested as a whole to determine whether the mixture is a health hazard, the mixture shall be assumed to present the same health hazards as do the components which comprise one percent (by weight or volume) or greater of the mixture, except that the mixture shall be assumed to present a carcinogenic hazard if it contains a component in concentrations of 0.1 percent or greater which is considered to be a carcinogen under paragraph (d)(4) of this section;

(iii) If a mixture has not been tested as a whole to determine whether the mixture is a physical hazard, the chemical manufacturer, importer, or employer may use whatever scientifically valid data is available to evaluate the physical hazard potential of the mixture; and,

(iv) If the chemical manufacturer, importer, or employer has evidence to indicate that a component present in the mixture in concentrations of less than one percent (or in the case of carcinogens, less than 0.1 percent) could be released in concentrations which would exceed an established OSHA permissible exposure limit or ACGIH Threshold Limit Value, or could present a health hazard to employees in those concentrations, the mixture shall be assumed to present the same hazard.

(6) Chemical manufacturers, importers, or employers evaluating chemicals shall describe in writing the procedures they use to determine the hazards of the chemical they evaluate. The written procedures are to be made available, upon request, to employees, their designated representatives, the Assistant Secretary and the Director. The written description may be incorporated into the written hazard communication program required under paragraph (e) of this section.

(e) Written hazard communication program.

(1) Employers shall develop, implement, and maintain at the workplace, a written hazard communication program for their workplaces which at least describes how the criteria specified in paragraphs (f), (g), and (h) of this section for labels and other forms of warning, material safety data sheets, and employee information and training will be met, and which also includes the following:

(i) A list of the hazardous chemicals known to be present using an identity that is refer-

enced on the appropriate material safety data sheet (the list may be compiled for the workplace as a whole or for individual work areas); and,

(ii) The methods the employer will use to inform employees of the hazards of non-routine tasks (for example, the cleaning of reactor vessels), and the hazards associated with chemicals contained in unlabeled pipes in their work areas.

(2) **Multi-employer workplaces.** Employers who produce, use, or store hazardous chemicals at a workplace in such a way that the employees of other employer(s) may be exposed (for example, employees of a construction contractor working on-site) shall additionally ensure that the hazard communication programs developed and implemented under this paragraph (e) include the following:

(i) The methods the employer will use to provide the other employer(s) with a copy of the material safety data sheet, or to make it available at a central location in the workplace, for each hazardous chemical the other employer(s)' employees may be exposed to while working;

(ii) The methods the employer will use to inform the other employer(s) of any precautionary measures that need to be taken to protect employees during the workplace's normal operating conditions and in foreseeable emergencies; and,

(iii) The methods the employer will use to inform the other employer(s) of the labeling system used in the workplace.

(3) The employer may rely on an existing hazard communication program to comply with these requirements, provided that it meets the criteria established in this paragraph (e).

(4) The employer shall make the written hazard communication program available, upon request, to employees, their designated representatives, the Assistant Secretary and the Director, in accordance with the requirements of 29 CFR 1910.20(e).

(f) **Labels and other forms of warning.**

(1) The chemical manufacturer, importer, or distributor shall ensure that each container of hazardous chemicals leaving the workplace is labeled, tagged or marked with the following information;

(i) Identity of the hazardous chemical(s);

(ii) Appropriate hazard warnings; and

(iii) Name and address of the chemical manufacturer, importer, or other responsible party.

(2) For solid metal (such as a steel beam or a metal casting) that is not exempted as an article due to its downstream use, the required label may be transmitted to the customer at the time of the initial shipment, and need not be included with subsequent shipments to the same employer unless the information on the label changes. The label may be transmitted with the initial shipment itself, or with the material safety data sheet that is to be provided prior to or at the time of the first shipment. This exception to requiring labels on every container of hazardous chemicals is only for the solid metal itself and does not apply to hazardous chemicals used in conjunction with, or known to be present with, the metal and to which employees handling the metal may be exposed (for example, cutting fluids or lubricants).

(3) Chemical manufacturers, importers, or distributors shall ensure that each container of hazardous chemicals leaving the workplace is labeled, tagged, or marked in accordance with this section in a manner which does not conflict with the requirements of the Hazardous Materials Transportation Act (49 U.S.C. 1801 *et seq.*) and regulations issued under that Act by the Department of Transportation.

(4) If the hazardous chemical is regulated by OSHA in a substance-specific health standard, the chemical manufacturer, importer, distributor or employer shall ensure that the labels or other forms of warning used are in accordance with the requirements of that standard.

(5) Except as provided in paragraphs (f)(6) and (f)(7) the employer shall ensure that each container of hazardous chemicals in the workplace is labeled, tagged or marked with the following information:

(i) Identity of the hazardous chemical(s) contained therein; and

(ii) Appropriate hazard warnings.

(6) The employer may use signs, placards, process sheets, batch tickets, operating procedures, or other such written materials in lieu of affixing labels to individual stationary process containers, as long as the alternative method identifies the containers to which it is applicable and conveys the information required by paragraph (f)(5) of this section to be on a label. The written materials shall be readily accessible to the employees in their work area throughout each work shift.

(7) The employer is not required to label portable containers into which hazardous chemicals are transferred from labeled containers, and which are intended only for the immediate use of the employee who performs the transfer.

(8) The employer shall not remove or deface existing labels or incoming containers of hazardous chemicals unless the container is immediately marked with the required information.

(9) The employer shall ensure that labels or other forms of warning are legible, in English, and prominently displayed on the container, or readily available in the work area throughout each work shift. Employers having employees who speak other languages may add the information in their language to the material presented, as long as the information is presented in English as well.

(10) The chemical manufacturer, importer, distributor or employer need not affix new labels to comply with this section if existing labels already convey the required information.

(g) Material safety data sheets.

(1) Chemical manufacturers and importers shall obtain or develop a material safety data sheet for each hazardous chemical they produce or import. Employers shall have a material safety data sheet for each hazardous chemical which they use.

(2) Each material safety data sheet shall be in English and shall contain at least the following information:

(i) The identity used on the label, and, except as provided for in paragraph (i) of this section on trade secrets:

(a) If the hazardous chemical is a single substance, its chemical and common name(s);

(b) If the hazardous chemical is a mixture which has been tested as a whole to determine its hazards, the chemical and common name(s) of the ingredients which contribute to these known hazards, and the common name(s) of the mixture itself; or,

(c) If the hazardous chemical is a mixture which has not been tested as a whole:

(1) The chemical and common name(s) of all ingredients which have been determined to be health hazards, and which comprise 1% or greater of the composition, except that chemicals identified as carcinogens under paragraph (d)(4) of this section shall be listed if the concentrations are 0.1% or greater; and,

(2) The chemical and common name(s) of all ingredients which have been determined to be health hazards, and which comprise less than 1% (0.1% for carcinogens) of the mixture, if there is evidence that the ingredient(s) could be released from the mixture in concentrations which would exceed an established OSHA permissible exposure limit or ACGIH Threshold Limit Value, or could present a health hazard to employees; and,

(3) The chemical and common name(s) of all ingredients which have been determined to present a physical hazard when present in the mixture;

(ii) Physical and chemical characteristics of the hazardous chemical (such as vapor pressure, flash point);

(iii) The physical hazards of the hazardous chemical, including the potential for fire, explosion, and reactivity;

(iv) The health hazards of the hazardous chemical, including signs and symptoms of exposure, and any medical conditions which are generally recognized as being aggravated by exposure to the chemical.

(v) The primary route(s) of entry;

(vi) The OSHA permissible exposure limit, ACGIH Threshold Limit Value, and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the material safety data sheet, where available;

(vii) Whether the hazardous chemical is listed in the National Toxicology Program (NTP) *Annual Report on Carcinogens* (latest edition) or has been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) *Monographs* (latest editions), or by OSHA;

(viii) Any generally applicable precautions for safe handling and use which are known to the chemical manufacturer, importer or employer preparing the material safety data sheet, including appropriate hygienic practices, protective measures during repair and maintenance of contaminated equipment, and procedures for clean-up of spills and leaks;

(ix) Any generally applicable control measures which are known to the chemical manufacturer, importer or employer preparing the material safety data sheet, such as appropriate engineering controls, work practices, or personal protective equipment;

(x) Emergency and first aid procedures;

(xi) The date of preparation of the material safety data sheet or the last change to it; and,

(xii) The name, address and telephone number of the chemical manufacturer, importer, employer or other responsible party preparing or distributing the material safety data sheet, who can provide additional information on the hazardous chemical and appropriate emergency procedures, if necessary.

(3) If not relevant information is found for any given category on the material safety data sheet, the chemical manufacturer, importer or employer preparing the material safety data sheet shall mark it to indicate that no applicable information was found.

(4) Where complex mixtures have similar hazards and contents (i.e. the chemical ingredients are essentially the same, but the specific composition varies from mixture to mixture), the chemical manufacturer, importer or employer may prepare one material safety data sheet to apply to all of these similar mixtures.

(5) The chemical manufacturer, importer or employer preparing the material safety data sheet shall ensure that the information recorded accurately reflects the scientific evidence used in making the hazard determination. If the chemical manufacturer, importer or employer preparing the material safety data sheet becomes newly aware of any significant information regarding the hazards of a chemical, or ways to protect against the hazards, this new information shall be added to the material safety data sheet within three months. If the chemical is not currently being produced or imported the chemical manufacturer or importer shall add the information to the material safety data sheet before the chemical is introduced into the workplace again.

(6) Chemical manufacturers or importers shall ensure that distributors and employers are provided an appropriate material safety data sheet with their initial shipment, and with the first shipment after a material safety data sheet is updated. The chemical manufacturer or importer shall either provide material safety data sheets with the shipped containers or send them to the employer prior to or at the time of the shipment. If the material safety data sheet is not provided with a shipment that has been labeled as a hazardous chemical, the employer shall obtain one from the chemical manufacturer, importer, or distributor as soon as possible.

(7) Distributors shall ensure that material safety data sheets, and updated information, are provided to other distributors and employers. Retail distributors which sell hazardous chemical to commercial customers shall provide a material safety data sheet to such employers upon request, and shall post a sign or otherwise inform them that a material safety data sheet is available. Chemical manufacturers, importers, and distributors need not provide material safety data sheets to retail distributors which have informed them that the retail distributor does not sell the product to commercial customers or open the sealed container to use it in their own workplaces.

(8) The employer shall maintain copies of the

required material safety data sheets for each hazardous chemical in the workplace, and shall ensure that they are readily accessible during each work shift to employees when they are in their work area(s).

(9) Where employees must travel between workplaces during a workshift, *i.e.*, their work is carried out at more than one geographical location, the material safety data sheets may be kept at a central location at the primary workplace facility. In this situation, the employer shall ensure that employees can immediately obtain the required information in an emergency.

(10) Material safety data sheets may be kept in any form, including operating procedures, and may be designed to cover groups of hazardous chemicals in a work area where it may be more appropriate to address the hazards of a process rather than individual hazardous chemicals. However, the employer shall ensure that in all cases the required information is provided for each hazardous chemical, and is readily accessible during each work shift to employees when they are in their work area(s).

(11) Material safety data sheets shall also be made readily available, upon request, to designated representatives and to the Assistant Secretary, in accordance with the requirements of 29 CFR 1910.20(e). The Director shall also be given access to material safety data sheets in the same manner.

(h) Employee information and training.

Employers shall provide employees with information and training on hazardous chemicals in their work area at the time of their initial assignment, and whenever a new hazard is introduced into their work area.

(1) **Information.** Employees shall be informed of:

(i) The requirements of this section;

(ii) Any operations in their work area where hazardous chemicals are present; and,

(iii) The location and availability of the written hazard communication program, including the required list(s) of hazardous chemicals, and material safety data sheets required by this section.

(2) **Training.** Employee training shall include at least:

(i) Methods and observations that may be used to detect the presence or release of a hazardous chemical in the work area (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);

(ii) The physical and health hazards of the chemicals in the work area;

(iii) The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used; and,

(iv) The details of the hazard communication program developed by the employer, including an explanation of the labeling system and the material safety data sheet, and how employees can obtain and use the appropriate hazard information.

(i) Trade secrets.

(1) The chemical manufacturer, importer, or employer may withhold the specific chemical identity, including the chemical name and other specific identification of a hazardous chemical, from the material safety data sheet, provided that:

(i) The claim that the information withheld is a trade secret can be supported;

(ii) Information contained in the material safety data sheet concerning the properties and effects of the hazardous chemical is disclosed;

(iii) The material safety data sheet indicates that the specific chemical identity is being withheld as a trade secret; and,

(iv) The specific chemical identity is made

available to health professionals, employees, and designated representatives in accordance with the applicable provisions of this paragraph.

(2) Where a treating physician or nurse determines that a medical emergency exists and the specific chemical identity of a hazardous chemical is necessary for emergency or first-aid treatment, the chemical manufacturer, importer, or employer shall immediately disclose the specific chemical identity of a trade secret chemical to that treating physician or nurse, regardless of the existence of a written statement of need of a confidentiality agreement. The chemical manufacturer, importer, or employer may require a written statement of need and confidentiality agreement, in accordance with the provisions of paragraphs (i)(3) and (4) of this section, as soon as circumstances permit.

(3) In non-emergency situations, a chemical manufacturer, importer, or employer shall, upon request, disclose a specific chemical identity, otherwise permitted to be withheld under paragraph (i)(1) of this section, to a health professional (i.e. physician, industrial hygienist, toxicologist, epidemiologist, or occupational health nurse) providing medical or other occupational health services to exposed employee(s), and to employees or designated representatives, if:

(i) The request is in writing;

(ii) The request describes with reasonable detail one or more of the following occupational health needs for the information:

(a) To assess the hazards of the chemicals to which employees will be exposed;

(b) To conduct or assess sampling of the workplace atmosphere to determine employee exposure levels;

(c) To conduct pre-assignment or periodic medical surveillance of exposed employees;

(d) To provide medical treatment to exposed employees;

(e) To select or assess appropriate personal protective equipment for exposed employees;

(f) To design or assess engineering controls or other protective measures for exposed employees; and,

(g) To conduct studies to determine the health effects of exposure.

(iii) The request explains in detail why the disclosure of the specific chemical identity is essential and that, in lieu thereof, the disclosure of the following information to the health professional, employee, or designated representative, would not satisfy the purposes described in paragraph (i)(3)(ii) of this section:

(a) The properties and effects of the chemical;

(b) Measures for controlling workers' exposure to the chemical;

(c) Methods of monitoring and analyzing worker exposure to the chemical; and,

(d) Methods of diagnosing and treating harmful exposures to the chemical;

(iv) The request includes a description of the procedures to be used to maintain the confidentiality of the disclosed information; and,

(v) The health professional, and the employer or contractor of the services of the health professional (i.e. downstream employer, labor organization, or individual employee), employee, or designated representative, agree in a written confidentiality agreement that the health professional, employee, or designated representative, will not use the trade secret information for any purpose other than the health need(s) asserted and agree not to release the information under any circumstances other than to OSHA, as provided in paragraph (i)(6) of this section, except as authorized by the terms of the agreement or by the chemical manufacturer, importer, or employer.

(4) The confidentiality agreement authorized by paragraph (i)(3)(iv) of this section;

(i) May restrict the use of the information to the health purposes indicated in the written statement of need;

(ii) May provide for appropriate legal remedies in the event of a breach of the agreement, including stipulation of a reasonable pre-estimate of likely damages; and,

(iii) May not include requirements for the posting of a penalty bond.

(5) Nothing in this standard is meant to preclude the parties from pursuing non-contractual remedies to the extent permitted by law.

(6) If the health professional, employee, or designated representative receiving the trade secret information decides that there is a need to disclose it to OSHA, the chemical manufacturer, importer, or employer who provided the information shall be informed by the health professional, employee, or designated representative prior to, or at the same time as, such disclosure.

(7) If the chemical manufacturer, importer, or employer denies a written request for disclosure of a specific chemical identity, the denial must:

(i) Be provided to the health professional, employee, or designated representative, within thirty days of the request;

(ii) Be in writing;

(iii) Include evidence to support the claim that the specific chemical identity is a trade secret;

(iv) State the specific reasons why the request is being denied; and,

(v) Explain in detail how alternative information may satisfy the specific medical or occupational health need without revealing the specific chemical identity.

(8) The health professional, employee, or designated representative whose request for information is denied under paragraph (i)(3) of this section may refer the request and the written denial of the request to OSHA for consideration.

(9) When a health professional, employee, or designated representative refers the denial to OSHA under paragraph (i)(8) of this section, OSHA shall consider the evidence to determine if:

(i) The chemical manufacturer, importer, or employer has supported the claim that the specific chemical identity is a trade secret;

(ii) The health professional, employee, or designated representative has supported the claim that there is a medical or occupational health need for the information; and,

(iii) The health professional, employee, or designated representative has demonstrated adequate means to protect the confidentiality.

(10)

(i) If OSHA determines that the specific chemical identity requested under paragraph (i)(3) of this section is not a *bona fide* trade secret, or that it is a trade secret, but the requesting health professional, employee, or designated representative has a legitimate medical or occupational health need for the information, has executed a written confidentiality agreement, and has shown adequate means to protect the confidentiality of the information, the chemical manufacturer, importer, or employer will be subject to citation by OSHA.

(ii) If a chemical manufacturer, importer, or employer demonstrates to OSHA that the execution of a confidentiality agreement would not provide sufficient protection against the potential harm from the unauthorized disclosure of a trade secret specific chemical identity, the Assistant Secretary may issue such orders or impose such additional limitations or conditions upon the disclosure of the requested chemical information as may be appropriate to assure that the occupational health services are provided without an undue risk of harm to the chemical manufacturer, importer, or employer.

(11) If a citation for a failure to release specific chemical identity information is contested by the chemical manufacturer, importer, or employer, the matter will be adjudicated before the Occupational Safety and Health Review Commission in accordance with the Act's enforcement scheme and the applicable Commission rules of procedure. In accordance with

the Commission rules, when a chemical manufacturer, importer, or employer continues to withhold the information during the contest, the Administrative Law Judge may review the citation and supporting documentation *in camera* or issue appropriate orders to protect the confidentiality of such matters.

(12) Notwithstanding the existence of a trade secret claim, a chemical manufacturer, importer, or employer shall, upon request, disclose to the Assistant Secretary any information which this section requires the chemical manufacturer, importer, or employer to make available. Where there is a trade secret claim, such claim shall be made no later than at the time the information is provided to the Assistant Secretary so that suitable determinations of trade secret status can be made and the necessary protections can be implemented.

(13) Nothing in this paragraph shall be construed as requiring the disclosure under any circumstances of process or percentage of mixture information which is a trade secret.

(j) Effective dates.

(1) Chemical manufacturers, importers, and distributors shall ensure that material safety data sheets are provided with the next shipment of hazardous chemicals to employers after September 23, 1987.

(2) Employers in the nonmanufacturing sector shall be in compliance with all provisions of this section by May 23, 1988. (Note: Employers in the manufacturing sector (SIS Codes 2 thru 39) are already required to be in compliance with this section.)

APPENDIX A TO 1910.1200
HEALTH HAZARD DEFINITIONS (MANDATORY)

Although safety hazards related to the physical characteristics of a chemical can be objectively defined in terms of testing requirements (e.g. flammability), health hazard definitions are less precise and more subjective. Health hazards may cause measurable changes in the body—such as decreased pulmonary function. These changes are generally indicated by the occurrence of signs and symptoms in the exposed employees—such as shortness of breath, a non-measurable, subjective feeling. Employees exposed to such hazards must be apprised of both the change in body function and the signs and symptoms that may occur to signal that change.

The determination of occupational health hazards is complicated by the fact that many of the effects or signs and symptoms occur commonly in non-occupationally exposed populations, so that effects of exposure are difficult to separate from normally occurring illnesses. Occasionally, a substance causes an effect that is rarely seen in the population at large, such as angiosarcomas caused by vinyl chloride exposure, thus making it easier to ascertain that the occupational exposure was the primary causative factor. More often, however, the effects are common, such as lung cancer. The situation is further complicated by the fact that most chemicals have not been adequately tested to determine their health hazard potential, and data do not exist to substantiate these effects.

There have been many attempts to categorize effects and to define them in various ways. Generally, the terms "acute" and "chronic" are used to delineate between effects on the basis of severity or duration. "Actue" effects usually occur rapidly as a result of short-term exposures, and are of short duration. "Chronic" effects generally occur as a result of long-term exposure, and are of long duration.

The acute effects referred to most frequently are those defined by the American National Standards Institute (ANSI) standard for Precautionary Labeling of Hazardous Industrial Chemicals (Z129.1-1982)—irritation, corrosivity, sensitization and lethal dose. Although these are important health effects, they do not adequately cover the considerable range of acute effects which may occur as a result of occupational exposure, such as, for example, narcosis.

Similarly, the term chronic effect is often used to cover only carcinogenicity, teratogenicity, and mutagenicity. These effects are obviously a concern in the workplace, but again, do not adequately cover the area of chronic effects, excluding, for example, blood dyscrasias (such as enemia), chronic bronchitis and liver atrophy.

The goal of defining precisely, in measurable terms, every possible health effect that may occur in the workplace as a result of chemical exposures cannot realistically be accomplished. This does not negate the need for employees to be informed of such effects and protected from them. Appendix B, which is also mandatory, outlines the principles and procedures of hazardous assessment.

For purposes of this section, any chemicals which meet any of the following definitions, as determined by the criteria set forth in Appendix B are health hazards:

1. Carcinogen: A chemical is considered to be a carcinogen if:

(a) It has been evaluated by the International Agency for Research on Cancer (IARC), and found to be a carcinogen or potential carcinogen; or

(b) It is listed as a carcinogen or potential carcinogen in the *Annual Report on Carcinogens* published by the National Toxicology Program (NTP) (latest edition); or,

(c) It is regulated by OSHA as a carcinogen.

2. Corrosive: A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact. For example, a chemical is considered to be corrosive if, when tested on the intact skin of albino rabbits by the method described by the U.S. Department of Transportation in Appendix A to 49 CFR Part 173, it destroys or changes irreversibly the structure of the tissue at the site of contact following an exposure period of four hours. This term shall not refer to action or inanimate surfaces.

3. Highly toxic: A chemical falling within any of the following categories:

(a) A chemical that has a median lethal dose (LD_{50}) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each

(b) A chemical that has a median lethal dose (LD_{50}) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.

(c) A chemical that has a median lethal concentration (LC_{50}) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each

4. Irritant: A chemical, which is not corrosive, but which causes a reversible inflammatory effect on living tissue by chemical action at the site of contact. A chemical is a skin irritant if, when tested on the intact skin of albino rabbits by the methods of 16 CFR 1500.41 for four hours exposure or by other appropriate techniques, it results in an empirical score of five or more. A chemical is an eye irritant if so determined under the procedure listed in 16 CFR 1500.42 or other appropriate techniques.

5. Sensitizer: A chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical.

6. Toxic. A chemical falling within any of the following categories:

(a) A chemical that has a median lethal dose (LD_{50}) of more than 50 milligrams per kilogram but not more than 500 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

(b) A chemical that has a median lethal dose (LD_{50}) of more than 200 milligrams per kilogram but not more than 1,000 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.

(c) A chemical that has a median lethal concentration (LC_{50}) in air of more than 200 parts per million but not more than 2,000 parts per million by volume of gas or vapor, or more than two milligrams per liter but not more than 20 milligrams per liter of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

7. Target organ effects. The following is a target organ categorization of effects which may occur, including examples of signs and symptoms and chemicals which have been found to cause such effects. These examples are presented to illustrate the range and diversity of effects and hazards found in the workplace, and the broad scope employers must consider in this area, but are not intended to be all-inclusive.

a. Hepatotoxins: Chemicals which produce liver damage
Signs & Symptoms: Jaundice; liver enlargement
Chemicals: Carbon tetrachloride; nitrosamines

b. Nephrotoxins: Chemicals which produce kidney damage
Signs & Symptoms: Edema; proteinuria
Chemicals: Halogenated hydrocarbons; uranium

c. Neurotoxins: Chemicals which produce their primary toxic effects on the nervous system
Signs & Symptoms: Narcosis; behavioral changes; decrease in motor functions
Chemicals: Mercury; carbon disulfide

d. Agents which act on the blood or hematopoietic system: Decrease hemoglobin function; deprive the body tissue of oxygen
Signs & Symptoms: Cyanosis; loss of consciousness
Chemicals: Carbon monoxide; cyanides

e. Agents which damage the lung: Chemicals which irritate or damage the pulmonary tissue
Signs & Symptoms: Cough; tightness in chest; shortness of breath
Chemicals: Silica; asbestos

f. Reproductive toxins: Chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis)
Signs & Symptoms: Birth defects; sterility
Chemicals: Lead; DBCP

g. Cutaneous hazards: Chemicals which affect the dermal layer of the boy
Signs & Symptoms: Defatting of the skin; rashes; irritation
Chemicals: Ketones; chlorinated compounds

h. Eye hazards: Chemicals which affect the eye or visual capacity
Signs & Symptoms: Conjunctivitis; corneal damage
Chemicals: Organic solvents; acids

APPENDIX B TO § 1910.1200 HAZARD DETERMINATION (MANDATORY)

The quality of a hazard communication program is largely dependent upon the adequacy and accuracy of the hazard determination. The hazard determination requirement of this standard is performance-oriented. Chemical manufacturers, importers, and employers evaluating chemicals are not required to follow any specific methods for determining hazards, but they must be able to demonstrate that they have adequately ascertained the hazards of the chemicals produced or imported in accordance with the criteria set forth in this Appendix.

Hazard evaluation is a process which relies heavily on the professional judgment of the evaluator, particularly in the area of chronic hazards. The performance-orientation of the hazard determination does not diminish the duty of the chemical manufacturer, importer or employer to conduct a thorough evaluation, examining all relevant data and producing a scientifically defensible evaluation. For purposes of this standard, the following criteria shall be used in making hazard determinations that meet the requirements of this standard.

1. Carcinogenicity: As described in paragraph (d)(4) and Appendix A of this section, a determination by the National Toxicology Program the International Agency for Research on Cancer, or OSHA that a chemical is a carcinogen or potential carcinogen will be considered conclusive evidence for purposes of this section

2. Human data: Where available, epidemiological studies and case reports of adverse health effects shall be considered in the evaluation.

3. Animal data: Human evidence of health effects in exposed populations is generally not available for the majority of chemicals produced or used in the workplace. Therefore, the available results of toxicological testing in animal populations shall be used to predict the health effects that may be experienced by exposed workers. In particular, the definitions of certain acute hazards refer to specific animal testing results (see Appendix A).

4. Adequacy and reporting of data. The results of any studies which are designed and conducted according to established scientific principles, and which report statistically significant conclusions regarding the health effects of a chemical, shall be a sufficient basis for a hazard determination and reported on any material safety data sheet. The chemical manufacturer, importer, or employer may also report the results of other scientifically valid studies which tend to refute the findings of hazard.

APPENDIX C TO 1910.1200 INFORMATION SOURCES (ADVISORY)

The following is a list of available data sources which the chemical manufacturer, importer, distributor, or employer may wish to consult to evaluate the hazards of chemicals they produce or import:

—Any information in their own company files, such as toxicity testing results or illness experience of company employees.

—Any information obtained from the supplier of the chemical, such as material safety data sheets or product safety bulletins.

—Any pertinent information obtained from the following source list (latest editions should be used):

Condensed Chemical Dictionary
Van Nostrand Reinhold Co., 135 West 50th Street, New York, NY 10020.

The Merck Index: An Encyclopedia of Chemicals and Drugs
Merck and Company, Inc., 126 E. Lincoln Ave., Rahway, NJ 07065.

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man
Geneva: World Health Organization, International Agency for Research on Cancer, 1972-Present. (Multivolume work). Summaries are available in supplement volumes. 49 Sheridan Street, Albany, NY 12210.

Industrial Hygiene and Toxicology, by F.A. Patty
John Wiley & Sons, Inc., New York, NY (Multivolume work).

Clinical Toxicology of Commercial Products
Gleason, Gosselin, and Hodge

Casarett and Doull's Toxicology; The Basic Science of Poisons
Doull, Klaassen, and Amdur, Macmillan Publishing Co., Inc., New York, NY.

Industrial Toxicology, by Alice Hamilton and Harriet L. Hardy
Publishing Sciences Group, Inc., Acton, MA.

Toxicology of the Eye, by W. Morton Grant
Charles C. Thomas, 301-327 East Lawrence Avenue, Springfield, IL.

Recognition of Health Hazards in Industry
William A. Burgess, John Wiley and Sons, 605 Third Avenue, New York, NY 10158.

Chemical Hazards of the Workplace
Nick H. Proctor and James P. Hughes, J.P. Lipincott Company, 6 Winchester Terrace, New York, NY 10022.

Handbook of Chemistry and Physics
Chemical Rubber Company, 18901 Cranwood Parkway, Cleveland, OH 44128.

Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment and Biological Exposure Indices with Intended Changes
American Conference of Governmental Industrial Hygienists (ACGIH), 6500 Glenway Avenue, Bldg. D-5, Cincinnati, OH 45211.

Information on the physical hazards of chemicals may be found in publications of the National Fire Protection Association, Boston, MA.

Note.—The following documents may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Occupational Health Guidelines
NIOSH/OSHA (NIOSH Pub. No. 81-123)

NIOSH Pocket Guide to Chemical Hazards
NIOSH Pub. No. 85-114

Registry of Toxic Effects of Chemical Substances
NIOSH Pub. No. 80-102

Miscellaneous Documents published by the National Institute for Occupational Safety and Health:
Criteria documents.
Special Hazard Reviews.
Occupational Hazard Assessments.
Current Intelligence Bulletins.

OSHA's General Industry Standards (29 CFR Part 1910)

NTP Annual Report on Carcinogens and Summary of the Annual Report on Carcinogens.
National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161: (703) 487-4650.

BIBLIOGRAPHIC DATA BASES

Service Provider	File name
Bibliographic Retrieval Services (BRS), 1200 Route 7, Lathom, NY 12110.	Biosis Previews CA Search Medlars NTIS Hazardline American Chemical Society Journal Excerpta Medica IRCS Medical Science Journal Pre-Med

	Intl. Pharmaceutical Abstracts
	Paper Chem
Lockheed—DIALOG Information Service, Inc., 3460 Hillview Avenue, Palo Alto, CA 94304	Biosis Prev. Files
	CA Search Files
	CAB Abstracts
	Chemical Exposure
	Chemname
	Chemsis Files
	Chemzero
	Embase Files
	Environmental Bibliographies
	Enviroline
	Federal Research in Progress
	IRL Life Science Collection
	NTIS
	Occupational Safety and Health (NIOSH)
	Paper Chem
SDC—Orbit, SDC Information Service, 2500 Colorado Avenue, Santa Monica, CA 90406.	CAS Files
	Chemdex, 2, 3
	NTIS
National Library of Medicine, Department of Health and Human Services, Public Health Service, National Institute of Health, Bethesda, MD 20209.	Hazardous Substances Data Bank (NSDB)
	Medline files
	Toxline Files
	Concerlit
	RTECS
	Chemline
Pergamon International Information Corp., 1340 Old Chain Bridge Rd., McLean, VA 22101.	Laboratory Hazard Bulletin
Questel, Inc., 1625 Eye Street, NW, Suite 818, Washington, DC 20006	CIS/ILO
	Concernet
Chemical Information System ICI (ICIS), Bureau of National Affairs, 1133 15th Street, NW, Suite 300, Washington, DC 20005.	Structure and Nomenclature Search System (SANSS)
	Acute Toxicity (RTECS)
	Clinical Toxicology of Commercial Products
	Oil and Hazardous Materials Technical Assistance Data System
	CCRIS
	CESARS
Occupational Health Services, 400 Plaza Drive, Secaucus, NJ 07094	MSDS
	Hazardline

APPENDIX D TO 1910.1200 DEFINITION OF "TRADE SECRET" (MANDATORY)

The following is a reprint of the *Restatement of Torts* section 757, comment *b* (1939):

b. Definition of trade secret. A trade secret may consist of any formula, pattern, device or compilation of information which is used in one's business, and which gives him an opportunity to obtain an advantage over competitors who do not know or use it. It may be a formula for a chemical compound, process of manufacturing, treating or preserving materials, a pattern for a machine or other device, or a list of customers. It differs from other secret information in a business (see § 759 of the *Restatement of Torts* which is not included in this Appendix in that it is not simply information as to single or ephemeral events in the conduct of the business, as, for example, the amount or other terms of a secret bid for a contract or the salary of certain employees, or the security investments made or contemplated, or the date fixed for the announcement of a new policy or for bringing out a new model or the like. A trade secret is a process or device for continuous use in the operations of the business. Generally it relates to the production of goods, as, for example, a machine or formula for the production of an article. It may, however, relate to the sale of goods or to other operations in the business, such as a code for determining discounts, rebates or other concessions in a price list or catalogue, or a list of specialized customers, or a method of bookkeeping or other office management.

Secrecy. The subject matter of a trade secret must be secret. Matters of public knowledge or of general knowledge in an industry cannot be appropriated by one as his secret. Matters which are completely disclosed by the goods which one markets cannot be his secret. Substantially, a trade secret is known only in the particular business in which it is used. It is not requisite that only the proprietor of the business know it. He may, without losing his protection, communicate it to employees involved in its use. He may likewise communicate it to others pledged to secrecy. Others may also know of it independently, as, for example, when they have discovered the process or formula by independent invention and are keeping it secret. Nevertheless, a substantial element of secrecy must exist, so that, except by the use of improper means, there would be difficulty in acquiring the information. An exact definition of a trade secret is not possible. Some factors to be considered in determining whether given information is one's trade secret are: (1) The extent to which the information is known outside of his business; (2) the extent to which it is known by employees and others involved in his business; (3) the extent of measures taken by him to guard the secrecy of the information; (4) the value of the information to him and his competitors; (5) the amount of effort or money expended by him in developing the information; (6) the ease or difficulty with which the information could be properly acquired or duplicated by others.

Novelty and prior art. A trade secret may be a device or process which is patentable; but it need not be that. It may be a device or process which is clearly anticipated in the prior art or one which is merely a mechanical improvement that a good mechanic can make. Novelty and invention are not requisite for a trade secret as they are for patentability. These requirements are essential to patentability because a patent protects against unlicensed use of the patented device or process even by one who discovers it properly through independent research.

The patent monopoly is a reward to the inventor. But such is not the case with a trade secret. Its protection is not based on a policy of rewarding or otherwise encouraging the development of secret processes or devices. The protection is merely against breach of faith and reprehensible means of learning another's secret. For this limited protection it is not appropriate to require also the kind of novelty and invention which is a requisite of patentability. The nature of the secret is, however, an important factor in determining the kind of relief that is appropriate against one who is subject to liability under the rule stated in this section. Thus, if the secret consists of a device or process which is a novel invention, one who acquires the secret wrongfully is ordinarily enjoined from further use of it and is required to account for the profits derived from his past use. If, on the other hand, the secret consists of mechanical improvements that a good mechanic can make without resort to the secret, the wrongdoer's liability may be limited to damages, and an injunction against future use of the improvements made with the aid of the secret may be inappropriate.

(Approved by the Office of Management and Budget under Control No. 1218–0072, except for (1) The requirement that material safety data sheets be provided on multi-employer worksites, (2) coverage of any consumer product excluded from the definition of "hazardous chemical" under Section 311(e)(3) of the Superfund Amendments and Reauthorization Act of 1986, and (3) coverage of any drugs regulated by the Food and Drug Administration in the non-manufacturing sector.)

[53 F.R. 15035, April 27, 1988]

SECTION 2

OCCUPATIONAL HEALTH
AND
SAFETY GUIDANCE DOCUMENTS

OCCUPATIONAL HEALTH
AND
SAFETY GUIDANCE DOCUMENTS

SECTION OBJECTIVE

The objective of this section is to provide students with a copy of the following US EPA health and safety guidance documents:

- US EPA Office of Solid Waste and Emergency Response (OSWER) Integrated Health and Safety Policy for Field Activities (1988)

- US EPA Environmental Response Team's (ERT) Occupational Medical Monitoring Program Guidelines for SARA Hazardous Waste Field Activity Personnel (Publication 9285.3-04-1990)

STUDENT PERFORMANCE OBJECTIVES

After completing this section and related lesson(s), the student will be able to:

- Discuss elements of an employer's overall safety and health program.

- Discuss recommended guidelines for implementation of a medical surveillance program, including purpose, frequency, and recommended test protocol for medical examinations.

SECTION 2

OCCUPATIONAL SAFETY
AND
HEALTH GUIDANCE DOCUMENTS

PART 1

US EPA OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE (OSWER)
INTEGRATED HEALTH AND SAFETY POLICY
FOR FIELD ACTIVITIES

OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE

INTEGRATED HEALTH AND SAFETY POLICY

FOR

FIELD ACTIVITIES

ASSISTANT ADMINISTRATOR

OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE

401 M Street, NW
Washington DC 20460

May 15, 1988

ABSTRACT

PURPOSE: The purpose of this document is to establish an Integrated Health and Safety Policy for all Office of Solid Waste and Emergency Response (OSWER) Superfund Amendment Reauthorization Act field activity employees who are engaged in hazardous substances or related activities.

BACKGROUND: The Environmental Protection Agency (EPA) is mandated by a number of laws and regulations to safeguard the health and safety of its employees. While the Occupational Health and Safety Staff (OHSS), within the Office of Administration and Resources Management's (OARM) Office of Administration (OA), has overall responsibility for the development, organization, and administration of EPA's Health and Safety Programs, the responsibilities for establishing, implementing, and enforcing an Occupational Health and Safety Program have been delegated to Assistant Administrators (AA) and Regional Administrators (RA) by the EPA Occupational Health and Safety Manual (EPA Order 1440). Since OSWER has the responsibility for developing and implementing specific health, safety, and training programs for its employees, this document is intended to inform the field activity employee of his/her duties and responsibilities in regard to specific health and safety policies, and to demonstrate OSWER's overall commitment to the protection of its employees.

APPLICABILITY: This policy is effective for all OSWER field activity employees who are either actively or potentially involved in various hazardous substances field activities (i.e., RCRA major corrective actions and RCRA storage, treatment, and disposal facilities regulated under 40 CFR parts 264 and 265; Hazardous Waste & Emergency Response; Chemical Preparedness; Underground Storage Tanks; Solid Wastes; etc., and other field activities involving hazardous or potentially hazardous substances). Applicability of this policy also extends to persons who are not employed by OSWER, but are either under a specific contract or otherwise under the jurisdiction of OSWER.

May 15, 1988

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May 15, 1988

1.0 PURPOSE

The purpose of this document is to establish an Integrated Health and Safety Policy for all OSWER employees who are presently, or who may be engaged in the future field activities (e.g. hazardous substance field activities and related activities involving hazardous chemicals/ substances).

1.1 Each OSWER employee involved in field activities shall receive appropriate training, equipment, and medical monitoring in accordance with the U.S. EPA Occupational Health and Safety Manual (Order 1440), U.S. EPA Orders 1440.2 and 1440.3, the Office of Emergency and Remedial Response (OERR), Hazardous Response Support Division Standard Operating Safety Guides, as well as other appropriate Federal/State requirements and guidelines such as 29 CFR 1910/1926.

1.2 Any extension of duty associated with hazardous substances or other similar OSWER field activities beyond the specific field category to which a particular employee is assigned or for which he/she is specifically qualified by training and practical experience is prohibited. No supervisor is authorized to order, direct, or otherwise instruct an employee to enter a situation that is more hazardous than that employee's field training certification (e.g., Occupational Health and Safety Manual [Chapter 7], EPA Order 1440.2 and 29 CFR 1910.120). Such an assumption of duty by an employee involves the concomitant assumption of all risks on the part of that individual should the employee be specifically informed that the assumption or duty is beyond the scope of his/her training.

2.0 OSWER POLICY

2.1 All employees who participate in field activities must be classified into field activity categories.

2.2 An employee must receive the required training and health monitoring prior to performing field activities.

2.3 All organizations that have their own health and safety programs, including private contractors and other Federal, state and local agencies, shall utilize and be responsible for the administration of their individual programs as long as these programs are at least as stringent as the OSWER requirements and OSHA standards.

2.4 EPA has delegated to the AA, OSWER, the Health and Safety responsibility for OSWER employees. It is OSWER policy that contractors shall be responsible for implementing the Office of Emergency and Remedial Response (OERR) Standard Operating Safety Guides (SOSG) for its employees and operations, including employee rights to know. In this regard, EPA at a minimum

requires that each contractor know and adhere to HRSD'S SOSG, 29 CFR 1910.120, and 29 CFR 1910/1926. EPA has chosen to implement this policy by allowing the contractor to design an internal health and safety program and to certify to EPA that the company's program complies with the SOSG and 29 CFR 1910/1926. Where a contractor's health and safety program differs from the SOSG, the contractor must certify to EPA that his program is at least as stringent as EPA requirements.

3.0 AUTHORITY

The authority for this program is derived from: U.S. EPA, OHSS, Occupational Health and Safety Manual, U.S. EPA Order 1440, 1440.2, and 1440.3, and all applicable Federal requirements.

4.0 RESPONSIBILITY

4.1 ADMINISTRATIVE

4.1.1 CATEGORIZATION - This order identifies four distinct field activity categories into which employees are assigned based upon their field training certification classification (EPA Order 1440.2 and 29 CFR 1910.120) and exposure potential. The categories are defined and outlined in Section 5.0. (Procedures and Duty Categories) of this document.

4.1.2 Office Directors are delegated the authority and responsibility to implement and enforce this policy. To ensure a truly integrated/coordinated program, each Office Director is required to assign at least one occupational and safety health person to serve as liaison on the OSWER Integrated Health and Safety Workgroup chaired by the Environmental Response Team (ERT), Edison, N.J.

4.1.3 Division Directors are delegated the authority to identify each field activity position in their Divisions.

Budgeting of funds for safety training and for the purchase, maintenance and storage of employee safety equipment is the responsibility of the Division Director.

4.1.4 Branch Chiefs are responsible for assigning field activity categories to Section Chiefs/first line supervisors.

The Branch Chiefs are also responsible for maintaining Employee Safety and Training Records, which contain all safety-related matters.

4.1.5 Section Chiefs/first line supervisors are responsible for assigning field activity categories to an individual employee. Each employee shall be provided with a complete description of the field activity categories. The Section Chief or designee is responsible for purchasing, issuing, and training his/her personnel concerning any phase of respiratory protection.

4.1.6 Employee must read and fully understand the OSWER policy and sign a statement attesting to that fact.

4.1.7 OSWER Integrated Health and Safety Workgroup will coordinate the implementation and maintenance of this policy. The Workgroup representative is the focal point for coordinating the office's activities with regard to OSWER employee occupational health and safety activities.

4.2 TRAINING

4.2.1 The development, implementation, and maintenance of safety training programs shall be the highest OSWER training priority. The AA, OSWER, or designee, is ultimately responsible for ensuring that all OSWER employees and contractors receive the appropriate safety equipment and training or equivalent in accordance with U.S. EPA Orders (e.g., 1440, 1440.2, 1440.3) and 29 CFR 1910/1926.

4.2.2 The responsibility for ensuring that all employees receive the appropriate mandatory safety training is shared jointly by the OSWER Office Directors, Division Directors, Branch Chiefs, Section Chiefs/first line supervisors, and employee.

4.2.3 All supervisors equivalent to or lower than Section Chiefs in charge of field activity employees should receive commensurate safety training in all applicable field safety categories.

4.3 MEDICAL SERVICES

4.3.1 The AA, OSWER, (or designee) is ultimately responsible for ensuring that all field activity employees actively participate in a Medical Monitoring Program (See Appendix B).

4.3.2 It is the employee's responsibility to seek medical assistance and advise his/her supervisor in the event of exposure or potential exposure to a contaminant. In addition, the employee must report all accidents/

exposure to his supervisor so the required workers' compensation form can be carried to the medical provider.

4.3.3 If an emergency exists, the employee must contact the supervisor and complete the necessary forms as soon as possible (see EPA Occupational Health and Safety Manual, Order 1440, Chapter 3).

4.4 OSWER INTEGRATED HEALTH AND SAFETY PROGRAM

The Agency's Occupational Health and Safety Manual (EPA ORDER 1440), particularly Chapter 9, establishes occupational health and safety policy and requirements, and assigns responsibilities for EPA employees engaged in hazardous substance field activities. In order to meet these requirements, the Environmental Response Team (ERT), Edison, NJ has been delegated the responsibility to manage the OSWER Integrated Health and Safety Program. The primary objective of the program is to ensure that all aspects of the safety and occupational health requirements are met in a timely fashion to afford each employee proper protection.

5.0 FIELD ACTIVITY CATEGORIES AND PROCEDURES

5.1 DEFINITION OF CATEGORIES

In order to meet the specific needs of the individual OSWER employees, this policy requires additional administrative controls over those of EPA Orders 1440.2 and 1440.3. The administrative control is a further restriction to EPA Order 1440.2 "Basic, Intermediate and Advanced" training certification, and is accomplished by assigning Categories No. 1-4 to the appropriate field activity personnel. Because of these additional administrative controls, Categories 2 and 3 employees are exempt from the EPA Order 1440.2 requirement of three days of on-the-job training <u>within three months</u> of classroom training unless requested by the employee. However, when applicable, they are still required to meet the three days of on-the-job training.

The employee's category assignment may be changed by the first line supervisor via written notification to the Manager, OSWER Integrated Health and Safety Program, U.S. EPA-ERT, (Mail Code MS101) Raritan Depot, Bldg. 10, Woodbridge Ave., Edison, NJ 08837 (FTS 340-6740). This notification consists of identifying the employee's necessary change(s) and verifying that the appropriate training, equipment, and medical examination have been provided to the employee for the reclassification.

5.1.1 Category 1 is established as the OSWER highest risk category. This category includes all employees whose job description/critical job elements require handling of, or potential exposure to, identified or unidentified hazardous chemicals. For example, employees responding to spill emergencies, uncontrolled hazardous waste sites, etc. (i.e., ERT personnel) are in this category. These employees are authorized to wear OERR Levels of Personnel Protective Equipment A, B, C, and D. Medical examinations are given every six months. See Appendix G for details.

5.1.2 Category 2 includes those OSWER personnel who are required to enter the "Exclusion Zone" or a facility's "Treatment/Storage Activity Area" where there is the potential of exposure to identified or unidentified hazardous chemicals, for more than approximately 20 days per calendar year[1]. Sampling and corrective action activities are some examples of the job function. These employees are authorized to wear OERR Levels of Personnel Protective Equipment C and D, and receive Medical Examinations annually. (Those employees that will <u>only</u> engage in RCRA activities will receive a Category 2A Listing.) See Appendix G for details.

5.1.3 Category 3 includes those OSWER personnel who are required to enter the "Exclusion Zone" or a facility's "Treatment/Storage Activity Area" where there is the potential of exposure to identified or unidentified hazardous chemicals situations, etc., for less than approximately 20 days per calendar year[1]. Sampling and corrective action activities are some examples of the job function. (Those employees that will <u>only</u> engage in RCRA activities will receive a Category 3A Listing.) See Appendix G for details.

Medical examinations are scheduled based on the employee's number/frequency of hours of potential exposure. This period may range from 1-4 years. These employees are authorized to wear OERR Levels of Personnel Protective Equipment C and D. See Appendix G for details.

5.1.4 Category 4 includes all other OSWER field activity personnel not specifically addressed in Categories 1-3, but who are required to perform his/her job function in a "Secure/Clean Area" of those activities identified in Categories 1 through 3. These employees are not authorized to wear OERR Levels of Personnel Protective Equipment.

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[1] The period of potential exposure of greater than or less than 20 days is derived from the 30-day standard in 29 CFR 1910.120 and may be modified as appropriate per supervisor and employee agreement.

Examples of this type of employee are: Certain operations conducted under RCRA as described in 29 CFR 1910.120(0); employees and supervisors who perform activities in the "Support Zone" at hazardous waste site emergency spills.

5.2 CATEGORY REQUIREMENTS

This section of the OSWER policy provides a basic framework for the safe conduct of Category 1-4 personnel while being directly or indirectly involved in a hazardous substance activity.

5.2.1 OSWER field activity personnel must be aware, in advance, of the objectives of each site visit and must be prepared to employ safe operations to avoid potential hazards. Each employee is required to enforce and comply with this policy and exercise good personal judgement and technical expertise on a case-by-case basis.

5.2.2 Whenever applicable, OSWER field activity personnel are required to implement the OERR, HRSD, Standard Operating Safety Guides for guidance and selection criteria. OSWER personnel must exercise extreme caution to prevent loss of life, injury, or health hazards to themselves and to the general public. OSWER field activity personnel are required to adhere to this policy whether or not the Regional requirements are as specific as this policy.

5.2.3 In the event of conflicting safety regulations, the employee must implement those safety practices affording the highest level of protection for everyone involved.

5.2.3.1 Qualifications

To be eligible to perform Category 1-3 duties, the employee must:

a) be assigned to the on-site work by his/her supervisor;
b) complete a Baseline Medical Examination and participate in a medical monitoring program;
c) complete the appropriate health and safety training program as per U.S. EPA Order 1440.2, 1440.3, and 29 CFR 1910.120 prior to involvement in field activities, and/or other types of similar field activities;
d) be assigned the appropriate Field Activity Category.

5.3 STANDARD OPERATING GUIDELINES

5.3.1 Pre-arrival Planning

In planning a field activity, it is the employee's responsibility to be aware of the purpose of the field activity and comply with the OSWER Integrated Health and Safety Policy, OHSS Occupational Health & Safety Orders, 29 CFR 1910.120, and all applicable requirements.

5.3.1.1 PRIOR to arrival at a field activity location, the employee shall complete Part One of the OSWER Incident Safety Check Sheet (refer to Appendix A) and furnish it to the first line supervisor or designee for review. It is recognized that lead time and availability of information are usually limited; however, the employee must attempt to complete this form (preferably prior to office departure). If any emergency arises, it is recommended that, the employee and his/her supervisor contact the Environmental Response Branch's Edison, NJ Hotline (201-321-6660) for technical assistance.

5.3.1.2 When Applicable, Site Safety Plans shall be completed and submitted in accordance with 29 CFR 1910.120, OHSS, Occupational Health and Safety Manual, and OERR, HRSD, Standard Operating Safety Guides.

5.3.2 Safety Onsite (When Applicable)

OSWER personnel shall implement on-site evaluation and inspection in accordance with the OERR, HRSD, Standard Operating Safety Guides.

5.3.2.1 The buddy system shall be utilized in the field; OSWER field personnel shall not enter an "Exclusion Area" or a RCRA hazardous waste TSD, etc., alone. Employees shall make use of their practical experience and technical expertise to keep alert to potentially dangerous situations. Guidance for these types of precautionary measures and procedures is provided in the OERR, HRSD, Standard Operating Safety Guides and other state-of-the-art technology documents.

5.3.2.2 If any condition suggestive of a situation more hazardous than anticipated is discovered, all field activity shall temporarily stop for a reevaluation of the hazard and the level of protection required.

5.3.2.3 In the event that an OSWER field activity employee experiences any adverse effects or symptoms of exposure while engaged in field activities, he/she must immediately leave the site/area, and contact the site/facility supervisor (OSC, etc.), and seek appropriate medical attention. Such incidents must be reported in accordance with Chapter 3 of the EPA Occupational Health and Safety Manual (EPA Order 1440).

5.4 Personnel Protection

If OSWER personnel are required to enter any area in which there is a risk of potential exposure or in which respiratory protection is needed, e.g., a hazardous site/spill exclusion zone, RCRA storage facility, manufacturers production area, etc., they are required to adhere to this Integrated Health and Safety Policy whether or not the Regions have a policy or a specific site safety plan. Employees are required to refer to the OERR, HRSD, Standard Operating Safety Guides for a detailed description of the levels of protection and selection criteria.

5.5 Site Departure and Decontamination Procedures

Disposable safety clothing and sampling equipment shall be properly disposed. If appropriate disposal facilities are not available, safety clothing, and sampling equipment shall be placed in a suitable container pending proper disposal. Nondisposable safety clothing and sampling equipment shall be decontaminated (preferably on-site) in accordance with the OERR, HRSD, Standard Operating Safety Guides. In the event that the adequacy of these procedures is questionable, nondisposable equipment shall be placed in appropriate containers until the exact nature of the sampled material is known. Suitable decontamination procedures shall then be employed to clean the equipment, or the equipment shall be properly disposed of at an approved RCRA hazardous waste facility that meets the requirements of the EPA offsite policy (OSWER Directive 9834.11) and EPA Land Disposal Restrictions (RCRA sections 268.30 and 268.32).

6.0 MEDICAL BASELINE AND MONITORING PROGRAMS

Based on their field exposure classification, OSWER field activity employees shall undergo routinely scheduled examinations to determine the possible health effects of such activity. A medical baseline health profile shall be established for this purpose. As a minimum, the OSWER medical monitoring program shall consist of OHSS guidelines and requirements. In general, the medical monitoring program shall be apportioned into three classes on the basis of employee field activities and potential exposure. In addition, OSWER field activity personnel shall immediately receive post-exposure medical/treatment examinations upon notifying their Section Chief(s) of an exposure. A tabular summary of the OSWER Medical Monitoring Requirements according to Field Activity Category is included in Appendix B of this document.

7.0 TRAINING

An adequate training program is essential for proper implementation of this Integrated Health and Safety Policy. The complexities of the topics of interest, the variety of courses offered, and the need for specific training within each category necessitates formulation of certain ground rules.

7.1 Each OSWER field activity employee shall receive safety training commensurate with the job requirements and field exposure classification. First line supervisors shall recommend additional safety training courses for an employee's future needs.

7.2 A series of core topics are designated for each category as tabulated in the Summary of the OSWER Health and Safety Training Requirements (Appendix C). These core topics are mandatory of all OSWER Field Activities Category Employees. The other topics identified as "desirable" should be taken by employees based upon the recommendations of their supervisors. The level of training provided shall be consistent with the employee's job function and responsibilities. Supervisors are responsible for insuring that their employees are properly trained.

7.3 The training plans and programs must remain flexible enough to include/delete any additional/obsolete topics as the need arises or new ideas are introduced. As per EPA Order 1440.2 and 29 CFR 1910.120, 8 hours of refresher training are required annually of most OSWER field activity personnel.

7.4 Training hour requirements vary on the specific field activity. The following summarizes the 29 CFR 1910.120 training requirements as it relates to the OSWER Field Activity Categories:

Category 1: Forty hours of training, plus 3 days of actual field experience under the direct supervision of a trained, experienced supervisor. (Field supervisor in this category will be required to have an additional 8 hours of "Supervisor Training.") All employees shall receive 8 hours of refresher training annually.

Category 2: Hazardous waste site and corrective action site workers are required to have the same as Category 1 (above). All other Category 2 personnel that do not enter an Exclusion Zone or equivalent area, may qualify for 29 CFR 1910.120(0) training requirements of 24 hours initial training and 8 hours refresher training annually.

Category 3: Hazardous waste site and corrective action site workers are required to have the same as Category 1 (above). All other Category 3 personnel that do not enter an Exclusion Zone or equivalent area, may qualify for 29 CFR 1910.120(0) training requirements of 24 hours initial training and 8 hours refresher training annually.

Category 4: Although not required by 29 CFR 1910.120, all Category 4 employees are required to have a minimum of 4 hours of training in those areas identified in Appendix C.

8.0 HAZARD COMMUNICATION/RIGHT-TO-KNOW

8.1 The EPA is required to communicate the hazards associated with the workplace to all EPA employees. EPA Order 1440.7, Hazard Communication, requires that employees be given information and training on hazardous substances in their work areas.

8.2 It is EPA policy that it will extend the hazardous communication/right-to-know requirement to its contractors or contractor representatives. At a minimum, OSWER employees and contractors and their representatives must be informed of the physical and health hazards of known substances in the work area, methods to detect hazardous substances, and measures employees can take to protect themselves from the hazards. In the case of OSWER employees, the hazardous substances are often unknown.

8.3 All parties working together at hazardous waste sites or spill emergencies/accidents must share all available information on the possible hazards involved.

8.4 As part of the hazard communication, employees are to be informed of the threat to human reproduction by chemicals in the workplace. OSWER employees (both male and female) who are potentially exposed to chemicals that affect reproduction, such as teratogens, mutagens, and chemicals that alter fertility,

have the right to request a temporary change in job assignment as needed to allow conception or to protect an unborn child. Each request will be handled on an individual basis. For each request the supervisor has the responsibility to assess the reproductive hazards associated with the job and to make reasonable accommodations of equal professional status.

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Appendix A
OSWER INCIDENT SAFETY CHECK-OFF LIST

I. BEFORE FIELD ACTIVITY Employee _____

1. Incident: Site_____ City_____ State_____
   a. Response Dates_____
2. Activity Description: Environmental Sampling____ Product Sampling____ Residential____ Site Evaluation____ Containment____ Well Drilling_____ Facility Inspection____
3. Type of Response: Spill_____ Site _____ Facility_____ Other____
4. Site Topography: Mountains_____ Rivers_____ Valley_____ Rural_____ Suburban_____ Urban_____ Level_____ Slopes_____ Facility_____
5. Incident Safety Plan: (when applicable) Not Developed _____ Reviewed _____ Region _____ Briefed _____ ERT _____
6. Site Accessibility: (when applicable) Road: Good_____ Fair_____ Poor_____ Air: Good_____ Fair_____ Poor_____
7. Suspected chemical(s) and pathway with source(s) involved: (A)_____ (B)_____ (C) _____ (D)_____
8. Emergency Response Teams present for First Aid, etc. Yes_____ No_____
9. Protective Level(s) Selected: (A)_____ (B)_____ (C)_____ (D)_____
   (a) If Level "C," Identify Canister_____
   If Level "D," JUSTIFY: write in comments section at bottom of page
10. If SCBA, Identify Buddy System: Office/Name_____
11. Last Response: (a) Level Used: (A)_____ (B)_____ (C)_____ (D)_____
    (b) Medical Attention/Exam Performed: Yes____ No____

II. AFTER RESPONSE

1. Protective Level Used: (A)_____ (B)_____ (C)_____ (D)_____

   a. Level "C," identify canister: _____ b. Level "D" (comment below)
   c. Level B/C skin protection: Tyvek___ Tyvek/Saran__ Acid/Rain__ Other___

2. List possible chemical exposure: Same as above: (A)_____ (B)_____ (C)_____ (D)_____
3. Equipment Decontamination: (a) clothing (b) respirator (c) monitoring
   Disposed: _____ _____ _____
   Cleaned: _____ _____ _____
   No Action: _____ _____ _____
4. Approximate time in exclusion area:_____hr/day for _____ days

PART I: Date Prepared _____ Reviewed by _____ Date _____

PART II: Date Prepared _____ Reviewed by _____ Date _____

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APPENDIX B
SUMMARY OF OSWER MEDICAL MONITORING REQUIREMENTS
PER EMPLOYEE CATEGORY

EMPLOYEE CATEGORY	1	2	3	4
Examination Class*	Base line plus Medical Monitoring Exam every 6 months	Base line plus Annual Medical Monitoring Exam	Base line plus periodic medical monitoring exam based on potential exposure freq. (avg 1-4 yr)	N/A

* Examination rate may increase with increasing incidence of exposure.

NOTE: A "calendar year" is a somewhat arbitrary term when discussing a measurement of exposure. For example, 8 one-day visits to a site where the exposure is great or the toxicity is high may be more critical to the health of the individual than 19 visits at another site. Therefore, all factors must be considered when selecting the Medical Monitoring Exam schedule.

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APPENDIX C

SUMMARY OF THE OSWER HEALTH AND SAFETY TRAINING COURSE REQUIREMENTS

Category	OERR Levels of Protection	EPA Order 1440.2 Classification	OSWER Policy Document	OERR Standard Operating Safety Guides	Properties of Hazardous Mtls.	Toxicology
1	A,B,C	Advance	X	X	X	X
2	C	Intermediate/Basic	X	X	X	X
3	C	Intermediate/Basic	X	X	X	X
4	NONE	N/A	X	X	N/A	N/A

Category	Basic Office First Aid	Basic Field First Aid	CPR	Protective Clothing	Respiratory Protection	Decontamination Procedures	Entry Procedures	Employee Rights and Responsibilities	Defensive Driving
1	O	X	O	X	X	X	X	X	X
2	O	X	O	X	X	X	X	X	X
3	O	X	O	X	X	X	X	X	X
4	O	O	O	N/A	N/A	N/A	N/A	X	X

Key: X = Mandatory, Core Topics
O = Desirable, But Not Mandatory
N/A = Not Applicable
* = Cardiopulmonary Resuscitation

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APPENDIX D

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE
RESPIRATORY PROTECTION PROGRAM
(Revised March 1988)

I. Purpose

The Office of Solid Waste and Emergency Response (OSWER) respiratory protection program is intended to control exposures to those agents that may cause occupational diseases when air is contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors.

II. Objective

Respiratory protection may be properly worn when effective engineering control methods are not feasible, while they are being implemented, or in emergencies. Generally, most corrective actions do not lend themselves to effective engineering controls. Therefore, respiratory protection is judged to be the best approach to ensure employee health protection. It is important to note, however, that effective work practices can minimize reliance on such devices. The primary objective of this program is to protect the employee against "potential" exposure as well as measured exposure.

III. Scope

This respiratory protection program is intended to address all OSWER field activity employees.

IV. Responsibility

It is the responsibility of Section Chiefs/first line supervisors to administer this program in close liaison with medical monitoring personnel. Supervisors are required to provide both the appropriate training and respiratory protection employees need, at no cost to the employee.

Employees shall use the respiratory protection provided in accordance with instructions and training received. Each employee shall guard against damage to the respirator, and report any respirator malfunctions to the supervisor.

V. Program Elements

A. The OSWER respiratory protection program meets all provisions of 29 CFR 1910.134 and 29 CFR 1910.120. In addition, it meets all EPA, OHSS's Occupational Health and Safety requirements and the OERR's, HRSD Standard Operating Safety Guides.

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B. Program Elements

1. Standard Operating Procedures. This respiratory protection program shall function as the written standard operating procedures governing the selection and use of respiratory protection for OSWER personnel.

2. Respirator Fitting and Selection

   a. The selection of the proper type of respiratory protection shall be based primarily on, but not limited to the:

      1) Nature of the field activity;
      2) Type of respiratory hazard;
      3) Location of the hazardous area;
      4) Period of time for which respiratory protection must be provided;
      5) Employee's potential exposure;
      6) Employee's activities;
      7) Employee's physical characteristics and functional activities;
      8) Limitations of the various types of respirators; and
      9) Respirator protection factors/respirator fit.

   b. Factors concerning both the potential and the measured hazard shall be considered when requiring the use of respiratory protection. These factors shall include, but not be limited to:

      1) Types of hazard;
      2) Physical and chemical properties;
      3) Physiological effects on the body;
      4) Expected concentration/level;
      5) Established ACGIH TLV's, OSHA PEL's, AIHA WEEL's.
      6) IDLH considerations; and
      7) Agent warning properties.

   c. U.S. EPA Environmental Response Team's (ERT) Air Monitoring Guidelines (FSOP #8) shall be followed, when applicable, to identify the type of respiratory hazards, define their nature and potential (i.e., vapor, particulate, etc.), and determine the concentration in the work area.

   d. Factors concerning potential and actual site activities shall be taken into account in selecting proper respiratory protection. These factors include a description of work activities; description of the potential hazards; agents of health concern, employee exposure potential and work activities. The selected respirator protection must be continuously evaluated to reflect changes in conditions or factors.

e. The work activity location, with respect to a safe/clean area, shall be considered in selecting respirator protection. Not only does this permit for a well identified contamination reduction zone, but also requires the presence of emergency access and exit areas.

f. The period of time a respirator is to be worn shall be considered when selecting respiratory protection.

g. Worker activities and locations during site activities shall be considered when selecting proper respiratory protection.

h. The physical characteristics, functional capabilities, and performance limitations of various types of respiratory protection shall be considered when selecting a respirator.

i. The hazards for which a particular respirator is designed shall be considered when selecting a respirator.

j. A qualitative respirator fit test shall be performed on each user to determine a satisfactory fit with negative pressure respirators. Test results shall be used to select specific types, makes, and models for individual workers. All OSWER Category 1 and 2 employees will be fit tested at least annually. Category 3 personnel will be fit tested before each respirator use after the initial testing. Fit testing is not required for positive pressure respirators (e.g., SCBA units). Individual workers shall be trained to qualitatively check respirator fit via the positive-negative pressure method each time a unit is donned. Whenever possible, a quantitative fit test shall be incorporated.

k. Respirators shall not be worn when conditions prevent a good seal. Employees shall not wear respirator temple bars, straps, head coverings, etc. between the sealing surface of the respirator. Neither shall respirators be worn if facial hair, features, etc., prevent a good fit.

l. Respirator fit testing records shall be kept. Records shall include type of fit-test method used, specific make and model of respirator tested, name of worker tested, name of test operator, date of test, and results of fit testing.

m. A variety of sizes of respirator facepieces shall be available to OSWER personnel to accommodate the wide range of facial shapes and dimensions among personnel.

n. Employee preference for a particular respirator model shall be considered when selecting suitable respiratory protection. This includes such factors such as comfort, breathing resistance, weight, field of vision, etc. However, the preferred model must have a satisfactory fit test.

o. Where feasible, respirators shall be individually assigned to workers for their exclusive use. If a respirator is marked for identification purposes, the marking shall not affect the respirator performance.

3. Training and Education

a. Each respirator wearer shall be given training that shall include explanations and discussions of respiratory hazards and misuse; the need for respiratory protection; the reason for selecting a particular respirator; the function, capabilities, and limitations of the selected respirator; the method for donning the respirator and checking its fit and operation; proper wearing instructions; respirator maintenance; recognizing and handling emergencies; special instructions as required; regulations concerning respirator use; and identification of respirator cartridges and canisters by color code.

b. The training shall include a hands-on portion that covers donning, wearing, and removing the respirator; adjusting the respirator for proper fit; wearing the respirator in a safe atmosphere and in a test atmosphere.

c. The Section Chief or designee is responsible for purchasing, issuing, and training his/her personnel concerning any phase of respiratory protection.

d. Trainers, employees, and others associated with the respiratory protection program shall be trained to ensure the proper use of respirators. Training shall include basic respiratory protection practices, the nature and extent of expected respiratory hazard exposure, principles and criteria for selecting respirators, using respirators and monitoring their use, maintenance and storage, and regulations governing respirator use.

e. Each respirator wearer shall be retrained and fit tested at least annually or as appropriate (e.g.,after large changes in body weight, dental surgery, etc.) when facial size or shape significantly changes (see Paragraph V.B.2.j).

4. Cleaning and Disinfecting

   a. Respirators shall be regularly cleaned and disinfected. Those issued for the exclusive use of one worker should be cleaned after each day's use, or more often if necessary. Those used by more than one worker shall be thoroughly cleaned and disinfected after each use (e.g., routine, non-routine, emergency, or rescue units).

5. Equipment Storage

   a. Respirators shall be stored in a convenient, clean, and sanitary location so that they are protected against dust, sunlight, extreme temperature, excessive moisture, or damaging chemicals.

   b. Respirators shall be stored to prevent distortion of rubber or other elastomeric parts. Respirators shall not be stored in such places as lockers and tool boxes unless they are adequately protected from contamination, distortion, and damage. Consult the "use and care" instructions, usually mounted inside the carrying case lid, for proper storage of emergency respirators.

6. Inspection and Repair

   a. Each respirator shall be inspected routinely before and after each use. A respirator shall be inspected by the user immediately before each use to ensure that it is in proper working condition.

   b. After cleaning and sanitizing, each respirator shall be inspected to determine if it is in proper working condition, if it needs replacement parts or repairs, or if it should be discarded. Each respirator stored for emergency or rescue use shall be inspected at least monthly and after each use by an experienced person. Respirator inspection shall include a check for tightness of connections; for the conditions of the respiratory inlet covering, head harness, valves, connecting tubes, harness assembly, filter(s), cartridges, canister, end-of-service-life indicator, and shelf life date(s); and for the proper function of regulators, alarms, and other warning systems.

   c. Each rubber or elastomeric part shall be inspected for pliability and signs of deterioration. Each air and oxygen cylinder shall be inspected to ensure that it is fully charged according to the manufacturer's instructions.

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d. Only parts designed for a specific respirator shall be used in its repair. Do not replace components or make adjustments or repairs beyond the manufacturer's recommendations. Reducing and admission valves or regulators shall be returned to the manufacturer or to a trained technician for adjustment or repair.

e. A record of inspection dates, findings, and remedial actions shall be kept for each SCBA respirator maintained for emergency or rescue use.

7. Surveillance

Appropriate surveillance or work area conditions and degree of employee exposure or stress shall be maintained.

8. Evaluation of Respiratory Protection Program

a. There shall be periodic (at least annual) inspection and evaluation to determine the continued effectiveness of the respiratory protection program. It is essential to ensure that all employees are provided with adequate protection. The program should be improved and deficiencies should be eliminated based on evaluation results.

b. Respirator wearers shall be consulted periodically about their acceptance of respirators. Frequent inspection of the program shall be conducted to ensure that proper types of respirators are selected, that users are properly trained, that appropriate equipment is issued and used, that respirators are worn properly, that respirators are in good operating condition, that respirators are inspected and maintained properly, that respiratory storage is acceptable, that respiratory hazards are monitored, and medical examinations are given as necessary, to evaluate user health.

c. The results of the inspection and evaluation shall be utilized to improve or maintain elements of the program as appropriate. Follow up investigations shall be conducted to ensure that sources of concerns are identified and corrected. Evaluation findings shall be documented. Plans to correct program concerns shall be documented (i.e., problem, target dates, responsibility, etc.).

9. Medical Approval

a. Each employee shall have a medical evaluation to determine fitness to wear respiratory protection and potential exposure. Adequate medical data shall be provided as part of the preplacement examination and all

subsequent examinations to allow a physician to make a judgement on each worker's fitness (Refer to Appendix B of the Integrated Health and Safety Policy for Field Activities for examination schedule).

b. Employees shall show the examining physician their exposure records (e.g., Incident Safety Check-off Sheet [See Appendix A of the Integrated Health and Safety Policy for Field Activities]) since the last examination.

10. Approved Respiratory Protection

Only approved respiratory protection shall be selected when available. Any modification of an approved respirator that is not authorized by the approval agencies (e.g., MSHA and NIOSH) voids the respirator approval.

VI. Air Quality

A. Compressed air, compressed oxygen, liquid air, and liquid oxygen used for respiratory protection shall be of high purity. Compressed air should be the principle source of breathing air. Compressed gaseous air shall meet at least the requirements for Type 1 - Grade D breathing air of Compress Gas Association Commodity Specification G-7.1-1966.

B. Breathing air should be supplied to respirators from cylinders. ll cylinders shall be tested for quality and maintained in accordance with applicable DOT specifications for shipping containers (Title 4-9, Code of Federal Regulations, Parts 173 and 178).

C. Breathing air containers shall be marked in accordance with ANSI Z48.1-1954 (R1971) or Interim Federal Specification GG-B-675b, September 23, 1976.

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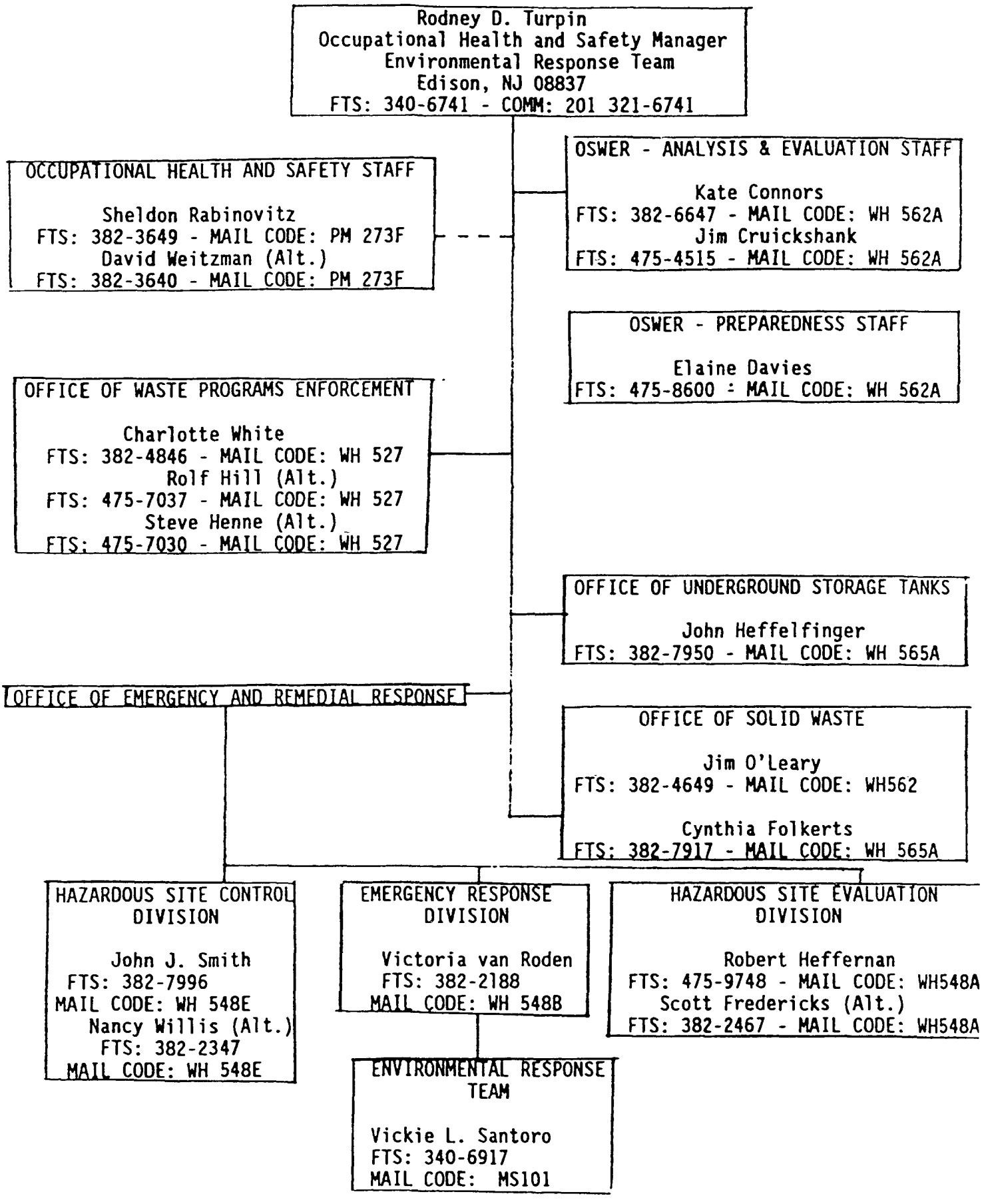
Appendix E

OSWER INTEGRATED HEALTH AND SAFETY WORKGROUP



APPENDIX F

EPA HEALTH AND SAFETY REQUIREMENTS AND GUIDELINE

1. EPA Occupational Health and Safety Manual (1440)

   Chapter 1. Policy and Responsibilities
   Chapter 2. Occupational Health and Safety Program Administration
   Chapter 3. Accident and Illness Investigation, Reporting, and Recordkeeping Requirements
   Chapter 4. Inspections and Correction of Unhealthful or Unsafe Working Conditions
   Chapter 5. Occupational Health and Safety Committees
   Chapter 6. Occupational Health and Safety Standards
   Chapter 7. Occupational Health and Safety Training
   Chapter 8. Laboratory Use of Toxic Substances
   Chapter 9. Hazardous Substances Responses
   Chapter 10. EPA Diving Safety Policy

2. EPA Health and Safety Orders

   1440.2 - Field Activities
   1440.3 - Respiratory Protection
   1440.4 - Health and Safety Training Requirements for Mine Safety
   1440.5 - Qualifications and Training Requirements for Occupational Health and Safety Program Personnel
   1440.6 - Motor Vehicle Occupant Restraining Systems
   1440.7 - Hazard Communication

3. Health and Safety Guidelines

   Respiratory Protection Program Guideline
   Eye Protection Program Guidelines
   Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities
   Medical Monitoring Program Guidelines
   Health and Safety Guidelines for EPA Asbestos Inspections
   Guidelines for the Selection of Chemical Protective Clothing, Second Edition

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APPENDIX G

GENERAL DESCRIPTION OF THE OERR LEVELS OF PROTECTION AND PROTECTIVE GEAR

Personal protective equipment has been divided into four categories based on the degree of protection afforded and are as follows:

Level A - To be selected when the greatest level of skin, respiratory, and eye protection is required.

Level A equipment; used as appropriate:

1. Pressure-demand, self-contained breathing apparatus, approved by the Mine Safety and Health Administration (MSHA) and National Institute of Occupational Safety and Health (NIOSH).

2. Fully encapsulating chemical-resistant suit.

3. Coveralls*

4. Long Underwear*

5. Gloves (outer) chemical-resistant

6. Gloves (inner) chemical-resistant

7. Boots, chemical-resistant, steel toe and shank. (Depending on suit construction, worn over/or under suit boot.)

8. Hard hat (under suit)*

9. Disposable protective suit, gloves, and boots (Depending on suit construction, may be worn over fully encapsulating suit boot.)

10. Two-way radios (worn inside encapsulating suit).

* Optional, as appropriate

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Level B - The highest level of respiratory protection is necessary but a lesser level of skin protection is needed.

Level B equipment; used as appropriate:

1. Pressure-demand, self-contained breathing apparatus (MSHA/NIOSH approved), or airline respirator.

2. Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; one or two-piece chemical-splash suit; disposable chemical-resistant overalls).

3. Coveralls*

4. Gloves (outer) chemical-resistant

5. Gloves (inner) chemical-resistant

6. Boots (outer), chemical-resistant, steel toe and shank.

7. Boot covers (outer), chemical-resistant (disposable)*.

8. Hard hat (face shield)*

9. Two-way radios (worn inside encapsulating suit).

* Optional, as appropriate

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Level C - The concentration(s) and type(s) of airborne substance(s) is *known and the criteria for using air purifying respirators are met.*

Level C equipment; used as appropriate:

1. Full-face, air purifying, canister-equipped respirators (MSHA/NIOSH approved).

2. Hooded chemical-resistant clothing (overalls; two-piece chemical-splash suit; disposable chemical-resistant overalls).

3. Coveralls*

4. Gloves (outer) chemical-resistant

5. Gloves (inner) chemical-resistant*

6. Boots (outer), chemical-resistant, steel toe and shank*.

7. Boot covers (outer), chemical-resistant (disposable)*.

8. Hard hat (face shield)*

9. Escape Mask *

10. Two-way radios (worn under outside protective clothing).

* Optional, as appropriate

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Level D - A work uniform.

Level D equipment; used as appropriate:

1. Coveralls
2. Gloves*
3. Boots/shoes, leather or chemical-resistant, steel toe and shank.
4. Boots (outer), chemical-resistant (disposable)*.
5. Safety glasses or chemical splash goggles*
6. Hard hat (face shield)*
7. Escape Mask*

* Optional, as appropriate

May 15, 1988

SECTION 2

OCCUPATIONAL SAFETY
AND
HEALTH GUIDANCE DOCUMENTS

PART 2

US EPA ENVIRONMENTAL RESPONSE TEAM'S OCCUPATIONAL MEDICAL MONITORING PROGRAM GUIDELINES FOR SARA HAZARDOUS WASTE FIELD ACTIVITY PERSONNEL

Publication 9285.3-04

U.S. EPA

ENVIRONMENTAL RESPONSE TEAM'S

OCCUPATIONAL MEDICAL MONITORING PROGRAM

GUIDELINES

FOR SARA HAZARDOUS WASTE FIELD ACTIVITY PERSONNEL

January 1990

Office of Solid Waste and Emergency Response

Office of Emergency and Remedial Response

Emergency Response Division

ABSTRACT

PURPOSE: The purpose of this document is to suggest guidelines covering the requirements for a comprehensive occupational medical monitoring program for those personnel involved in SARA hazardous waste field activity.

BACKGROUND: Occupational medical monitoring is the surveillance of the health status of selected employees by means of periodic examinations. Occupational medical monitoring assists in the early detection and prevention of adverse effects from occupational exposure to hazardous agents and physical stress. Specifically, such a program would provide:

- Early recognition of effects from unsuspected hazards;
- Evaluation of health status with respect to work assignments;
- Indication of effectiveness of protective measures taken for known hazards;
- Data for studies of the longterm subtle effects of occupational exposures;
- Assurance from a physician that employees are physically able to work under unique physical stresses, such as wearing respirators.

APPLICABILITY: It is EPA's policy that a program of medical surveillance must be instituted for each employee exposed to potentially hazardous working conditions (i.e., SARA hazardous waste field activity). Furthermore, the Agency's Occupational Medical Monitoring Program must accommodate changes associated with variation in working conditions, advances in the practice of occupational medicine, current health and safety standards and regulations, and changes indicated by findings from medical examinations.

January 10, 1990

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REFERENCES

1. Title 5, United States Code, Sections 7901 and 7902.

2. Executive Order 12196, Occupational Safety and Health Programs for Federal Employees.

3. 29 CFR 1960, Basic Program Elements for Federal Employee Occupational Safety and Health, Occupational Safety and Health Administration (OSHA), Department of Labor.

4. OPM, Federal Personnel Manual, Chapter 339, Medical Examinations for Appointment.

5. OPM, Federal Personnel Manual, letter 293-20.

6. EPA, Occupational Health and Safety Manual, Chapter 8, Laboratory Use of Toxic Substances.

7. EPA, Order 1440.2, Health and Safety Requirements for Employees Engaged in Field Activities.

8. EPA, Order 1440.3, Respiratory Protection.

9. EPA, Occupational Medical Monitoring Guidelines.

10. 29 CFR 1910.20, General Industry Standards, OSHA, Department of Labor.

11. 29 CFR 1910.20, General Industry Standards, OSHA, Department of Labor.

January 10, 1990

1.0 PURPOSE

The purpose of this document is to suggest guidelines covering the requirements for an occupational medical monitoring program for those personnel involved in SARA hazardous waste field activity.

2.0 GENERAL REQUIREMENTS

2.1 All occupational medical monitoring examinations and procedures must be performed by or under the supervision of a licensed physician. The physician chosen should be experienced and/or board certified in occupational medicine. If a specialist in occupational medicine is not available, a local physician should be chosen who is equipped to conduct thorough physical examinations and who is familiar with, or is willing to become familiar with the Agency's programs and the hazards to which its employees could potentially be exposed. All examinations must be handled through the medical provider, and employees may not substitute an examination by his/her personal physician.

2.2 All federal employees participating in the occupational medical monitoring program must read and sign a copy of the Privacy Act Statement. The original form must be filed with the employee's official occupational medical monitoring records, and a copy should be provided to the employee.

2.3 Each employee who is required to have an examination or medical certificate before assignment, should complete a medical history form and give the form to the physician at the time of the examination.

2.3 The nature and extent of the medical examinations must be based on the individual's potential for exposure.

2.4 Each employee is required to have baseline, periodic, termination, and unscheduled examinations. Each of these examinations is briefly described below. Complete descriptions of each type of examination are identified in Appendix A.

3.0 BASELINE

The baseline or preemployment/preplacement medical examination is given to ensure that employees are physically able to perform the duties of their intended positions without danger to themselves and/or others. This examination is a comprehensive medical evaluation intended to provide reference information for the evaluation of subsequent examination findings. These examinations are a condition of employment for otherwise acceptable applicants for positions that require such an examination, or which require a medical certificate before assignment.

4.0 PERIODIC EXAMINATION

Periodic examinations are regularly scheduled examinations to identify physical changes or illnesses thereby ensuring that prompt treatment and remedial actions can be taken. The interval or frequency of these examinations must be based on recommendations made by the Employer's Occupational Medical Monitoring Coordinator.

5.0 UNSCHEDULED EXAMINATION

Unscheduled examinations are conducted to determine adverse health effects of exposure to specific significant hazards or stresses, or where results of a periodic, baseline or exit examination have indicated an actual or potential health problem.

5.1 An episodic examination should be given whenever there is a direct question about an employee's continued capacity to meet the physical or medical requirements of the position (i.e., employee's direct exposure to hazardous materials).

6.0 TERMINATION EXAMINATION

A termination examination can be the same comprehensive examination as the baseline or preemployment/preplacement examination. This examination documents the health status of the employee at the end of employment and provides information on any changes that have occurred during the employment period.

7.0 REPORTING REQUIREMENTS

Any physician or medical facility that conducts a medical examination should be required to meet the following criteria:

7.1 After each examination, furnish the employee with a written, nontechnical evaluation report of examination findings, and a statement of the employee's fitness for the position. The employee should be provided with the opportunity to discuss the results with the examining physician.

7.2 Advise the employee of abnormal test results that are felt to be the results of non-occupationally-related causes so that the employee may contact his/her private physician for follow-up.

7.3 Notify the employee first, and second, notify the Occupational Medical Monitoring Coordinator, of abnormal occupational-related findings so that any follow-up examinations or treatment can be scheduled, or so that remedial actions can be taken in the employee's workplace.

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(The Medical Monitoring Coordinator should notify the employee's supervisor and/or the Director, Occupational Health and Safety Staff, of abnormal test results within 48 hours of receipt of a report of occupational-related positive findings. This notice should be general in nature to protect the employee's Confidentiality Rights.)

7.4 Furnish the employee with a written statement that his/her health and physical condition are satisfactory to wear respiratory protective devices.

8.0 SPECIAL REQUIREMENTS

8.1 Immunizations. The special situations where immunizations are recommended are outlined in the U.S. EPA Occupational Medical Monitoring Guidelines, Washington D.C. See Appendix B for general information regarding immunizations.

8.2 Research Tests. Research tests for the purpose of investigation or experimentation aimed at the discovery and interpretation of medical facts, revision of accepted theories in the light of new facts, or practical application of such new or revised theories are not recommended as a part of the occupational medical monitoring program because of their limited clinical value.

8.3 Reproductive Hazards. Extreme caution must be exercised to ensure that employees are not exposed to harmful quantities of classified or unclassified substances that are known or suspected of affecting reproduction in both males and females.

As part of a hazardous substances communication, employees are to be informed of the threat to human reproduction by chemicals in the workplace. Employees (both male and female) who can potentially be exposed to chemicals that effect reproduction, such as teratogens, mutagens, and chemicals that alter fertility, have the right to request a temporary change in job assignment as needed to allow conception or to protect an unborn child. Each request should be handled on an individual basis and each supervisor should have the responsibility to assess the reproductive hazards associated with the job and to make reasonable accommodations of equal professional status.

8.0 RELATIONSHIP BETWEEN OCCUPATIONAL MEDICAL MONITORING AND WORKERS' COMPENSATION

The intent of the Occupational Medical Monitoring Program is to detect the deleterious consequences of occupational exposure to hazardous substances or conditions, or harmful physical agents. Once such a possibility is detected, the employee may file a claim for worker's compensation. The federal employee's medical expenses from that point are covered by the Office of Worker's Compensation (OWCP), U.S. Department of Labor. If the claim is disallowed by OWCP, the employee may use his/her medical coverage to pay the costs.

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APPENDIX A - MINIMUM EXAMINATION TYPES AND CONTENT

	BASELINE	PERIODIC	TERMINATION	UNSCHEDULED
History and Physical Exam				
Complete Medical History	X		X	X
Interval History		X		
Physical Examination by Physician	X	X	X	X
Visual Acuity	X	X	X	0
Routine Laboratory Tests/Procedures				
Pulmonary Function	X	X	X	0
Audiometry	X	X	X	0
Electrocardiogram	X	0	X	0
Chest x-ray	X	0	X	0
Complete Blood Count	X	X	X	0
Routine Urinalysis	X	X	X	0
Blood Chemistry	X	X	X	0
Special Tests*				
Cholinesterase	X	0	0	0
Methemoglobin	0	0	0	0
Heavy Metal Screen	X	0	0	0
Urine and Sputum Cytology	0	0	0	0
Polychlorinated Biphenyl (PCB)	0	0	0	0
Cardiovascular Stress Test	X	0	-	-

X - Recommended
0 - As indicated

* Any special test which may be considered on a periodic basis should be included in the baseline test.

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What are the basic laboratory tests to be included for each participant for the baseline, periodic, and termination examinations?

A. Blood Tests

Each individual should receive a basic panel of blood counts and chemistries to evaluate blood-forming organs, kidney, liver, and endocrine/metabolic function. The following blood tests are considered to be the minimum desirable:

- o White blood cell count and differential cell count
- o Hemoglobin and/or hematocrit
- o Albumin, globulin, and total protein
- o Serum glutamic oxalacetic transaminase (SGOT)
- o Lactic dehydrogenase (LDH)
- o Alkaline phosphatase
- o Calcium
- o Phosphorus
- o Uric acid
- o Creatinine
- o Urea nitrogen
- o Cholesterol
- o Glucose

B. Urinalysis

Each employee should have a routine urinalysis that consists of the following:

- o Specific gravity
- o pH

- Microscopic examination
- Protein
- Acetone
- Glucose

For further information in determining the content of medical examination with regard to specific hazardous materials, refer to Chapter Five of the NIOSH/OSHA/USCG/EPA Occupational Safety and Health Guidance.

APPENDIX B - GUIDELINES FOR IMMUNIZATION REQUIREMENTS

Immunization of adult employees is rarely required after the 18th birthday.

Hepatitis Vaccine - Pre-exposure prophylaxis (Hepatitis A - ISG) for personnel in close contact with newly imported primates is recommended every four months. Emphasis should be also be placed on other measures such as scrupulous hygiene practices, use of protective clothing and the limiting of human contact with animals.

Tetanus prophylaxis - Should be the responsibility of the examining physician when an employee is wounded. Managing of the wounded employee should be based in the history of previous tetanus vaccinations and the condition of the wound.

Poliomyelitis vaccine - Routine primary polio vaccination of adults (those past the 18th birthday) residing in the United States is not necessary. Most adults are already immune and have a very small risk of exposure to poliomyelitis. Those at increased risks such as laboratory workers handling specimens which may contain the polioviruses should receive the vaccine as adults. Unvaccinated adults and incompletely immunized adults (at increased risks) should be given a full course.

Rabies prophylaxis - Local and state public health officials should be consulted if questions arise about the need for prophylaxis.

Plague vaccine - (Infection of humans resulting from exposure to wild rodents/their fleas occurring mostly in the western part of the United States.) Routine bacteriologic precautions are sufficient to prevent accidental infection with plague.

Guidelines for Female Field Investigators

Female employees of child-bearing age should not be exposed to large quantities of unclassified chemicals. Since the teratogenic effect of some chemical exposures on the unborn fetus is not known, extreme caution should be exercised in said situation. Reassignment of the female should be made to nonhazardous duties as soon as pregnancy is diagnosed.

* CDC Monograph, September, 1980.

December 6, 1988

SECTION 3

QUICK REFERENCE FACT SHEETS

QUICK REFERENCE FACT SHEETS

SECTION OBJECTIVE

The objective of this section is to provide students with a copy of the following U.S. Environmental Protection Agency Environmental Response Team (USEPA-ERT) Health and Safety Quick Reference Fact Sheets:

- Publication 9285.1-02: Health and Safety Roles and Responsibilities at Remedial Sites
- Publication 9285.2-06FS: Establishing Work Zones at Uncontrolled Hazardous Waste Sites
- Publication 9285.2-07FS: Hazardous Waste Operations and Emergency Response: RCRA TSD and Emergency Response Without Regard to Location
- Publication 9285.2-08FS: Hazardous Waste Operations and Emergency Response: Uncontrolled Hazardous Waste Sites and RCRA Corrective Actions
- Publication 9285.2-09FS: Hazardous Waste Operations and Emergency Response: General Information and Comparison
- Publication 9285.2-10FS: Hazardous Waste Operations and Emergency Response: Available Guidance

STUDENT PERFORMANCE OBJECTIVES

After completing this section and related lesson(s), the student will be able to:

- Understand the historical development of hazardous waste and emergency response worker protection standards.
- Identify key occupational health and safety standards and guidance documents.
- Identify to whom and to what operations OSHA 29 CFR 1910.120 applies, and the major legal requirements under paragraphs (a) through (q) in 1910.120.

SECTION 3

QUICK REFERENCE FACT SHEETS

PART 1

HEALTH AND SAFETY ROLES AND RESPONSIBILITIES AT REMEDIAL SITES

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response

Publication 9285.1-02 July 1991

EPA

HEALTH AND SAFETY ROLES AND RESPONSIBILITIES AT REMEDIAL SITES

Office of Emergency and Remedial Response
Hazardous Site Control Division OS - 220W

Quick Reference Fact Sheet

Additional fact sheets which address health and safety at Superfund sites have been compiled by the Environmental Response Team (ERT). The ERT Fact Sheets are listed in the Bibliography on page 6.

INTRODUCTION

The complex inter-relationships between the many parties involved in remedial activities make it difficult to administer the health and safety program. To implement an effective, well coordinated program all participants must be made aware of the health and safety roles and responsibilities of all parties involved in site remediation.

The purpose of this fact sheet is to define the major components of the health and safety program and to delineate the health and safety roles and responsibilities for Remedial Project Managers (RPM), lead parties/agencies, and contractors during the remedial action phase of Superfund clean-ups. It addresses the various roles of all parties in the overall health and safety program for a site, with emphasis on Occupational Safety and Health Act/Agency (OSHA) compliance. More detailed health and safety guidance documents are available through the Environmental Protection Agency's (EPA's) Environmental Response Team (ERT), Edison, NJ, (908) 321-6740 and OSHA.

OCCUPATIONAL HEALTH & SAFETY OVERVIEW

All governmental agencies and private employers are directly responsible for the health and safety of their employees. This general rule applies to the many parties involved in the hazardous waste clean-up at Superfund sites (i.e. OSHA citations to abate unsafe or unhealthful working conditions would be written to the party whose employees are at risk).

OSHA requires that a written (site-specific) occupational safety and health program, that includes a safety and health plan, be in place for remedial activities at all Superfund sites. EPA, OSHA, and the U.S. Army Corps of Engineers (USACE) often use different terminology to describe written safety and health programs and plans. EPA uses the term Health and Safety Plan (HASP), OSHA uses Safety and Health Program and/or Plan, while USACE uses the term Site Safety and Health Plan (SSHP). In this document the term HASP is used. The objective of the HASP is to protect workers through the identification, evaluation, and control of health and safety hazards and to provide for emergency response contingency planning.

The party responsible for the HASP should be identified in the work plan. It is usually developed and implemented by the prime contractor's site coordinator, and reviewed and accepted by the construction manager for Fund-Lead projects and by the RPM and oversight official for enforcement lead projects. The construction manager is usually USACE, the U. S. Bureau of Reclamation (USBR), or an Alternative Remedial Contracting Strategy (ARCS) contractor. Accepted means the HASP has been reviewed by the construction manager/oversight official and any deficiencies have been identified and corrected prior to the start of work. OSHA requires the HASP to be developed and implemented before work begins at the site.

The HASP shall include a written statement delineating the responsibilities, authority, and accountability of the various parties involved in the remedial action. A goal of the HASP is to facilitate coordination and communication of

health and safety issues among personnel responsible for the various activities. The HASP is mandated by OSHA and/or the construction contract as the legally enforceable plan for the job site. The prime contractor is usually responsible for review and approval (after acceptance by the RPM and construction manager) of subcontractor health and safety programs. The HASP will be incorporated into each subcontractor health and safety program.

The EPA must be provided an original and a copy of all changes to the HASP prior to implementation, as they may affect public health, the environment, overall cost, scheduling, or technical quality of a project. It is an RPM's responsibility to insure that all Federal safety and health requirements are met at a site, however the construction manager, not the RPM, accepts and enforces changes to the HASP.

Specific topics/statements in the HASP include:

Training

The HASP shall specify that a training plan complying with OSHA training requirements outlined in 29 CFR 1910.120 (e) and the Hazard Communication Standard, 29 CFR 1926.59 for construction, will be implemented (it is usually the prime contractor's responsibility). OSHA requires both on-site and off-site training for workers at RA sites. Increased OSHA enforcement of the training requirements of these standards is likely at RA sites as exemplified by recent OSHA enforcement actions. For specific requirements, consult the sources of information listed at the end of this fact sheet.

The requirements for off-site training are a function of both the potential for exposure and management responsibility. Information pertaining to off-site (initial) training is available through a number of sources including courses offered by ERT, USACE (Huntsville Division) and through the National Clearinghouse on Occupational and Environmental Health (funded by a National Institute of Environmental Health Sciences Grant). Additional sources of information are listed at the end of this fact sheet.

EPA employees who have not had the 40-hours training are not permitted to enter areas where occupational exposures above established limits are likely. The use of respirators implies that exposures are likely. Exceptions are strongly discouraged, but can be made on a case-by-case basis with the approval of the site safety and health officer if respirators are NOT required, time on site is limited, and visitors are given a pre-entry site briefing and accompanied by trained personnel at all times.

On-site construction managers normally are required to have completed a 40 hour off-site course. For those construction managers who have on-site supervisory responsibilities, an additional 8-hour supervisory training is required. An 8-hour annual refresher training is required for all site workers. Training requirements for entry to sites where occupational exposures above established limits are likely, or where respirators or other personal protective equipment are required are described in the ERT Fact Sheets listed at the end of this publication.

On-site training must be tailored to the conditions of individual sites. At RA sites, construction managers, RPMs, and authorized visitors must receive on-site training prior to entering restricted areas.

Logistics and Resources

The HASP should specify that the party responsible for health and safety plan implementation (i.e.the prime contractor) will provide for logistics and resources, such as qualified health and safety managers to meet plan tasks and objectives.

The Site-Specific HASP

OSHA, 29 CFR 1910.120 (b), requires that a site HASP be developed and reviewed by qualified personnel for each remedial action. Subcontractors can modify the plan to account for their own work. However, their plan or modifications shall be formally incorporated into the general site plan. Only one HASP is applicable to a particular site. It must be kept on site and shall be made available for review by employees, emergency response personnel, or, if applicable, employee representatives.

The plan should not be generic, but should be based on specific site characterizations, anticipated hazards and expected work conditions at the site. OSHA requires the plan address the following elements:

(1) A safety and health risk or hazard analysis for each site task and operation found in the workplan.

(2) Employee training.

(3) Personal protective equipment for each task or operation.

(4) Medical surveillance.

(5) Frequency and types of air monitoring, personal monitoring, environmental sampling techniques, instrumentation, and methods to be used.

(6) Site control measures.

(7) Decontamination procedures.

(8) An Emergency Response Plan.

(9) Confined Space entry procedures

(10) A spill containment program.

Emergency Response

Most sites are too small to warrant fully staffed on-site medical and fire fighting facilities. Where services can be provided by surrounding communities, EPA may provide limited training and support to compensate for OSHA requirements specific to hazardous waste response training and support on a case-by-case basis. The amount of training and support that local fire fighting and emergency response personnel will require for OSHA compliance (Paragraph (q) of the Worker Protection Standard if off-site responders) depends on site-specific conditions and on Response Tasks (i.e. off-site training duration can vary between 24 and 40 hours). Examples of the types of support that may be provided by EPA to local responders on a case-by-case basis include off and on-site training, no-cost personal protective equipment and specialized haz-mat equipment loans, medical surveillance, and reimbursement of response funds.

As a minimum, the emergency response plan should be a separate section of the site HASP. The designer (for design operations involving site entry) and the party responsible for the remedial action health and safety plan (usually the prime contractor) have the responsibility to arrange for emergency response support and written agreements prior to commencement of operations involving site entry. This will entail an evaluation of the capabilities of local fire departments, hospitals, police departments, etc. to provide coordinated and integrated services to the RD and RA. Selection of the provider should be based on an evaluation of current capabilities, required support levels, response time, jurisdictional authority, and cost to the Government. This information is often available from information obtained during pre-design activities. Because failure to secure agreements can result in remedial project delays or work stoppage, it is important for the RPM to address emergency response in pre-design work plans, etc. and solicit early involvement with community relations staff in the process.

The site safety officer (or equivalent position) should make a copy of the HASP (to include the emergency response plan) available, and provide on-site training for local fire fighting and emergency response personnel subject to respond to calls at Superfund RA sites.

Health and Safety Plan Improvements

Feedback or communications from safety meetings, training and inspections should be openly encouraged so that the HASP can be adjusted and improved. EPA strongly endorses an open communication policy in which all health and safety inquiries receive a prompt, professional response. The HASP should outline procedures for response to health and safety inquiries and for modifications. Consistent with the OSHA worker protection standard, ongoing inspections and/or monitoring will, at times, require changes to the HASP. Modifications should be drafted by professional staff (i.e. the prime contractor's industrial hygienist) and approved by the construction manager.

INSPECTIONS

Health and safety program oversight is an RPM responsibility, however, the RPM is not required to conduct health and safety inspections. Inspections for enforcement purposes are the responsibility of OSHA. If inspections uncover conditions that may adversely affect public (or worker) health and/or the environment, the overall cost, scheduling, or technical quality of the project, then prompt lead party and RPM notification is necessary. For RA projects the construction manager or oversight official is responsible for enforcing the terms of the contract or settlement agreement to include the issuance of stop work orders in situations where the health and safety provisions of the contract are violated.

Employee Representatives

A worker representative (if applicable, the Union health and safety representative) should be given the opportunity to accompany the inspector during non-OSHA health and safety inspections or evaluations. For OSHA inspections, the worker representative has the right to accompany the inspector. In situations where more than one union represents workers at the site being inspected, the inspecting official should select a health and safety representative for each area being inspected. The selection and participation of the employee health and safety representative during inspections and evaluations should be addressed in the HASP.

Imminent Danger

Whenever, and as soon as the RPM (or any other party) is made aware of a danger which could reasonably be expected to cause death or serious physical harm, that person has the responsibility to IMMEDIATELY notify the affected employees, and parties with the responsibility and authority to remove the danger. In situations where an imminent danger exists, both the prime contractor's site coordinator and the construction manager's on-site representative (or equivalent) have the responsibility and

authority to stop all activities or withdraw employees. The RPM does NOT shut down or remove personnel from unsafe operations, but recommends action for decisions by lead agency officials. If steps are not taken to remove the danger, OSHA shall be consulted.

Other Unsafe or Unhealthful Working Conditions

For Federal-lead RA projects, health and safety inquiries should be channeled through the construction manager, who has the responsibility to notify the site coordinator verbally and in writing of the unsafe or unhealthful condition. For other than Federal-lead projects, the RPM should notify the site coordinator (or responsible party) verbally and in writing of unsafe or unhealthful working conditions. IF NOT SATISFIED WITH THE CORRECTIVE ACTION TAKEN, THE RPM SHOULD CONSULT WITH THE REGIONAL SAFETY AND HEALTH OFFICER, THE ENVIRONMENTAL RESPONSE TEAM (ERT) ((908) 321-6740) OR THE HEADQUARTERS HAZARDOUS SITE CONTROL DIVISION (HSCD) ((703) 308-8393) PRIOR TO SEEKING INTERVENTION FROM OSHA.

OSHA STANDARDS

OSHA Standards are found in Title 29 of the Code of Federal regulations (29 CFR). Two parts must be followed during remediation activities: Part 1910, General Industry Standards and Part 1926, Construction Standards. The interpretation as to which parts of Title 29 apply to a particular activity is often complex. EPA Standard Operating Safety Guides (and USACE regulations for USACE managed projects) supplement OSHA regulations. If a conflict arises, the more protective standard should be applied to a particular operation.

Worker Protection

OSHA's Worker Protection Standard for Hazardous Waste Operations and Emergency Response, 29 CFR 1910.120, will have the most applicability to remediation activities. Guidance on interpretation of the Standard can be found in ERT Fact Sheets. Compliance with the standard should be addressed in the preliminary assessment/site inspection stage, during the remedial investigation/feasibility study stage, and through the remedial design and remedial action. The delineation of a site into work zones where the worker protection standard applies should be addressed in the remedial design site HASP. In situations where competent health and safety professionals lack sufficient information to conclude that occupational exposure will be well within limits considered acceptable, a protective interpretation of the standard is recommended (However, overprotection, as well as underprotection can be hazardous and should be avoided wherever possible).

Hazard Communication

The OSHA hazard communication standard(s), 29 CFR 1926.59 for construction and 1910.1200 for general industry, require that all hazardous chemicals on a site be identified. Every potentially exposed worker must be given hazard communication training at the time of initial work assignment and each time a new hazard is introduced into a work area. Material Safety Data Sheets (MSDS) must be available for all hazardous materials brought onto the site except hazardous wastes, as defined by the Resource Conservation and Recovery Act (RCRA), which are exempt. Training centers around information contained in the MSDS. Similar requirements are contained in the worker protection standard, 29 CFR 1910.120, which requires a worker risk assessment for hazardous materials found on-site. Problem areas commonly encountered include the lack of access to and the quality of information in Material Safety Data Sheets (MSDS).

ROLES AND RESPONSIBILITIES

The basic health and safety responsibilities of the various parties involved in the RD and RA phases of work at Superfund sites follow:

Remedial Design

The remedial design contractor is responsible for the development and implementation of a HASP for all on-site RD activities; for the development of specifications for the remedial action site health and safety plan; and for the description of minimum requirements for health, safety, and emergency response. The following should be specified in the final design:

1. An estimate of increased hazards (over background).

2. The degree of existing hazard based on contamination identified in the site characterization report, on the Agency for Toxic Substances and Disease Registry (ATSDR) Health Assessment, and on the short term effects component of the feasibility study.
3. Minimal acceptable standards for:
   - -Worker protection
   - -The general public
   - -Monitoring, reporting and interpretation (what constitutes acceptable concentration)
   - -Emergency response and evacuation
   - -Site control; decontamination of personnel and equipment; clean-up procedures

During the design phase, it is the responsibility of the designer to establish site boundaries where 29 CFR

1910.120 applies and to describe criteria utilized in such determinations. These boundaries should be reviewed and approved by a qualified health and safety professional such as a certified industrial hygienist, certified health physicist, etc.

Remedial Action

OSHA, or its State counterpart, has Occupational Safety and Health Act enforcement authority at RA sites. In addition to complying with Federal standards, the prime contractor must also comply with contractual health and safety policies and guidelines from EPA. For Alternative Remedial Contract Strategy (ARCS), the U.S. Army Corps of Engineers (USACE), and the U.S. Bureau of Reclamation (BUREC) managed projects, health and safety enforcement responsibilities under the contract are delegated to the construction manager's resident inspector (or equivalent position). For State lead projects these responsibilities are delegated to the State's on-site official; and for Potentially Responsible Party (PRP) projects, health and safety enforcement is the responsibility of EPA's oversight official. The resident inspector must be certified to be on site (i.e. have a medical examination, training, experience, etc.), conduct health and safety inspections and evaluations of contractor compliance with the health and safety contract provisions, and possess a complete understanding of the contract.

Implementation of the health and safety program is the responsibility of the prime contractor. The State's on-site official or the PRP oversight official is responsible for health and safety during the implementation of the operation and maintenance phase.

HEALTH & SAFETY PROGRAM OVERSIGHT

RPM Responsibilities

As the EPA's prime contact or representative for a site, it is important for the RPM to be a strong health and safety advocate. The RPM has the responsibility to coordinate, direct, and review the work of EPA contractors responsible parties and other agencies to assure compliance with the National Contingency Plan. As such the RPM oversees compliance with occupational health and safety programs. The RPM normally does not have direct line authority over the RA prime contractor but recommends action through the lead agency or PRPs. The RPM will be informed of situations where health and safety issues impact overall project cost, scheduling, technical quality or public health/environmental protection. However, the RPM's primary responsibility is oversight, not action. Items requiring action should be referred to the appropriate individuals or agencies (Prime contractor, USACE, BUREC, ARCS, Responsible Party, the State, or OSHA).

SOURCES OF INFORMATION

For questions about OSHA regulations or EPA/OSHA relationships, how to contact Regional or Federal OSHA representatives, and/or HASP computer software package, contact:

Rod Turpin
USEPA Environmental Response Team
2890 Woodbridge Avenue
Building 18 (MS-101)
Edison, NJ 08837-3679
(908) 321-6740 or FTS 340-6740

For OSHA publications contact:

U.S. Department of Labor - OSHA
Publications Office, Room N3101
200 Constitution Avenue N.W.
Washington, D.C. 20210
(202) 523-9667

For questions pertaining to health and safety during remedial design/remedial action, contact:

Joe Cocalis
USEPA Hazardous Site Control Division
Design and Construction Management Branch
Mailstop OS-220W
401 M. Street SW
Washington, D.C. 20460
(703) 308-8356 or FTS 398-8356

SOURCES OF INFORMATION
(continued)

For information pertaining to health and safety training contact ERT or the National Institute for Environmental Health Sciences Training Grant Clearinghouse:

USEPA ERT
26 West Martin Luther King
Cincinnati, OH 45268
(513) 569-7537

or

National Clearinghouse on Occupational & Environmental Health
c/o Workplace Health Fund
815 16th Street, N.W. Suite 301
Washington, D.C. 20006
(202) 842-7833

BIBLIOGRAPHY

29 CFR 1910, OSHA General Industry Standards

(1) 1910.120 Hazardous Waste Operations and Emergency Response
(2) 1910.134 Respiratory Protection
(3) 1910.1200 Hazard Communication

29 CFR 1926, OSHA Construction Industry Standards

OSWER Directive 9285-01, Health and Safety Plan (HASP), June 1989.

ERT Fact Sheets

A. Hazardous Waste Operations and Emergency Response: General Information and Comparison (#9285.2 - 09fs)

B. Establishing Work Zones at Uncontrolled Hazardous Waste Sites (#9285.2 - 06fs)

C. Hazardous Waste Operations and Emergency Response: Uncontrolled Hazardous Waste Sites and RCRA Corrective Action (#9285.2 - 08fs)

D. Hazardous Waste Operations and Emergency Response: RCRA TSD and Emergency Response Without Regard to Location (#9285.2 - 07fs)

E. Hazardous Waste Operations and Emergency Response: Available Guidance (#9285.2-10fs)

SECTION 3

QUICK REFERENCE FACT SHEETS

PART 2

ESTABLISHING WORK ZONES AT UNCONTROLLED HAZARDOUS WASTE SITES

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response

Publication 9285.2-06FS
April 1991

EPA

Establishing Work Zones at Uncontrolled Hazardous Waste Sites

Office of Emergency and Remedial Response
Emergency Response Division MS-101

Quick Reference Fact Sheet

Under the authority of section 126 of the Superfund Amendments and Reauthorization Act of 1986 (SARA), the U.S. Environmental Protection Agency (EPA) and the U.S. Occupational Safety and Health Administration (OSHA) promulgated identical health and safety standards to protect workers engaged in hazardous waste operations and emergency response. The OSHA regulations became effective on March 6, 1990 and are codified at 29 CFR 1910.120 (54 FR 9294, March 6, 1989); the EPA regulations also became fully effective on March 6, 1990 and are codified at 40 CFR 311 (54 FR 26654, June 23, 1989). The EPA regulations incorporate the OSHA standards by reference.

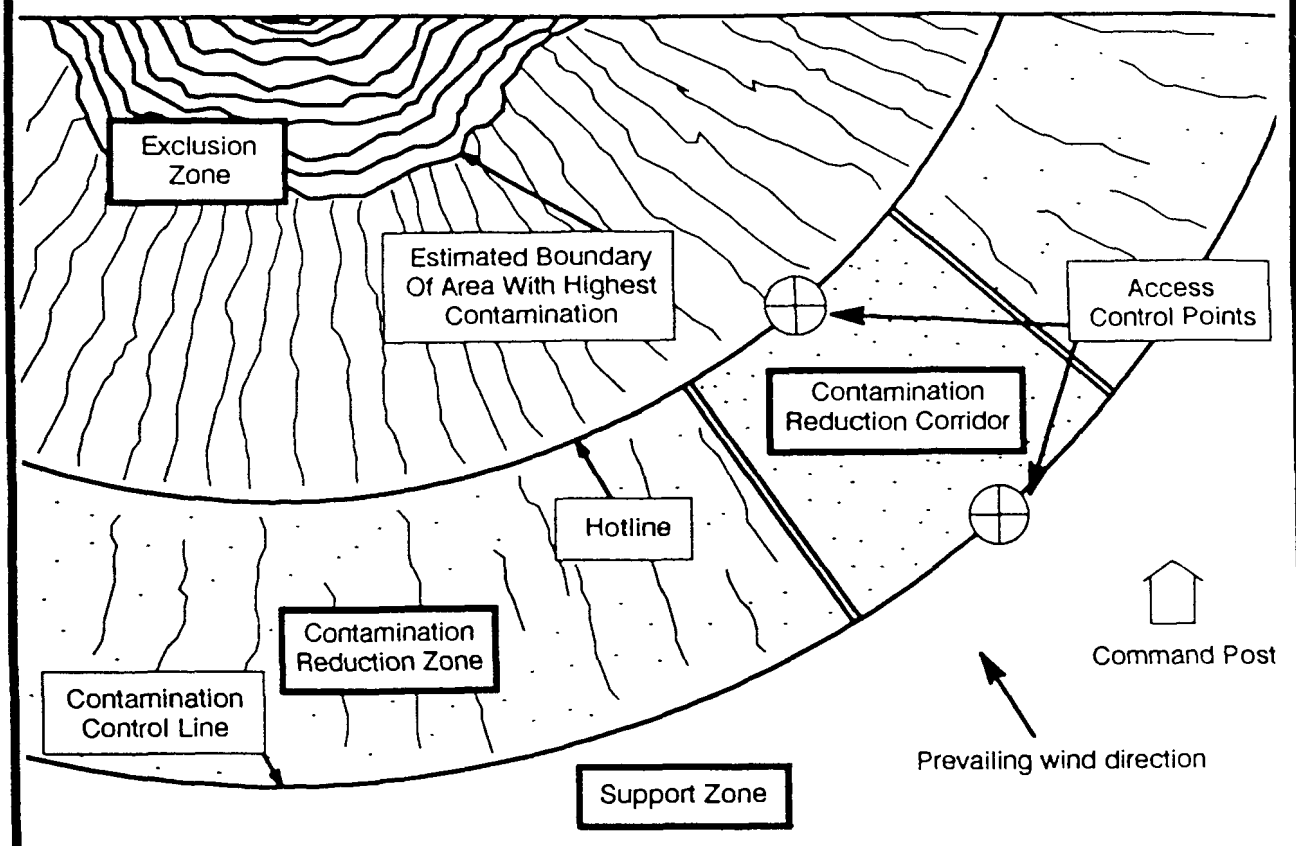
Although the two sets of standards contain identical *substantive* provisions, EPA and OSHA address different *audiences*. In states *without* an OSHA-approved program, federal OSHA standards protect all private and federal employees engaged in hazardous waste operations and emergency response; the EPA worker protection standards protect all state and local government employees. In states *with* an OSHA-approved program, the state program covers all private, state, and local government employees; OSHA covers federal employees in those states. Another Fact Sheet, *Hazardous Waste Operations and Emergency Response: Uncontrolled Hazardous Waste Sites and RCRA Corrective Action* (OSWER Publication No. 9285.2-08FS), provides a general overview of the worker protection standards as they apply to operations conducted at uncontrolled hazardous waste sites.

The purpose of this Fact Sheet is to summarize the procedures and requirements for establishing and maintaining work zones, including Support Zones, at hazardous waste sites. This Fact Sheet is divided into five parts. The first provides definitions for the work zones that are commonly designated at hazardous waste sites. The second describes the data collection requirements for the initial site characterization. Part 3 discusses evaluation of site data and other considerations in work zone selection. Part 4 describes methods for ensuring the integrity of Support Zones during remedial or removal actions. The final part of this Fact Sheet provides additional references and contacts for further information.

PART 1: INTRODUCTION TO WORK ZONES

The worker protection standards at 29 CFR 1910.120(b) require that employers with employees engaged in hazardous waste operations at uncontrolled hazardous waste sites develop and implement a written health and safety program for their employees. The purpose of this program is to identify, evaluate, and control safety and health hazards, and provide for emergency response during hazardous waste operations. As part of the overall health and safety program, 29 CFR 1910.120(d) specifies that appropriate site control procedures must be implemented before clean-up work begins, to minimize employee exposure to hazardous substances. One of the basic elements of a site control program is the delineation of work zones. This delineation specifies the type of operations that will occur in each zone, the degree of hazard at different locations within the site, and the areas at the site that should be avoided by unauthorized or unprotected employees.

EXHIBIT 1
Illustration of Typical Work Zones



Note: Area dimensions not to scale. Distances between points may vary.

EPA's *Standard Operating Safety Guides* describes the process for establishing and maintaining work zones. Although a site may be divided into as many zones as necessary to ensure minimal employee exposure to hazardous substances, the three most frequently identified zones are the Exclusion Zone, the Contamination Reduction Zone (CRZ), and the Support Zone. The purpose of establishing the zones is to (1) reduce the accidental spread of hazardous substances by workers or equipment from the contaminated areas to the clean areas; (2) confine work activities to the appropriate areas, thereby minimizing the likelihood of accidental exposure; and (3) facilitate the location and evacuation of personnel in case of an emergency. Movement of personnel and equipment among these zones is minimized and restricted to specific access control points to prevent cross-contamination from contaminated areas to clean areas. A representation of the three most commonly designated work zones is found in **Exhibit 1**. A description of each zone is provided below.

Exclusion Zone

The Exclusion Zone is the area where contamination does or could occur and the greatest potential for exposure exists. In order to separate the Exclusion Zone from the rest of the site, the outer boundary of the Exclusion Zone, known as the Hotline, should be clearly marked. Access of personnel and equipment to and from the Exclusion Zone should be restricted by access control points on the zone's periphery. *All persons who enter the Exclusion Zone should wear the appropriate level of personal protective equipment (PPE) for the degree and types of hazards at the site.*

The Exclusion Zone also may be subdivided into different areas of contamination, based on the known or expected type and degree of hazard or the incompatibility of waste streams. If the Exclusion Zone is subdivided in this manner, additional demarcations and access control points may be necessary.

Contamination Reduction Zone

As the transition area between the contaminated area and the clean area, the CRZ is the area in which decontamination procedures take place. This zone is designed to reduce the probability that the Support Zone will become contaminated or affected by other site hazards. Due to both distance and decontamination procedures, the degree of contamination in the CRZ generally will decrease as one moves from the Hotline to the Support Zone.

Support Zone

The Support Zone is defined as the uncontaminated area where workers should not be exposed to hazardous conditions. Any potentially contaminated clothing, equipment, and samples must remain outside of the Support Zone until decontaminated. The Support Zone is the appropriate location for the command post, medical station, equipment and supply center, field laboratory, and any other administrative or support functions that are necessary to keep site operations running efficiently. Because the Support Zone is free from contamination, personnel working within it may wear normal work clothes, and access to and from the area is not restricted for authorized site personnel. Such personnel, however, should receive instruction in the proper evacuation procedures in case of a hazardous substance emergency.

PART 2: SITE CHARACTERIZATION -- DATA COLLECTION

To establish a Support Zone, the specific hazards and the degree of potential employee exposure at the site must be considered. The site characterization, as specified in 29 CFR 1910.120(c), is the basis for developing the site health and safety plan (HASP), and provides information needed to identify site hazards, select proper PPE, and implement safe work practices. Site characterization generally proceeds in three phases:

- Prior to site entry, an off-site characterization, including data gathering and perimeter reconnaissance.
- An on-site survey.
- Ongoing monitoring to provide a continuous source of information about site conditions.

Off-site characterization and the on-site survey are discussed below. Ongoing monitoring is discussed in Part 4 of this Fact Sheet, Ensuring Integrity of Work Zones.

Data-Gathering Prior to Initial Site Entry

The initial stages of site characterization must be accomplished off-site, so as not to endanger the health and safety of workers. For example, at new uncontrolled hazardous sites, or at those sites with areas that have not been evaluated, the range of potential hazards and exposure risks is unknown. As much information as possible should be obtained during off-site characterization to evaluate the hazards and institute preliminary controls for protecting initial entry personnel. Once the off-site characterization is completed and the appropriate information is obtained, the information is used to develop an initial draft of the site-specific HASP. (For more information on developing a HASP, refer to the fact sheet *Hazardous Waste Operations and Emergency Response: Uncontrolled Hazardous Waste Sites and RCRA Corrective Action*, OSWER Publication No. 9285.2-08FS, 1991.)

29 CFR 1910.120(c)(i) through (c)(viii) identifies the generic information that must be considered and evaluated before designated personnel enter a site. These requirements are listed in **Exhibit 2**, along with resources that can be useful for obtaining the required information. These information sources include general background documents (e.g., area maps), site records, interviews with persons who have knowledge about the site, and perimeter reconnaissance.

Interview/Records Research. Records of the site or interviews with persons who have knowledge of the site can provide useful information about the potential hazards at a site.

EXHIBIT 2
Information Required Prior to Site Entry
29 CFR 1910.120(c)(4)

Regulatory Requirements:	Sources of Information					
	General Background References	Records/Interviews		Perimeter Reconnaissance		Site Manager Assessment
		Site-Specific	Interviews	Visual	Sampling	
Location, Size of Site (c)(4)(i)	✓	✓		✓	✓	
Description of Job or Activity to be Performed (c)(4)(ii)						✓
Activity Duration (c)(4)(iii)						✓
Site Topography and Accessibility (c)(4)(iv)	✓	✓		✓	✓	
Safety and Health Hazards at Site (c)(4)(v)	✓	✓	✓	✓	✓	
Pathways for Hazardous Substance Dispersion (c)(4)(vi)		✓		✓	✓	
Status of Response Teams (c)(4)(vii)						✓
Hazardous Substances and Health Hazards (c)(4)(viii)	✓	✓	✓	✓	✓	

Examples of records that may be useful are found in **Exhibit 3**.

Perimeter Reconnaissance. In addition to the interview/records research, data-gathering at the site perimeter may help in identifying site hazards and determining the appropriate level of PPE for the initial site entry. Many of the activities that occur during perimeter reconnaissance, including making visual observations, monitoring atmospheric concentrations of airborne pollutants, and collecting soil samples, are similar to the activities that occur during the initial site entry. Perimeter reconnaissance activities, however, are generally not as extensive or specific as the activities undertaken during the on-site survey. To determine the scope and level of effort for the perimeter reconnaissance, the information from the interview/records research should be evaluated. Historical data on chemicals stored at the site, for example, may help to identify the appropriate air monitoring techniques for the perimeter reconnaissance.

Initial Site Entry and Data Collection

The goal of the on-site survey is to gather the additional information needed to identify the risks and hazards presented by the site, so that the work zones can be established and the appropriate controls, PPE, and medical monitoring program can be selected for the tasks that will be performed at the site. Risks that should be considered are specified in 29 CFR Part 1910.120 (c)(7) and are listed in **Exhibit 4**.

Immediately upon entering the site, entry personnel should monitor the air for immediately dangerous to life and health (IDLH) and other conditions that may cause death or serious harm (e.g., combustible or explosive atmospheres, oxygen deficiency, toxic substances) and monitor for ionizing radiation. In addition, entry personnel should visually observe for signs of actual or potential IDLH hazards or other dangerous conditions. **Exhibit 5** provides examples of visible indicators of potential IDLH hazards and other dangerous conditions.

EXHIBIT 3
Sources of Site-Specific Information

- Company records, receipts, logbooks, or ledgers that describe the activity that occurred at the site.
- Waste storage inventories and manifests or shipment papers.
- Records from state and federal pollution control regulatory and enforcement agencies, state Attorney General's Office, state occupational safety and health agencies, state Fire Marshal's office.
- Water and sewage district records.
- Previous survey, sampling, and monitoring results.
- Local fire and police department records.
- Site and aerial photos.
- Media reports (all information from the media should be verified).
- Interviews with personnel (all interview information should be verified).
- Interviews with nearby residents (note possible site-related medical problems and verify all information from interviews).
- Maps (e.g., USGS, land use, etc.).
- Meteorological data (e.g., wind direction, temperature profiles).

If IDLH hazards or other dangerous conditions are not present, or if proper precautions can be taken, the survey can continue. *At a minimum, the initial on-site survey should consist of a visual survey for potential hazards and air monitoring.*

Visual Survey. An accurate and comprehensive visual survey of the site will assist in identifying potential hazards and determining where additional information (e.g., air monitoring, sampling of soil or containers) may be needed.

EXHIBIT 4
Risks to Consider
29 CFR 1910.120 (c)(7)

Risks to consider include, but are not limited to:

- Exposure exceeding the permissible exposure limits (PELs) and published exposure levels.
- IDLH concentrations.
- Potential skin absorption and irritation.
- Potential eye irritation.
- Explosion sensitivity and flammability ranges.
- Oxygen deficiency.

EXHIBIT 5
Visible Indicators of Potential IDLH and Other Dangerous Conditions

- Large containers or tanks that must be entered.
- Enclosed spaces such as buildings or trenches that must be entered.
- Potentially explosive or flammable situations (indicated by bulging drums, effervescence, gas generation, or instrument readings)
- Extremely hazardous materials (such as cyanide, phosgene, or radiation sources).
- Visible vapor clouds.
- Areas where biological indicators (such as dead animals or vegetation) are located.

This visual survey should include the following activities:

- Noting the types of containers, impoundments, or other storage systems (e.g., paper or wood packages, barrels or drums, tanks, lagoons).
- Noting the condition of waste containers and storage systems (e.g., undamaged, rusted or corroded, leaking).
- Noting the types and quantities of material in containers (e.g., full or empty; labels indicating corrosive, explosive, flammable, radioactive, or toxic materials).
- Noting the physical condition of the materials (e.g., solid, liquid, or gas; conditions conducive to contact).
- Noting any unusual conditions (e.g., clouds, discolored liquids, oil slicks, discolored soil, free-standing liquid, stressed vegetation).
- Determining the potential pathways of exposure and dispersion (e.g., air, soil, surface water, ground water).
- Noting any indicators of potential exposure to hazardous substances (e.g., dead fish, animals, or vegetation; pools of liquids; foams or oils on liquid surfaces; deteriorating containers; discolored soils).
- Identifying natural wind barriers (e.g., buildings, hills, tanks).

The results of the visual survey may help to identify a potential location for the Support Zone, which can be confirmed through air monitoring and soil sampling.

Air Monitoring. The purpose of air monitoring is to identify and quantify airborne contaminants in order to determine the level of worker protection and identify additional medical monitoring needs in any given area of the site. Air monitoring should be used to confirm that the areas considered for the Support Zone do not contain concentrations of hazardous substances that require worker protection. The two methods that generally are available for identifying and/or quantifying airborne contaminants are (1) on-site use of direct-reading instruments and (2) laboratory analysis of air samples obtained by gas sampling bag, filter, sorbent, or wet-contaminant collection methods.

Direct-reading instruments may be used to rapidly detect flammable or explosive atmospheres, oxygen deficiency, certain gases and vapors, and ionizing radiation, as well as to identify changing site conditions. Because direct-reading instruments provide information at the time of sampling and allow for rapid decision-making, they are the primary tools of initial site characterization. All direct-reading instruments, however, have inherent constraints in their ability to detect hazards. Direct-reading instruments detect and/or measure only specific classes of chemicals and are usually not designed to detect airborne concentrations below 1 ppm. In addition, many of the direct-reading instruments that have been designed to detect one particular substance also detect other substances and, consequently, may give false readings. *Direct-reading instruments must be operated, and their data interpreted, by qualified individuals using properly calibrated instruments and relying on chemical response curves.* Additional monitoring should be conducted at any location where a positive instrument response occurs.

Exhibit 6 lists several direct-reading instruments and the conditions and/or substances they measure. Additional information concerning direct-reading instruments is available in the references.

Because direct-reading instruments are available for only a few specific substances and are rarely sensitive enough to detect low concentrations of hazardous substances that may nonetheless present health risks, air samples must also be collected and analyzed in a laboratory.

Exhibit 7 lists some sample collection and analytical methods that are appropriate for certain types of substances that are likely to be encountered at hazardous waste sites. Additional information concerning air sampling and monitoring is available in the references listed in Part 5 of this Fact Sheet.

Other Information. At some sites, air monitoring, the visual survey, and consideration of activities that will be occurring at the site will be

EXHIBIT 6
Some Direct-reading Air Monitoring Instruments

Instrument	Hazard Monitored
Combustible Gas Indicator (CGI)	Combustible gases and vapors
Flame Ionization Detector (FID) with Gas Chromotography Option	Many organic gases and vapors
Gamma Radiation Survey Instrument	Gamma radiation
Portable Infrared (IR) Spectrophotometer	Many gases and vapors
Ultraviolet (UV) Photoionization Detector (PID)	Many organic and some inorganic gases and vapors
Direct-reading Colorimetric Indicator Tube	Specific gases and vapors
Oxygen Meter	Oxygen (O_2)

adequate to determine the appropriate level of PPE, to establish additional medical monitoring needs, and to define work zones. For many sites, however, consideration of planned site activities may reveal the need for more extensive environmental sampling. Analysis of surface soil and soil borings may be required if site workers are expected to be exposed to surface and subsurface soil that may be contaminated. Ground water or surface water sampling may be necessary if site workers are likely to be exposed via these media.

To determine whether additional monitoring is required to designate work zones, the results of the air monitoring survey and visual characterization of site hazards and contaminants should be reviewed and potential pathways of contaminant dispersion should be evaluated. If there is any question that contaminants may have migrated into the area

EXHIBIT 7
Some Air Sampling Collection Methods

Substance	Collection Device
Anions: Bromide Chloride Fluoride Nitrate Phosphate Sulfate	Prewashed silica gel tube
Aliphatic or aromatic amines	Silica gel
Asbestos Metals Particulates	Mixed cellulose ester filter (MCEF)
High MW hydrocarbons Organophosphorus compounds Selected pesticides	Tenax/Chromosorb
Organics	Charcoal tube
PCBs	Glass fiber filter and florisil tube
Pesticides	13mm glass fiber filter/chromosorb 102 tube PUF/filter

considered for the Support Zone, both air and surface soil samples should be collected and compared with on-site and off-site background samples.

Soil sampling can be simple or complex, depending on site conditions. Sampling plan designs routinely fall into the following categories: judgmental random, stratified random, systematic, and search. Prior to beginning any sampling activities, it is imperative that the purpose of the effort and ultimate use of the acquired data be established. Strategies should be selected based on the information required. Certain target

contaminants may warrant special considerations. For example, when sampling for the extent of contamination of a dioxin site, tiered sampling and designed grid-laying approaches should be considered to achieve the 95 percent confidence level. Additional information concerning soil sampling is available in the references listed in Part 5 of this Fact Sheet.

PART 3: SITE CHARACTERIZATION -- SELECTION OF WORK ZONES

After the off-site and on-site data collection are complete, the collected information is used to establish work zones. In addition, the HASP is revised to address the specific on-site hazards.

Data Compilation

All of the information should be compiled in a format that facilitates a decision concerning the placement of work zones. A site map can provide a useful format for compiling the collected data. The locations of all the potential hazards that were identified through the interview/records research, the perimeter reconnaissance, and the initial on-site survey should be plotted on the map. The map should indicate both the hazards that were observed and any areas that interviews or records suggest may be contaminated with hazardous wastes. In addition, all sampling results from the on-site and off-site surveys should be plotted on the map. It is important to record locations where hazardous substances were detected and locations where hazardous substances were not detected. *The absence of sampling results should not be considered evidence that an area is clean.* Information concerning exposure pathways, particularly the predominant wind direction, also should be included on the map.

Data Evaluation

After all available site characterization data have been compiled, the data are used to select a location for the Support Zone. One of the most important criteria for selection of an area for the Support Zone is that it must be located in a clean area. The Support Zone should be in an area that is <u>known</u> to be free of elevated (i.e. higher than background) concentrations of hazardous substances. When evaluating on-site concentrations of hazardous substances, it is important to consider the background concentrations of these substances in the area. Non-zero background concentrations of hazardous substances may be present at some sites.

SUPPORT ZONE MUST BE CLEAN

Other Considerations

The size and position of the Support Zone also may be directly affected by the size of the exclusion and contamination reduction zones. For example, the Support Zone may be constrained by the distances needed to prevent an explosion or fire from affecting personnel outside the Exclusion Zone, or the physical area required for activities in the Exclusion Zone. In addition, the Support Zone should, whenever possible, be upwind from the Exclusion Zone. The Support Zone should be located as far from the Exclusion Zone as practicable. Whenever possible, line-of-sight contact with all activities in the Exclusion Zone should be maintained. Accessibility to support services (e.g., power lines, access roads, telephones, shelter, and water) also must be considered in selecting a Support Zone. The expected duration of the removal action also will affect the placement of work zones.

It is also conceivable that the Support Zone may inadvertently become contaminated after site remediation begins, despite everyone's best efforts. For example, changes in wind speed and direction, temperature, and rainfall may result in exposures different from those experienced during the initial on-site survey. The integrity of the Support Zone should be reconfirmed during remedial activities.

PART 4: ENSURING INTEGRITY OF WORK ZONES

Several procedures can be used to ensure that the area chosen for the Support Zone remains clean during removal or remedial operations. Use of site controls will minimize the transfer of contamination to the Support Zone. In addition, periodic monitoring of the Support Zone will indicate whether changes in site activities or conditions have resulted in contamination. In the event that contamination has occurred, the boundaries of work zones should be reevaluated.

Use of Site Controls

The CRZ is designed to reduce the probability that the clean Support Zone will become contaminated or affected by other site hazards. The distance between the Exclusion and Support Zones provided by the CRZ, together with decontamination of workers and equipment, limits the physical transfer of hazardous substances into clean areas. The boundary between the Support Zone and the CRZ, called the contamination control line, separates the Support Zone from an area of possible low contamination. Access to the CRZ from the Support Zone should be through two access control points, if feasible: one for personnel and one for equipment. Persons entering the CRZ should be required to wear PPE appropriate for the degree and types of hazards they may encounter when working in this area. To reenter the Support Zone from the CRZ, workers should remove gross contamination, doff any protective clothing, leave equipment in the CRZ, and exit through the personnel access control point.

Periodic Monitoring of Support Zone

A monitoring and sampling program for the Support Zone should be established to ensure that this area remains free from contamination. Monitoring should take place on a routine basis and whenever exposure is likely to change. Situations where additional monitoring may be appropriate are specified in 29 CFR 1910.120 (h)(3) and are listed in Exhibit 8. Increased concentrations of hazardous substances in air, soil, or other environmental media may indicate a breakdown in site control procedures or a change in on-site conditions. In addition, site personnel should be constantly alert to changes in site conditions or the presence of any potentially dangerous situations. Exhibit 9 lists the monitoring and sampling activities that may be conducted to ensure that the Support Zone remains clean.

Considering Additional Site Characterization Information

Additional information concerning locations of contaminated environmental media may become available during monitoring or in the later stages of site investigation and clean up, particularly for remedial actions. For example, more detailed soil sampling will occur during the site inspection (SI) and remedial investigation (RI). This additional information may indicate that areas initially considered clean are, in fact, contaminated. The location of the Support Zone should be reevaluated whenever new site characterization studies are conducted.

EXHIBIT 8
Conducting Additional Monitoring
29 CFR 1910.120 (h)(3)

Situations that require consideration of the possibility that exposures have risen are:

- 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).
- When employees are handling leaking drums or containers or working in areas with obvious liquid contamination (e.g., a spill or lagoon).

EXHIBIT 9
Periodic Support Zone Monitoring Activities

- Air monitoring using direct-reading instruments.
- Collecting air samples for particulate, gas, or vapor analysis.
- Analysis of soil samples from heavily trafficked areas.
- Occasional swipe tests in trailers and other areas used by personnel.

PART 5: CONSULTATION AND REFERENCES

For more information regarding work zones, the following references may be consulted.

Federal Regulations

- OSHA Regulations (particularly 29 CFR 1910 and 1926)
- EPA Regulation 40 CFR 311

Guidance Documents

The following publications explain site operating procedures and guidelines, including safety procedures for decontamination, considerations for establishing work zones, and sampling and monitoring programs:

- *EPA Standard Operating Safety Guides*; U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Environmental Response Team, OSWER Directive 9285.1-01C, 1988.
- *Field Standard Operating Procedures for Establishing Work Zones F.S.O.P. 6*; U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, OSWER Directive 9285.2-04, 1985.
- *Field Standard Operating Procedures for Air Surveillance F.S.O.P. 8*; U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, OSWER Directive 9285.2-03, 1985.
- *Environmental Response Team (ERT) Standard Operating Procedures, Soil Sampling SOP # 2012*, U.S. Environmental Protection Agency, Environmental Response Team, 1988.
- *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*; NIOSH/OSHA/USCG/EPA, DHHS (NIOSH) Publication Number 85-115, GPO No. 017-033-00419-6, 1985.

The following publication provides step-by-step guidance for assessing preliminary evaluations, health and safety plans, and off-site emergency response plans:

- *EPA Health and Safety Audit Guidelines*; U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Emergency Response Division, EPA-540/G-89/010, OSWER Directive 9285.8-02, 1989.

The following publications provide general information concerning the development of a specific health and safety program for workers at hazardous waste sites:

- *EPA Standard Operating Safety Guides*; U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Environmental Response Team, OSWER Directive 9285.1-01C, 1988.
- *Field Standard Operating Procedures for Site Safety Plan F.S.O.P. 9*; U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, OSWER Directive 9285.2-05, 1985.
- *Generic Site Safety Plan*; U.S. Environmental Protection Agency, OSWER Directive 9285.8-01.
- *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*; NIOSH/OSHA/USCG/EPA, DHHS (NIOSH) Publication Number 85-115, GPO No. 017-033-00419-6, 1985.

The following two volumes entitled *Characterization of Hazardous Waste Sites - A Methods Manual* address issues related to characterization of hazardous waste sites, from preliminary data gathering to sampling and analysis:

- *Volume I - Site Investigations*; U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring Systems Laboratory, Las Vegas, NV, EPA-600/4-84/075, 1985.
- *Volume II - Available Sampling Methods, Second Edition*; U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring Systems Laboratory, Las Vegas, NV, EPA-600/4-84/076, 1984.

The following publication provides information on sampling design and associated statistical methods for determining contaminant concentrations:

- *Methods for Evaluating the Attainment of Cleanup Standards, Volume I: Soil and Solid Media*; U.S. Environmental Protection Agency, Office of Policy, Planning, and Evaluation, EPA-230/02-89-042, 1989.

The following publication provides guidance for using portable instruments for assessing airborne pollutants arising from hazardous waste:

- *Draft International Document on Guide to Portable Instruments for Assessing Airborne Pollutants Arising from Hazardous Wastes*; U.S. National Working Group (NWG-4 OIML) Pilot Secretariat PS-17: "Measurement of Pollution" Reporting Secretariat RS-5: "Measurement of Hazardous Waste Pollution." ISBN: 0-936712-75-9.

The following four volumes collectively entitled *Procedures for Conducting Air Pathway Analyses for Superfund Applications* address a variety of issues relevant to the air impacts at Superfund sites:

- *Volume I: Application of Air Pathway Analyses for Superfund Applications*; U.S. Environmental Protection Agency, EPA-450/1-89-001, 1989. NTIS PB90 113374/AS.

- *Volume II: Estimation of Baseline Air Emissions at Superfund Sites*; U.S. Environmental Protection Agency, EPA-450/1-89-002, 1989. NTIS PB89 180053/AS.

- *Volume III: Estimation of Air Emissions from Clean-up Activities at Superfund Sites*; U.S. Environmental Protection Agency, EPA-450/1-89-003, 1989. NTIS PB89 180061/AS.

- *Volume IV: Procedures for Dispersion Modelling and Air Monitoring for Superfund Air Pathway Analysis*; U.S. Environmental Protection Agency, EPA-450/1-89-004, 1989. NTIS PB90 113382/AS.

Fact Sheets

The following fact sheet provides a summary of the federal regulations at 29 CFR 1910.120 and 40 CFR 311, as they pertain to worker protection at uncontrolled hazardous waste sites:

- *Hazardous Waste Operations and Emergency Response: Uncontrolled Hazardous Waste Sites and RCRA Corrective Action*; U.S. Environmental Protection Agency, Environmental Response Team, OSWER Publication No. 9285.2-08FS, 1991.

The following fact sheet provides a list and description of computer software, fact sheets, guidance documents and ERT training programs that pertain to the worker protection standards:

- *Hazardous Waste Operations and Emergency Response: Available Guidance;* U.S. Environmental Protection Agency, Environmental Response Team, OSWER Publication No. 9285.2-10FS, 1991.

Contact Persons or Groups

Several contact persons or groups can provide additional information on the establishment of work zones at uncontrolled hazardous waste sites. These contacts include:

- U.S. EPA's Environmental Response Team
  2890 Woodbridge Avenue
  Building 18 (MS-101)
  Edison, NJ 08837-3679
  (908) 321-6740 or (FTS) 340-6740

- U.S. Department of Labor, OSHA
  Office of Health Compliance Assistance
  200 Constitution Avenue, NW
  Washington, D.C. 20210
  (202) 523-8036 or (FTS) 523-8036

In addition, addresses and telephone numbers for EPA and OSHA regional offices are listed in **Exhibit 10.**

EXHIBIT 10
Regional Addresses and Telephone Numbers

EPA Regional Offices

- EPA Region 1
  John F. Kennedy Federal Building
  Room 2203
  Boston, MA 02203
  (617) 565-3715 or (FTS) 835-3715

- EPA Region 2
  Jacob K. Javitz Federal Building
  26 Federal Plaza
  New York, NY 10278
  (212) 264-2657 or (FTS) 264-2657

- EPA Region 3
  841 Chestnut Building
  Philadelphia, PA 19107
  (215) 597-9800 or (FTS) 597-9800

- EPA Region 4
  345 Courtland Street, NE
  Atlanta, GA 30365
  (404) 347-4727 or (FTS) 257-4727

- EPA Region 5
  230 South Dearborn Street
  Chicago, IL 60604
  (312) 353-2000 or (FTS) 353-2000

- EPA Region 6
  1445 Ross Avenue, 9th Floor
  Dallas, TX 75202
  (214) 655-6444 or (FTS) 255-6444

- EPA Region 7
  726 Minnesota Avenue
  Kansas City, KS 66115
  (913) 551-7000 or (FTS) 276-7000

- EPA Region 8
  999 18th Street, Suite 500
  Denver, CO 80202-2405
  (303) 293-1603 or (FTS) 293-1603

- EPA Region 9
  215 Fremont Street
  San Francisco, CA 94105
  (415) 556-6322 or (FTS) 556-6322

- EPA Region 10
  1200 6th Avenue
  Seattle, WA 98101
  (206) 442-1200 or (FTS) 399-1200

OSHA Regional Offices

- OSHA Region 1
  133 Portland Street, 1st Floor
  Boston, MA 02114
  (617) 565-7164 or (FTS) 835-7164

- OSHA Region 2
  201 Varick Street, Room 670
  New York, NY 10014
  (212) 337-2325 or (FTS) 660-2378

- OSHA Region 3
  Gateway Building, Suite 2100
  3535 Market Street
  Philadelphia, PA 19104
  (215) 596-1201 or (FTS) 596-1201

- OSHA Region 4
  1375 Peachtree Street, NE, Suite 587
  Atlanta, GA 30367
  (404) 347-3573 or (FTS) 257-3573

- OSHA Region 5
  230 South Dearborn Street
  32nd Floor, Room 3244
  Chicago, IL 60604
  (312) 353-2220 or (FTS) 353-2220

- OSHA Region 6
  525 Griffin Street, Room 602
  Dallas, TX 75202
  (214) 767-4731 or (FTS) 729-4731

- OSHA Region 7
  911 Walnut Street
  Kansas City, MO 64106
  (816) 426-5861 or (FTS) 867-5861

- OSHA Region 8
  1951 Stout Street
  Denver, CO 80204
  (303) 844-3061 or (FTS) 564-3061

- OSHA Region 9
  71 Stevenson Street, Suite 415
  San Francisco, CA 94105
  (415) 744-6670 or (FTS) 484-6670

- OSHA Region 10
  1111 Third Avenue, Suite 715
  Seattle, WA 98101-3212
  (206) 442-5930 or (FTS) 399-5930

SECTION 3

QUICK REFERENCE FACT SHEETS

PART 3

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE: RCRA TSD AND EMERGENCY RESPONSE WITHOUT REGARD TO LOCATION

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response

Publication 9285.2-07FS
April 1991

EPA

Hazardous Waste Operations and Emergency Response:

RCRA TSD and Emergency Response Without Regard to Location

Office of Emergency and Remedial Response
Emergency Response Division MS-101

Quick Reference Fact Sheet

INTRODUCTION

Under the authority of section 126 of the Superfund Amendments and Reauthorization Act of 1986 (SARA), the U.S. Environmental Protection Agency (EPA) and the U.S. Occupational Safety and Health Administration (OSHA) promulgated *identical* health and safety standards to protect workers engaged in hazardous waste operations and emergency response. The OSHA regulations, codified at 29 CFR 1910.120, became effective on March 6, 1990 (54 FR 9294). Corrections to the OSHA regulations were published on April 13, 1990 (55 FR 14072). The EPA regulations, published originally on June 23, 1989 at 54 FR 26654, incorporate the OSHA standards by reference and are codified at 40 CFR 311.

Although the EPA and OSHA worker protection standards for hazardous waste operations and emergency response (HAZWOPER) contain identical substantive provisions, the regulations differ with respect to the scope of coverage. The OSHA standards apply directly to private employees and to federal employees through Executive Order 12196. OSHA has no authority to enforce regulations protecting state and local government employees. However, under section 18(b) of the OSH Act, a state may elect to develop and implement its own occupational safety and health program. This program must be at least as effective as the federal OSHA standards and must be reviewed and approved by OSHA prior to implementation of the plan. Through its review and approval authority, OSHA *requires states to extend occupational* safety and health protection to all state and local government employees, as well as to private employees, within the state's jurisdiction.

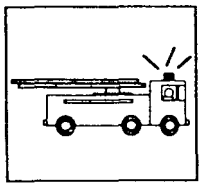
EPA's authority extends to state and local government employees conducting hazardous waste operations and emergency response in states that *do not have in effect a delegated OSHA program.* The EPA regulations also cover both compensated and uncompensated workers. Therefore, the EPA standards protect volunteers, such as fire fighters. Although federal OSHA recommends that states with delegated programs define "employee" to include both compensated and uncompensated workers, not all states have followed this recommendation.

Despite the fact that the EPA and OSHA regulations differ in their scope of coverage, both regulations apply to three primary groups of workers: (1) employees engaged in emergency response without regard to location; (2) employees engaged in routine hazardous waste operations at treatment, storage, and disposal (TSD) facilities regulated under the Resource Conservation and Recovery Act (RCRA); and (3) employees engaged in mandatory or voluntary clean-ups at uncontrolled hazardous waste sites, including corrective actions at RCRA TSD facilities. The standards, however, do not cover those employees who will not be exposed to, or who do not have the potential to be exposed to, hazardous substances.

The purpose of this Fact Sheet is to explain the principle requirements of the EPA and OSHA worker protection standards as they apply to employees who perform emergency response operations irrespective of location and employees who perform hazardous waste operations at RCRA TSD facilities. Requirements that apply at

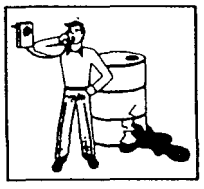
uncontrolled hazardous waste sites are addressed in a Fact Sheet entitled "Hazardous Waste Operations and Emergency Response: Uncontrolled Hazardous Waste Sites and RCRA Corrective Action" Publication No. 9285.2-08FS.

This Fact Sheet is divided into three parts. The first two parts describe the planning, training, and medical surveillance requirements as they apply to emergency response activities without regard to location and hazardous waste operations at RCRA TSD facilities. The final part of this Fact Sheet provides important addresses and telephone numbers.



PART 1: Requirements for Planning, Training, and Medical Surveillance for Emergency Response Without Regard to Location (29 CFR 1910.120(q))

This part of the Fact Sheet addresses the requirements in 29 CFR 1910.120(q) that apply to emergency responders who respond to hazardous waste emergencies wherever they may occur (i.e., without regard to location). Although there are eleven required elements specified at 29 CFR 1910.120(q) for protecting workers who perform emergency response operations without regard to location, this Fact Sheet addresses only the planning, training, and medical surveillance requirements. For a complete list of the requirements at 29 CFR 1910.120(q), refer to Exhibit 1.



Overview of Emergency Response

An "emergency response" is defined at 29 CFR 1910.120(a)(3) as a response effort by employees from outside the immediate release area or by other responders, such as local fire fighters, to an incident that results, or is likely to result, in an uncontrolled release of a hazardous substance. A response to an incidental release of a hazardous substance that can be absorbed, neutralized, or otherwise controlled by employees in the immediate area or by maintenance personnel is not considered an emergency response within the scope of the standard.

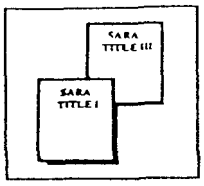
EXHIBIT 1
Emergency Response Operations Conducted without Regard to Location (29 CFR 1910.120(q))

- Emergency response plan
- Elements of an emergency response plan
- Procedures for handling emergency response
- Skilled support personnel
- Specialist employees
- Material handling program
- Training based on the duties and functions performed by each level of responder
- Refresher training program
- Medical surveillance and consultation
- Chemical protective equipment clothing
- Post-emergency response operations

The worker protection standards contain several requirements that apply to workers engaged in "emergency response." These requirements are specified at 29 CFR 1910.120(l) for emergency responders at uncontrolled hazardous waste sites; 29 CFR 1910.120(p)(8) for emergency responders at RCRA TSD facilities; and *29 CFR 1910.120(q)* for employees who perform emergency response operations irrespective of location.

The emergency response requirements at (p) and (l) apply to site workers who will respond to emergencies only at their specific work site; the emergency response requirements at 29 CFR 1910.120(q) are specifically designed to protect employees who respond to a variety of emergencies at different locations with various extenuating circumstances. This part of the Fact Sheet only addresses the requirements specified at (q). These requirements cover a variety of emergency response workers, including public and private HAZMAT teams, fire fighters, and police officers. Examples of emergency response operations that occur irrespective of location could include a fire at a gas station; a transportation accident, such as an overturned tractor trailer or a train derailment; or a chemical spill at a fixed facility, such as a

manufacturing plant or a pharmacy, where outside assistance is needed to cleanup the spill.



Planning Requirements

Under 29 CFR 1910.120(q)(1), employers must develop and implement an emergency response plan to handle anticipated emergencies prior to the commencement of emergency response operations. In developing this plan, the employer must take into account the variety of possible emergencies that could occur within the employer's jurisdiction. Exhibit 2 provides a comprehensive list of the elements that must be addressed in the emergency response plan. In addition to these elements, the emergency response plan must include the procedures for setting up an Incident Command System (ICS) and identify the chain of command that will be operative during an emergency. For example:

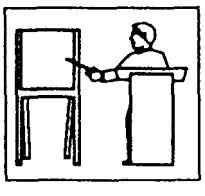
- The senior response official responding to an emergency will become the individual in charge of a site-specific ICS. All emergency responders and their communications must be coordinated and controlled through the individual in charge of the ICS. The emergency response plan should address the responsibilities of the individual in charge; these responsibilities are specified at 29 CFR 1910.120(q)(3).

- The Safety Official, designated by and accountable to the individual in charge of the ICS, must be knowledgeable in the operations being implemented at the incident site and be able to identify and evaluate hazards. The Safety Official also has authority to alter, suspend, or terminate activities at a site if it is determined that an immediately dangerous to life or health (IDLH) condition or imminent danger condition exists.

In addition to the planning requirements specified at 29 CFR 1910.120(q), there are a multitude of planning requirements specified under SARA Title III that address emergency response planning for a community. The goal of the Title III planning requirements is to protect the public in the event of an emergency involving an extremely hazardous substance. Emergency response organizations should incorporate the local emergency response plan or the state emergency response plan or both as part of their emergency response plan to avoid any unnecessary duplication of information. For additional information on the SARA Title III planing requirements, please contact the Title III Hotline at (800) 535-7672, or (202) 475-9652 in the Washington, D.C. metropolitan area.

EXHIBIT 2
Required Elements of an Emergency Response Plan (29 CFR 1910.120(q)(2) and (p)(8)(ii))

- Pre-emergency planning and coordination with outside parties.
- Personnel roles, lines of authority, and communication.
- Emergency recognition and prevention.
- Safe distances and places of refuge.
- Site security and control.
- Evacuation routes and procedures.
- Decontamination procedures.
- Emergency medical treatment and first aid.
- Emergency alerting and response procedures.
- Critique of response and follow-up.
- Personal protective equipment (PPE) and emergency equipment.



Training Requirements

The purpose of the training requirements for emergency response personnel is to give employees the knowledge and skill to perform an emergency response with minimal risk to their own health and safety and the health and safety of others. Employees who respond to emergencies may become exposed to a hazardous substance. The risks of exposure, however, will vary with each response. As such, the amount and type of training required under the worker protection standards for employees who perform emergency response operations is linked directly to an employee's potential for exposure to hazardous substances and to other health hazards during an

emergency response. *No employee may participate in an emergency response activity unless they have been adequately trained.*

The specific training requirements for employees who perform emergency response operations without regard to location are specified at 29 CFR 1910.120(q)(6). These training requirements are based on "Levels" that are generally recognized in the hazardous materials response industry. There are five Levels of emergency response personnel; each Level specifies unique training requirements. The following is an overview of the responsibilities of each Level of responder and a brief summary of the training requirements for that Level.

Level 1 Responders
(Awareness Level)
Must Have Sufficient Training
or Proven Experience
in Specific Competencies

Level 1. Level 1 Responders are most likely to witness or discover a hazardous substance release and to initiate an emergency response sequence by notifying the proper authorities. Police officers who do not actually respond to a release are good examples of a Level 1 Responder. For example, a State Trooper who responds to an overturned truck carrying hazardous materials on a highway, contacts the police dispatcher to report the location and the type of accident, and uses his patrol car to block lines of traffic, would be a Level 1 Responder, so long as he does not try to contain the release. The number of training hours that a Level 1 Responder must receive is not specified in the regulation. Level 1 Responders, however, must have sufficient training or experience to demonstrate competency in the following areas:

- Understanding hazardous substances and their risks;
- Understanding the implications of hazardous substance emergencies;
- Recognizing the presence of hazardous substances;
- Identifying hazardous substances;
- Understanding the first responder role; and
- Recognizing the need for additional resources.

Level 2 Responders
(Operations Level)
Must Have Level 1 Competency,
plus a Minimum of 8 Hours of Training
to Demonstrate Specific Competencies

Level 2. Level 2 Responders are part of the initial response to a release or potential release of hazardous substances. Local police officers, fire fighters, and rescue personnel, who try to contain the effects of a release without necessarily stopping it, are typical Level 2 Responders. Specifically, a Level 2 Responder may assist with evacuation proceedings, contain the release from a safe distance, and prevent further exposures. Level 2 Responders must have Level 1 competency and a minimum of 8 hours training or sufficient experience to demonstrate competency in the following areas:

- Understanding basic hazard and risk assessment techniques;
- Selecting and using PPE;
- Understanding basic hazardous materials terms;
- Performing basic control, containment, and/or confinement operations;
- Implementing basic decontamination procedures; and
- Understanding the relevant standard operating procedures and termination procedures.

Level 3 Responders
(HAZMAT Technicians)
Must Have a Minimum of 24 Hours
of Training at Level 2, plus
Sufficient Experience to Demonstrate
Specific Competencies

Level 3. Level 3 Responders are Hazmat Technicians responsible for attempting to stop the release, as compared to a Level 2 responder who attempts only to contain the release and contact the appropriate authorities. Level 3 Responders must have a minimum of 24 hours of training at Level 2, and sufficient experience to demonstrate competency in the following areas:

- Implementing the employer's emergency response plan;
- Classifying, identifying, and verifying known and unknown materials by using field survey instruments and equipment;
- Functioning within an assigned role in the Incident Command System;
- Selecting and using specialized chemical PPE;
- Understanding hazard and risk assessment techniques;
- Implementing advance control, containment, and/or confinement operations;
- Implementing decontamination procedures;
- Understanding termination procedures; and
- Understanding basic chemical and toxicological terminology and behavior.

Level 4 Responders
(HAZMAT Specialists)
Must Have a Minimum of 24 Hours
of Training at Level 3, plus
Sufficient Experience to Demonstrate
Specific Competencies

Level 4. Level 4 Responders are Hazmat Specialists. They respond with and provide support to the Hazardous Materials Technicians (Level 3). Level 4 Responders are expected to be more knowledgeable about hazardous substances than are Level 3 Responders. Hazmat Specialists will sometimes act as liaisons with government authorities, explaining site activities and associated risks. Level 4 Responders must have a minimum of 24 hours of training at Level 3, and sufficient experience to demonstrate competency in the following areas:

- Implementing the local emergency response plan;
- Classifying, identifying, and verifying known and unknown materials;
- Having knowledge of the state emergency response plan;
- Selecting and using specialized chemical PPE;
- Understanding in-depth hazard and risk techniques;
- Performing specialized control, containment, and/or confinement operations;
- Determining and implementing decontamination procedures;
- Developing a site safety and control plan; and
- Understanding chemical, radiological, and toxicological terminology and behavior.

Level 5 Responders
(On-Scene Incident Commanders)
Must Have a Minimum of 24 Hours
of Training at Level 2, plus
Sufficient Experience to Demonstrate
Specific Competencies

Level 5. The Level 5 Responder is the On-Scene Incident Commander or Senior OIC. The Senior OIC assumes control of the emergency response incident scene. Senior OICs coordinate the activities of all emergency responders and ensure that open lines of communications exist between them. The OIC is usually a generalist with broad knowledge in managing emergency incidents. Level 5 Responders must have a minimum of 24 hours of training at Level 2, and additional competency in the following areas:

- Implementing the Incident Command System;

- Implementing the employer's emergency response plan;
- Implementing the local emergency response plan;
- Having knowledge of the state emergency response plan and the Federal Regional Response Team;
- Understanding the hazards and risks associated with chemical protective clothing; and
- Understanding the importance of decontamination procedures.

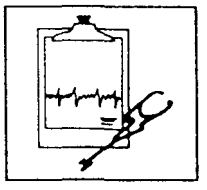
In addition to the aforementioned training requirements, each emergency responder must receive either annual refresher training, or must demonstrate sufficient competency in the relevant areas on a yearly basis. With respect to refresher training, there are no specific hourly requirements, however, it should be of sufficient content and duration to enable responders to maintain their competencies. If an employee does not submit to refresher training but is able to demonstrate competency to the employer in the relevant areas, the employer must document on a yearly basis the statement of competency and maintain a record of the method used to determine competency.

There are two types of workers who may be needed during an emergency response, but are not covered by the training requirements in 29 CFR 1910.120(q)(6). These employees include skilled support personnel and specialist employees. Skilled support personnel are trained in the operation of specialized mechanical equipment such as crane and hoisting equipment or a backhoe, and generally are not employed by the same organization as the other emergency response personnel at the incident scene. Such skilled personnel would be used in special situations to assist with an emergency. Although they may be exposed to hazards during an emergency response, they are only at the scene temporarily to perform immediate emergency support work that cannot reasonably be performed by fully trained hazardous response personnel.

The only training required for such skilled personnel is that they receive an initial briefing of the site, which must include instruction on the proper use of PPE, a review of the potential hazards at the site, an overview of the duties to be performed, and an overview of other safety and health precautions. Such personnel must be briefed at the site prior to their participation in any emergency response operations.

In addition to skilled support personnel, an employer may call upon specialist employees to assist in an emergency response effort. Specialist employees have specialized knowledge about some aspect of emergency response or hazardous substances. These individuals are called upon on an as needed basis to provide technical advice or assistance to the individual in charge at an incident where there has been a release of a hazardous substance. For example, if an emergency release involves two or more hazardous substances, a chemist may be called in to predict the potential reactivity of the agents involved at the scene.

Although there is no statutory limitation on a specialist employee's functions, they must receive proper training prior to performing any operations. Specifically, specialist employees must receive training commensurate with their area of specialization on an annual basis. There are, however, no hourly training requirements specified under the worker protection standards for specialist employees.



Medical Surveillance Requirements

Employers whose employees engage in emergency response operations without regard to location must develop and implement a medical surveillance program that includes provisions for baseline, periodic, and termination medical examinations.

As specified in 29 CFR 1910.120(q)(9), a medical surveillance program must be provided for the following three groups of employees:

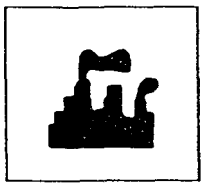
- Hazardous Materials Specialists;
- Members of an organized and designated HAZMAT Team; and
- Employees who exhibit signs or symptoms that may have resulted from exposure to hazardous substances during the course of an emergency incident, either immediately or subsequently.

Employers are not required to provide a formal medical monitoring program for first responders at the awareness and operations levels (i.e., Levels 1 and 2) and Level 3 Responders who are not members of designated HAZMAT teams. These employees, however, must be provided with medical examinations if they are injured due to overexposure during an emergency incident. Furthermore, because coverage under 29 CFR 1910.120(f)(2) does not apply to emergency responders without regard to location, fire fighters who wear respirators for 30 days or more per year are only required to undergo medical surveillance if they are members of designated HAZMAT Teams or are injured due to overexposure to hazardous substances during an emergency incident.

If employees fall within the first two groups listed above, they must undergo a baseline medical examination prior to an assignment. After this initial examination, employees must have a follow-up medical examination once a year; an attending physician may suggest a shorter or longer interval, but this period may not exceed two years. The content of these examinations is to be determined by the attending physician, but certain key elements must be included. For example, the physician must complete a medical and work history and determine the employee's fitness for the type of duties to be assigned, including the ability of the employee to wear PPE.

In addition to these requirements, an employee must receive a medical examination as soon as possible if the employee is injured or becomes ill from exposure to hazardous substances during an emergency, or the employee develops signs or symptoms that indicate a possible overexposure to hazardous substances. In addition, employees must receive a final examination when they are reassigned or terminate employment and thus no longer are exposed to hazardous substances. This examination is only required if the employee has not had an examination within the past six months. All required medical examinations must be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

Medical records for employees must be maintained for a period of thirty years following termination of employment. These records must include the name and social security number of the employee; the physician's written opinions, including recommended occupational limitations and results of examinations and tests; any employee medical complaints related to exposure to hazardous substances; and a copy of the information provided to the examining physician by the employer. The employer is responsible for retaining the records if the employee or physician leaves the area. For additional information on medical recordkeeping requirements, refer to 29 CFR 1910.20.

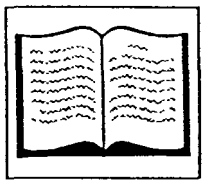


PART 2: Requirements for Planning, Training, and Medical Surveillance at RCRA TSD Facilities (29 CFR 1910.120(p))

This part of the Fact Sheet explains the applicability of 29 CFR 1910.120(p) and describes several of the requirements specified in the OSHA standards for personnel involved in hazardous waste operations and emergency response activities at RCRA TSD facilities. Although there are eight required elements specified at 29 CFR 1910.120(p) for protecting workers who perform hazardous waste operations and emergency response at RCRA TSD facilities, this Fact Sheet addresses only the planning, training, and medical surveillance requirements. For a complete list of the requirements at 29 CFR 1910.120(p), refer to Exhibit 3.

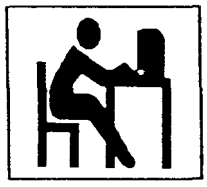
EXHIBIT 3
Operations Conducted Under the RCRA Act of 1976 (29 CFR 1910.120(p))

- Safety and health program
- Hazard communication program
- Medical surveillance program
- Decontamination program
- New technology program
- Material handling program
- Training program
- Emergency response program



Applicability of 29 CFR 1910.120(p)

The requirements under the worker protection standards for personnel engaged in hazardous waste operations and emergency response at a RCRA TSD facility are specified at 29 CFR 1910.120(p). These requirements apply to any TSD facility regulated under 40 CFR 264 and 265, or by a state program authorized under RCRA; the requirements apply to both permitted and interim status facilities. Facilities that have been granted exemptions from the RCRA TSD requirements (as detailed at 40 CFR 264 and 265), however, are exempt from the worker protection requirements, except those at 29 CFR 1910.120(p)(8) which detail the requirements for an emergency response plan, emergency response training, and other procedures for handling emergencies.



Planning Requirements

Employers at RCRA TSD facilities must develop and implement a written safety and health program for their employees engaged in hazardous waste operations. The program must be designed to identify, evaluate, and control safety and health hazards at the facility, and provide for emergency response during hazardous waste operations at the TSD facility. In addition, the program must address appropriate site analysis, engineering controls, maximum exposure limits, hazardous waste handling procedures, and uses of new technologies. One important component of the safety and health program is the emergency response plan. This plan must be developed and implemented as a separate part of the safety and health program.

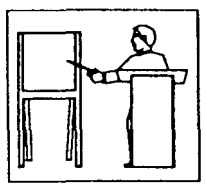
The emergency response plan must be developed prior to the commencement of operations at the facility. This plan must include a description of how an emergency would be handled at the facility and how the risks associated with a response would be minimized. The elements required in an emergency response plan for a RCRA TSD facility are identical to the requirements shown in Exhibit 2; the RCRA requirements are codified at 29 CFR 1910.120(p)(8)(ii).

In addition to the requirements outlined in Exhibit 2, the emergency response plan must include information on site topography, layout, and prevailing weather conditions, and procedures for reporting incidents to local, state, and federal agencies. The emergency response plan should also be rehearsed regularly and reviewed periodically to ensure that it accounts for new or changing site conditions or new information on potential hazards at the site.

When preparing an emergency response plan, employer's need not duplicate any of the subjects that are addressed fully in the contingency plan required under RCRA regulations, provided that the contingency plan is incorporated into the emergency response plan. Employer's may also incorporate local emergency response plans or state emergency response plans, or both, into the emergency response plan, if appropriate.

In lieu of preparing an emergency response plan under 29 CFR 1910.120(p)(8), employers may prepare an emergency action plan in accordance with 29 CFR 1910.38(a). This plan may only be developed in lieu of the emergency response plan if employers plan to evacuate their employees from the facility when an emergency occurs, and not permit employees to assist in responding to the emergency.

In addition to developing an emergency response plan, employers must also address the following items in their safety and health plan, as appropriate: the selection of engineering controls, hazardous waste handling procedures, and uses of new technologies.



Training Requirements

An employer must develop and implement a training program as part of the safety and health program, for employees engaged in hazardous waste operations at RCRA TSD facilities. The worker protection standards reflect a tiered approach to training; the amount and type of training is linked directly to an employee's potential for exposure to hazardous substances and to other hazards during a hazardous waste operation. *The standards require that only those employees that have been appropriately trained may perform hazardous waste operations or emergency response at a facility.* A summary of the training requirements for workers

engaged in hazardous waste operations at RCRA TSD facilities is provided below. An overview of the basic hourly training requirements is also provided in Exhibit 4.

THE RULE IS:
IF YOU ARE NOT TRAINED,
YOU CANNOT PARTICIPATE

EXHIBIT 4
Training Requirements for Employees at RCRA TSD Facilities
(29 CFR 1910.120(p)(7) and p(8)(iii))

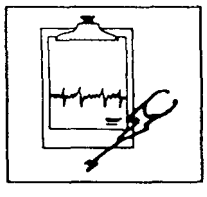
General Site Employees	24 Hours or Equivalent and 8 hours of annual refresher training
Emergency Response Personnel	Trained to a Level of Competency -- no specific hourly requirements

The training requirements specified at 29 CFR 1910.120(p)(7)(i) for all *new* employees engaged in hazardous waste operations at RCRA TSD facilities include a minimum of 24 hours of initial training. The purpose of this training is to prepare employees to "perform their duties and functions in a safe and healthful manner so as not to endanger other employees." The regulation does not specify what topics and issues should be covered during training.

The initial training requirements can be waived for current employees, if it is determined that their prior work experience or training is equivalent to the initial training requirements in the standard. Equivalent training includes the training an employee may have already received from actual site work experience.

In addition to the initial training requirements, all new and current employees subject to the worker protection standards, including managers and supervisors, must receive a minimum of eight hours of refresher training annually. The purpose of refresher training is to ensure that employees maintain certain competencies. There are several ways to satisfy the annual refresher training requirement, such as attending applicable seminars or participating in a critique of an actual response.

The training requirements for employees who engage in *emergency response operations* at a RCRA TSD facility differ from the initial training requirements specified above; there are no specified hourly requirements for either training or refresher training for emergency responders at RCRA TSD facilities. The training requirements for emergency personnel are specified at 29 CFR 1910.120(p)(8)(iii) and require employees who participate in emergency response activities to be familiar with the elements of the emergency response plan, standard operating procedures established for the response, and appropriate PPE. Employees must also be trained to a level of competence in the recognition of various health and safety hazards at the facility. Specifically, training should include information on the safe use of control equipment and the proper techniques of coordination among parties involved in the incident.



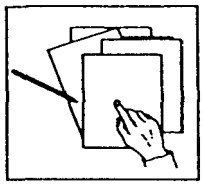
Medical Surveillance Requirements

Employers at RCRA TSD facilities must provide a medical monitoring program for the following four groups of employees:

- Employees who wear a respirator for more than 30 days a year;
- Hazardous Materials Specialists;
- Members of an organized and designated HAZMAT Team; and
- Employees who exhibit signs or symptoms that may have resulted from exposure to hazardous substances during the course of an emergency incident, either immediately or subsequently.

The medical surveillance requirements for these four groups of employees are identical to those requirements outlined earlier in this Fact Sheet for emergency responders without regard to location

(pages 6 and 7). The requirements for medical examinations and recordkeeping for employees at RCRA TSD facilities are specified at 29 CFR 1910.120(p)(3).



PART 3: Sources of Additional Information

The following is a brief summary of where to obtain additional information on the EPA and OSHA worker protection standards on hazardous waste operations and emergency response. Please refer to Exhibit 5 for the appropriate addresses and telephone numbers of the contacts referenced below.

- If you have questions regarding the existing relationship between EPA and OSHA with respect to the implementation of the standards, contact the Environmental Response Team (ERT) in Edison, NJ.

- For information about EPA's training courses, contact ERT's Operations Section in Cincinnati, OH.

- For information on guidance on the substance of 29 CFR 1910.120, contact the appropriate OSHA Regional Office. If additional information is needed, contact OSHA's Office of Health Compliance Assistance in Washington, D.C.

- For information on how to establish a Hazmat Team, refer to the *Hazmat Team Planning Guidance* Document (U.S. EPA, 1990, Pub. No. EPA/540/G-90/003). This Document identifies equipment that may be necessary for an emergency response and suggests ways to acquire and maintain such equipment. In addition, the Document offers guidance in determining actual HAZMAT response requirements.

  To obtain a copy of the *Hazmat Team Planning Guidance* Document, please call the National Technical Information Service at (703) 487-4600. When requesting the Document, be certain to specify the publication number.

- There are four other Fact Sheets that are available on the worker protection standards for hazardous waste operations and emergency response:

  -- *Hazardous Waste Operations and Emergency Response: General Information and Comparison* (Pub. No. 9285.2-09FS) explains the scope of the worker protection standards and distinguishes these standards from regulations and consensus standards covering the same or similar subject matter.

  -- *Hazardous Waste Operations and Emergency Response: Uncontrolled Hazardous Waste Sites and RCRA Corrective Action* (Pub. No. 9285.2-08FS) explains the specific requirements for operations conducted at uncontrolled hazardous waste sites, including corrective actions at RCRA TSD facilities.

  -- *Establishing Work Zones at Uncontrolled Hazardous Waste Sites* (Pub. No. 9285.2-06FS) describes the requirements and procedures for establishing support zones at uncontrolled hazardous waste sites.

  -- *Hazardous Waste Operations and Emergency Response: Available Guidance* (Pub. No. 9285.2-10FS) describes guidance materials developed by the Environmental Response Team to help workers engaged in hazardous waste operations and emergency response understand the HAZWOPER requirements.

Copies of these Fact Sheets may be obtained by calling or writing ERT in Edison, NJ. (Refer to Exhibit 5 for the appropriate address and telephone number.) Please specify the title and publication number of the Fact Sheet(s).

EXHIBIT 5
Important Telephone Numbers and Addresses

- U.S. EPA/ERT
  2890 Woodbridge Avenue
  Building 18 (MS-101)
  Edison, NJ 08837-3679
  (908) 321-6740 or (FTS) 340-6740

- U.S. EPA/ERT
  Operations Section
  26 West Martin Luther King
  Cincinnati, OH 45268
  (513) 569-7537 or (FTS) 684-7537

- U.S. Department of Labor, OSHA
  Office of Health Compliance Assistance
  200 Constitution Avenue, NW
  Washington, D.C. 20210
  (202) 523-8036 or (FTS) 523-8036

OSHA Regional Offices

- U.S. Department of Labor, OSHA
  Region 1
  133 Portland Street, 1st Floor
  Boston, MA 02114
  (617) 565-7164 or (FTS) 835-7164

- U.S. Department of Labor, OSHA
  Region 2
  201 Varick Street, Room 670
  New York, NY 10014
  (212) 337-2325 or (FTS) 660-2378

- U.S. Department of Labor, OSHA
  Region 3
  Gateway Building, Suite 2100
  3535 Market Street
  Philadelphia, PA 19104
  (215) 596-1201 or (FTS) 596-1201

- U.S. Department of Labor, OSHA
  Region 4
  1375 Peachtree Street, NE, Suite 587
  Atlanta, GA 30367
  (404) 347-3573 or (FTS) 257-3573

- U.S. Department of Labor, OSHA
  Region 5
  230 South Dearborn Street
  32nd Floor, Room 3244
  Chicago, IL 60604
  (312) 353-2220 or (FTS) 353-2220

- U.S. Department of Labor, OSHA
  Region 6
  525 Griffin Street, Room 602
  Dallas, TX 75202
  (214) 767-4731 or (FTS) 729-4731

- U.S. Department of Labor, OSHA
  Region 7
  911 Walnut Street
  Kansas City, MO 64106
  (816) 426-5861 or (FTS) 867-5861

- U.S. Department of Labor, OSHA
  Region 8
  1951 Stout Street
  Denver, CO 80204
  (303) 844-3061 or (FTS) 564-3061

- U.S. Department of Labor, OSHA
  Region 9
  71 Stevenson Street, Suite 415
  San Francisco, CA 94105
  (415) 744-6670 or (FTS) 484-6670

- U.S. Department of Labor, OSHA
  Region 10
  1111 Third Avenue, Suite 715
  Seattle, WA 98101-3212
  (206) 442-5930 or (FTS) 399-5930

EPA Regional Offices

- U.S. Environmental Protection Agency
  Region 1
  John F. Kennedy Federal Building
  Room 2203
  Boston, MA 02203
  (617) 565-3715 or (FTS) 835-3715

EXHIBIT 5 (continued)
Important Telephone Numbers and Addresses

EPA Regional Offices (continued)

- U.S. Environmental Protection Agency
  Region 2
  Jacob K. Javitz Federal Building
  26 Federal Plaza
  New York, NY 10278
  (212) 264-2657 or (FTS) 264-2657

- U.S. Environmental Protection Agency
  Region 3
  841 Chestnut Building
  Philadelphia, PA 19107
  (215) 597-9800 or (FTS) 597-9800

- U.S. Environmental Protection Agency
  Region 4
  345 Courtland Street, NE
  Atlanta, GA 30365
  (404) 347-4727 or (FTS) 257-4727

- U.S. Environmental Protection Agency
  Region 5
  230 South Dearborn Street
  Chicago, IL 60604
  (312) 353-2000 or (FTS) 353-2000

- U.S. Environmental Protection Agency
  Region 6
  1445 Ross Avenue, 9th Floor
  Dallas, TX 75202
  (214) 655-6444 or (FTS) 255-6444

- U.S. Environmental Protection Agency
  Region 7
  726 Minnesota Avenue
  Kansas City, KS 66115
  (913) 551-7000 or (FTS) 276-7000

- U.S. Environmental Protection Agency
  Region 8
  999 18th Street, Suite 500
  Denver, CO 80202-2405
  (303) 293-1603 or (FTS) 293-1603

- U.S. Environmental Protection Agency
  Region 9
  215 Fremont Street
  San Francisco, CA 94105
  (415) 556-6322 or (FTS) 556-6322

- U.S. Environmental Protection Agency
  Region 10
  1200 6th Avenue
  Seattle, WA 98101
  (206) 442-1200 or (FTS) 399-1200

- Call the Emergency Planning and Community Right-to-Know Information Hotline for the addresses and telephone numbers of state emergency response commissions and local emergency planning committees in your area. The telephone numbers for the Hotline are: toll-free 800-535-7672, or 202-475-9652 in the Washington, D.C. area.

SECTION 3

QUICK REFERENCE FACT SHEETS

PART 4

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE: UNCONTROLLED HAZARDOUS WASTE SITES AND RCRA CORRECTIVE ACTIONS

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response

Publication 9285 2-08FS
April 1991

EPA

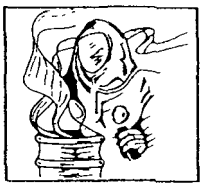
Hazardous Waste Operations and Emergency Response:

Uncontrolled Hazardous Waste Sites and RCRA Corrective Actions

Office of Emergency and Remedial Response
Emergency Response Division MS-101

Quick Reference Fact Sheet

INTRODUCTION



Under the authority of section 126 of the Superfund Amendments and Reauthorization Act of 1986 (SARA), the U.S. Environmental Protection Agency (EPA) and the U.S. Occupational Safety and Health Administration (OSHA) promulgated *identical* health and safety standards to protect workers engaged in hazardous waste operations and emergency response. The OSHA regulations, codified at 29 CFR 1910.120, became effective on March 6, 1990 (54 FR 9294). Corrections to the OSHA regulations were published on April 13, 1990 (55 FR 14072). The EPA regulations, published on June 23, 1989 at 54 FR 26654, incorporate the OSHA standards by reference and are codified at 40 CFR 311.

The EPA and OSHA worker protection standards for hazardous waste operations and emergency response (HAZWOPER) apply to three primary groups of workers: (1) employees engaged in voluntary and mandatory clean-ups at uncontrolled hazardous waste sites, including corrective actions at treatment, storage, and disposal (TSD) facilities regulated under the Resource Conservation and Recovery Act (RCRA); (2) employees engaged in routine hazardous waste operations at RCRA TSD facilities; and (3) employees engaged in emergency response operations without regard to location.

The purpose of this Fact Sheet is to explain the principle requirements of the EPA and OSHA worker protection standards as they apply to employees engaged in hazardous waste operations at uncontrolled hazardous waste sites, including employees who perform corrective actions at RCRA TSD facilities. The other two groups of employees affected by the regulations are addressed in a separate Fact Sheet entitled *Hazardous Waste Operations and Emergency Response: RCRA TSD and Emergency Response Without Regard to Location* (Publication No. 9285.2-07FS). The requirements that apply to individuals engaged in hazardous waste operations at RCRA TSD facilities and emergency responders who respond to emergencies without regard to location are specified at 29 CFR 1910.120(p) and (q), respectively.

The HAZWOPER requirements for workers who engage in hazardous waste operations and emergency response at uncontrolled hazardous waste sites are specified at 29 CFR 1910.120(a) through (o), and are summarized in Exhibit 1, these requirements also apply to those workers who perform corrective actions at RCRA TSD facilities. These requirements apply to any employee working at an uncontrolled hazardous waste site who has the potential to be exposed to hazardous substances. As such, the On-Scene Coordinator (OSC) and the Remedial Project Manager (RPM) are both covered by the standards and must fully implement the standards for other employees engaged in hazardous waste site clean-ups. These provisions also apply to any activities performed during the preliminary planning and evaluation stages of the remedial investigation and feasibility study (RI/FS), such as the preliminary assessment and site investigation (PA/SI)

In sum, all stages of a removal and remedial operation performed at a site in which there is a potential for exposure to hazardous substances must be conducted in accordance with the worker protection standards specified at 29 CFR

EXHIBIT 1
Hazardous Waste Operations and Emergency Response at Uncontrolled Hazardous Waste Sites
(29 CFR 1910.120(a)-(o))

(a) Scope, application, and definitions

(b) Safety and health program

(c) Site characterization and analysis

(d) Site control

(e) Training.

(f) Medical surveillance

(g) Engineering controls, work practices, and personal protective equipment for employee protection.

(h) Monitoring

(i) Informational programs

(j) Handling drums and containers.

(k) Decontamination.

(l) Emergency response by employees at uncontrolled hazardous waste sites.

(m) Illumination.

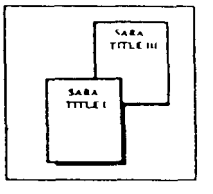
(n) Sanitation at temporary workplaces.

(o) New technology programs

1910.120(a) through (o). The standards, however, do not apply to employees who do not have the potential to be exposed to hazardous substances. For example, administrative support personnel in the Incident Command Post may not be covered by HAZWOPER. These employees, however, must be made aware of the provisions of the emergency response plan. Specifically, they must be briefed on the procedures to take during an emergency at the site, and they must be familiar with general site operations, such as the location of work zones. Employees not covered by HAZWOPER are, of course, protected by other OSHA standards including the Hazard Communication Standard (HAZCOM).

In addition to the requirements specified at 29 CFR 1910.120(a) through (o), other worker protection requirements may also apply at uncontrolled hazardous waste sites. For example, 29 CFR 1910.120(q) applies to workers, such as local HAZMAT team members, who come on-site specifically to perform emergency response operations. The requirements specified at (q), however, do not apply to regular site employees who perform routine clean-up operations at the site and who may also perform emergency response operations; these individuals are covered by the requirements in 29 CFR 1910.120(e)

This Fact Sheet is divided into six parts. The first three parts describe the planning, training, and medical surveillance requirements for workers engaged in hazardous waste operations and emergency response at uncontrolled hazardous waste sites. The fourth part of this Fact Sheet discusses other requirements of HAZWOPER that must be implemented at uncontrolled hazardous waste sites. The fifth part of this Fact Sheet discusses employee rights under section 8 of the Occupational Safety and Health Act of 1970, as amended (OSH Act). The final part of this Fact Sheet provides important addresses and telephone numbers.



PART 1: PLANNING REQUIREMENTS

Part 1 of this Fact Sheet explains the purpose of the comprehensive safety and health program and the site-specific health and safety plan (HASP); describes the specific steps that must be taken to develop a HASP; explains the type of information that must be included in the HASP; and summarizes the responsibilities of the OSC, RPM, and the Environmental Response Team (ERT) in developing a HASP at an EPA-lead site.

There are many different types of entities, including state agencies, private corporations, and the federal government, that may have lead responsibility in cleaning up an uncontrolled hazardous waste site or a contaminated RCRA TSD facility. Each of these entities uses different titles to identify the person who has overall responsibility for site activities. For purposes of this Fact Sheet, this responsible person is referred to as the OSC/RPM, as it is at EPA-lead sites.

Safety and Health Program

Any employer whose workers engage in hazardous waste operations and emergency response at an uncontrolled hazardous waste site or who perform corrective actions at a RCRA TSD facility must develop and implement a written safety and health program. This program must be designed to identify, evaluate, and control safety and health hazards at any site, and to provide for emergency response during site operations. The written safety and health program must include an organizational structure; a site-specific health and safety plan (HASP); a comprehensive workplan; a medical surveillance program; and a description of the employer's standard operating procedures. For a complete list of the elements required in the written safety and health program, refer to 29 CFR 1910.120(b)(1)(ii).

The primary purpose of the safety and health program is to serve as the organization's comprehensive health and safety policy that applies to all employees of the company, irrespective of the location of the actual site where they are working. This program must be maintained by the employer and made available to any employee or employee representative; contractor, subcontractor, or other representative working for the employer who will be potentially exposed to hazardous substances; OSHA personnel; and personnel of federal, state, and local agencies with regulatory authority over the site. It is important to note that only one safety and health program should be developed by an employer, even if the employer has workers that perform operations at several different sites.

If an employer has already developed a safety and health program to meet the requirements of other federal, state, and local regulations, the employer may use the existing program to satisfy the HAZWOPER requirements, so long as any additional information not covered in the existing program but required under HAZWOPER is incorporated into the program.

Site-Specific HASP

Although the standards require employers to develop and implement only one safety and health program, a site-specific HASP must be developed and implemented for each site where workers are potentially exposed to hazardous substances.

The purpose of the site-specific HASP is to address the safety and health hazards that may exist at each phase of site operations and to identify procedures for protecting employees. Exhibit 2 presents a comprehensive list of the elements that must be included in the HASP.

Information gained during the site characterization, as specified at 29 CFR 1910.120(c), must be considered in developing the HASP. The site characterization may be divided into three stages: preliminary evaluation (PE), initial site entry, and ongoing monitoring. Under the requirements of 29 CFR 1910.120(b)(4), the HASP must be developed after the PE has been performed and before any site entry. The following is a brief discussion of the specific steps that must be taken to develop, implement, and maintain a HASP.

Step 1: Preliminary Evaluation

The first step in developing a HASP is to perform a preliminary evaluation (PE) of the site's characteristics. *The PE must be accomplished off-site, so as not to endanger the health and safety of site workers.* The purpose of the PE is to obtain preliminary information to help identify the specific hazards at the site and determine the appropriate safety and health control procedures (e.g., engineering controls, personal protective equipment (PPE), and any additional medical surveillance needs) that are necessary to ensure the protection of employees who perform tasks on-site The specific information that must be obtained during the PE is summarized below and outlined in Exhibit 3. The information obtained during the PE should be used to develop the HASP

There are several ways in which the information specified in Exhibit 3 can be obtained. For example, records of the site or interviews with persons who are knowledgeable about the site can provide useful information about the potential hazards at a site. Potentially useful sources of information include: company records, receipts, logbooks, or ledgers that describe site activities, records from state and federal pollution control regulatory and enforcement agencies and state occupational and health offices; local fire and police department records; site photos, and media reports.

In addition to interviewing knowledgeable persons and researching the history of the site,

EXHIBIT 2
The Specific Components
of a HASP

- Key personnel.
- Safety and health risk or hazards analysis for each site task and operation found in the workplan.
- Employee training assignments to assure that each employee receives the training required before they engage in any operation that could potentially lead to exposure to a hazardous substance or to safety or health hazards
- Personal protective equipment appropriate for each site task or operation conducted
- Medical surveillance requirements
- Employee and air monitoring equipment and environmental sampling techniques and instrumentation to be used.
- Site control measures that include at a minimum - a site map, a buddy system, site communications system (including emergency alerting), standard operating procedures or safe work practices, and identification of the nearest medical assistance.
- Decontamination procedures both for individuals and equipment on site and in places where there is a potential for exposure to a hazardous substance.
- An emergency response plan for safe and effective responses to emergencies.
- Confined space entry procedures.
- A spill containment program to contain and isolate the entire volume of any hazardous substance spilled in the course of a transfer.
- Hazard communications plan (29 CFR 1910.1200 and 29 CFR 1926.59).

data-gathering at the site perimeter (i.e., perimeter reconnaissance) may help in identifying site hazards and potential pathways for exposure, and determining the appropriate level of PPE for the initial site entry. *Perimeter reconnaissance activities during the PE must be conducted off-site.* To identify the appropriate sampling techniques for perimeter reconnaissance, the safety and health officer should review the information obtained during the records/interview research. The most important thing to remember is that the OSC/RPM must not, under any circumstances, allow a worker to enter the site to collect information for the PE.

THE PE MUST BE COMPLETED PRIOR TO ANYONE ENTERING THE SITE

Step 2 Developing the HASP

Once the PE is completed and the appropriate information is obtained, the OSC/RPM at the site must use the information gathered during the PE to develop the initial draft of the site-specific HASP. The initial draft of the HASP must include all elements listed in Exhibit 2. Specifically, it must identify each anticipated safety and health hazard for each work operation or activity, and describe how those hazards will be eliminated or controlled. In addition, the HASP should identify appropriate monitoring procedures and PPE for the initial site entry. The HASP must remain on-site at all times and only one HASP should be developed for each site.

NO ONE MAY ENTER THE SITE UNTIL THE HASP HAS BEEN DEVELOPED, APPROVED, AND IMPLEMENTED

Step 3: Initial Site Entry

Once the HASP is developed and implemented, the second stage of the site characterization and analysis (i.e., the initial site entry) may begin. The purpose of the initial site entry is to gather additional information and further evaluate the site's specific characteristics to identify and confirm existing site hazards and to aid in the selection of appropriate engineering controls and PPE.

At a minimum, activities during the initial site entry should consist of a visual survey for

EXHIBIT 3
Specific Components of the Preliminary Evaluation (29 CFR 1910.120(c)(4))

- Site location and size
- Description of response activity and/or the job to be performed
- Duration of the planned activity.
- Site topography and accessibility by air and roads.
- Safety and health hazards expected at the site.
- Pathways for hazardous substance dispersion.
- Present status and capabilities of emergency response teams that would provide assistance for on-site emergencies.
- Hazardous substances and health hazards involved or expected at the site, and the chemical and physical properties of these substances.

potential hazards and, when there is potential for exposure, air monitoring. Multi-media sampling should also be performed if the OSC/RPM has reason to believe that contamination may have occurred.

An accurate and comprehensive visual survey of the site will assist the OSC/RPM in identifying and determining what additional information (e.g., sampling of soil or containers) may be needed. This visual survey could include noting the condition of waste containers (e.g., undamaged or rusted); noting any unusual conditions; and determining potential pathways for exposure.

When entering the site, entry personnel should monitor the air using direct reading instruments for immediately dangerous to life and health (IDLH) conditions (e.g., combustable or explosive atmospheres, oxygen deficiency, toxic substances) and for ionizing radiation. Such monitoring, however, need only be conducted if the PE produces information that indicates (1) existing IDLH conditions, or (2) the potential for ionizing radiation, or if the information from the PE is insufficient to reasonably conclude that neither of these two conditions exists. When monitoring, entry personnel should look for signs of actual or potential IDLH hazards or other dangerous conditions. Examples of hazards that may be identified at a site include confined space entry, visible vapor clouds, or areas that contain biological indicators such as dead vegetation. The specific monitoring requirements for initial site entry are specified at 29 CFR 1910.120(c)(6) and (h)(2).

In addition to air monitoring, multi-media sampling should be performed during the initial site entry, if the OSC/RPM believes contamination may exist. The soil sampling techniques employed will differ with each site. Prior to beginning site activities, it is imperative that the purpose of the effort and the ultimate use of the data be established. Specific strategies should be selected based on the information required

One important goal of the initial site entry is to identify the risks and hazards at the site so that the work zones can be established. The three most frequently identified zones are the Exclusion Zone, the Contamination Reduction Zone, and the Support Zone (also known as the Clean Zone). The Support Zone should be an area of the site that is free from contamination and that may safely be used as a staging area for other hazardous waste operations at the site. For additional information and guidance on how to designate work zones, consult the Fact Sheet entitled *Establishing Work Zones at Uncontrolled Hazardous Waste Sites* (Publication No. 9285.2-06FS).

Any information concerning the chemical, physical, and toxicological properties of hazardous substances identified during the initial site entry must be made available to employees prior to the commencement of operations at the site.

INITIAL SITE ENTRY ACTIVITIES MUST, AT A MINIMUM, INCLUDE A VISUAL SURVEY AND, WHEN THERE IS POTENTIAL FOR EXPOSURE, AIR MONITORING

Step 4: Update the HASP

Once the initial site entry is completed, the OSC/RPM is responsible for updating the HASP to ensure that it adequately identifies any new

tasks or hazards at the site. At most sites, any air and multi-media sampling performed during the initial site entry will provide the OSC/RPM with more accurate information regarding the appropriate level of PPE to be worn by site employees and the proper designation of work zones.

UPDATE THE HASP AFTER THE INITIAL SITE ENTRY

Step 5: On-Going Site Activities

Once the HASP is revised to reflect the information gathered during the initial site entry, on-going monitoring must occur at the site to ensure that all new hazards are identified in a timely manner and that the appropriate controls are implemented to protect site employees.

If new tasks or hazards are identified at a site, do not develop a new HASP; instead, update the original HASP. If a subcontractor is working at a site, the subcontractor should carefully evaluate and identify all tasks associated with the subcontracted activities, and prepare a health and safety plan addressing any identified hazards. This plan should be submitted to the OSC/RPM who will incorporate it into the general site HASP after it has been reviewed for concurrence with the site workplan.

THE RULE IS: ONE SITE, ONE HASP

When developing a HASP, be careful to ensure that all required information as specified at 29 CFR 1910.120(b)(4)(ii) is addressed in the HASP. The remainder of this part of the Fact Sheet will explain the specific elements that must be included in the HASP.

Elements of the HASP

The information that must be included in the HASP is specified at 29 CFR 1910.120(b)(4)(ii) and summarized in Exhibit 2. Some of the areas that must be addressed in the HASP, such as the employer's monitoring and decontamination programs, are discussed in further detail below. In addition to the elements specified at 29 CFR 1910.120(b)(4)(ii), the HASP must identify key personnel and HAZCOM requirements and provide for pre-entry briefings to be held before site activity is initiated. These meetings should be held at any time they appear necessary to ensure that employees are adequately apprised of the safety and health procedures being followed at the site.

Monitoring program (29 CFR 1910.120(h)). The OSC/RPM's proposed monitoring program must be included in the HASP The monitoring program must include procedures for initial entry monitoring, periodic monitoring, and monitoring of high risk employees. The monitoring requirements for initial site entry are specified at 29 CFR 1910.120(c)(6) and (h)(2) and are discussed in detail on p. 5.

In general, monitoring must be performed whenever there is any possibility that employees may be exposed to hazardous substances The purpose of monitoring is to ensure that the proper engineering controls, work practices, and PPE are used to protect employees at the site.

Periodic monitoring should be conducted whenever there is any indication that exposures have risen above the permissible exposure limits (PELs), or other dangerous conditions exist such as the presence of flammable atmospheres or environments that are oxygen-deficient. Monitoring of high risk employees should be conducted on those employees suspected of having the highest exposures to hazardous substances and health hazards.

In addition to the monitoring requirements specified in 29 CFR 1910.120, there are other applicable OSHA standards, specifically Subpart Z, 29 CFR 1910.1000, that refer to particular air sampling and monitoring procedures for chemical contaminants. These standards also specify certain PPE and recordkeeping requirements for a variety of compounds. The compounds and their accompanying regulations are listed in Exhibit 4.

Site control program (29 CFR 1910.120(d)). The site control program in the HASP specifies the procedures that will be used to minimize employee exposure to hazardous substances before clean-up operations commence and during site operations. The site control program must be developed

EXHIBIT 4
Toxic and Hazardous Substances
Subpart Z, 29 CFR 1910.1000

Compound	OSHA Reference
Asbestos	29 CFR 1910.1001
Coal tar pitch volatiles	29 CFR 1910.1002
4-nitrobiphenyl	29 CFR 1910.1003
Alpha-Naphthylamine	29 CFR 1910.1004
Methyl chloromethyl ether	29 CFR 1910.1006
3,3'-dichlorobenzidine	29 CFR 1910.1007
bis-chloromethyl ether	29 CFR 1910.1008
Benzidine	29 CFR 1910.1010
4-aminodiphenyl	29 CFR 1910 1011
Ethyleneimine	29 CFR 1910.1012
beta-propiolactone	29 CFR 1910.1013
2-acetylaminofluorene	29 CFR 1910.1014
4-dimethylaminoazo-benzene	29 CFR 1910.1015
N-nitrosodimethylamine	29 CFR 1910.1016
Vinyl chloride	29 CFR 1910.1017
Inorganic arsenic	29 CFR 1910.1018
Lead	29 CFR 1910.1025
Benzene	29 CFR 1910.1028
Coke oven emissions	29 CFR 1910.1029
1,2-dibromo-3-chloro propane	29 CFR 1910.1044
Acrylonitrile	29 CFR 1910.1045
Ethylene oxide	29 CFR 1910.1047
Formaldehyde	29 CFR 1910.1048

during the planning stages of a hazardous waste clean-up operation, and must be modified as any new information becomes available. The site control program must, at a minimum, include a site map, work zones, communications, identification of the nearest medical assistance, and safe work practices.

Engineering controls and safe work practices must be specified in the site control program to protect employees from exposure to hazardous substances and other safety and health hazards. Engineering controls and work practices should be implemented to reduce and maintain employee exposure to levels at or below the PELs for those hazardous substances at the site. Examples of engineering controls that may be used include pressurized cabins and control booths on equipment. *If, for whatever reason, it is not possible to maintain employee exposure to levels at or below PELs, technical assistance should be obtained from other sources before proceeding with site activities (e.g., ERT or OSHA).*

PPE should be used as a last resort to protect employees against possible exposure to hazardous substances. It should only be used when engineering controls and work practices are insufficient to adequately protect against exposure. The PPE used at the site must be reflective of the potential site hazards identified during the PE and initial site characterization

Decontamination program (29 CFR 1910.120(k)). The decontamination procedures should be developed and appropriately communicated to all employees before they enter a site where potential for exposure to hazardous substances exists. The OSC/RPM must develop and include decontamination procedures in the HASP that identify standard operating procedures at the site, such procedures should provide employees with information on how to minimize their contact with hazardous substances. In addition, the decontamination program must include procedures for employees who leave a contaminated area on the site. Such employees must be decontaminated and their equipment must be disposed of or decontaminated. The requirements for a decontamination program are codified at 29 CFR 1910.120(k).

Emergency response plan (29 CFR 1910.120(l)). One of the most important components of the HASP is the written site-specific emergency response plan. This plan must include a description of how anticipated emergencies would be handled at the site and how the risks associated with a response would be minimized. *The emergency response plan must be developed and implemented prior to commencing operations at a site.*

The requirements for an emergency response plan at an uncontrolled hazardous waste site are summarized in Exhibit 5 and are codified at 29 CFR 1910.120(l)(2)

In addition to these elements, the emergency response plan must include information relevant for conducting emergency operations at the site, such as information on site topography, layout, and prevailing weather conditions, and procedures for reporting incidents to local, state, and federal agencies. The emergency response plan must also be rehearsed regularly and reviewed periodically to ensure that it accounts for new or

EXHIBIT 5
Required Elements of an Emergency Response Plan at an Uncontrolled Hazardous Waste Site (29 CFR 1910.120(l)(2))

- Pre-emergency planning.
- Personnel roles, lines of authority, and communication.
- Emergency recognition and prevention.
- Safe distances and places of refuge.
- Site security and control.
- Evacuation routes and procedures.
- Decontamination procedures.
- Emergency medical treatment and first aid
- Emergency alerting and response procedures.
- Critique of response and follow-up
- PPE and emergency equipment.

changing site conditions or new information on potential hazards at the site.

In lieu of preparing an emergency response plan, OSC/RPMs may prepare an emergency action plan in accordance with 29 CFR 1910.38(a). This plan may only be developed in lieu of the emergency response plan if employees are evacuated from the site when an emergency occurs, and are not permitted to assist in responding to the emergency. An emergency action plan includes an evacuation plan in which persons responsible for an orderly exit are identified. These designated individuals will direct employees to leave the site, maintain a safe distance, and call the appropriate emergency response organization.

If an emergency action plan is prepared, arrangements must be made with the local response community (e.g., fire department or other local response services) for them to respond to emergencies that may occur during site operations. The local response community must be provided with sufficient information on site activities, including the types of operations being conducted at the site, the type and degree of contamination at the site, the location of work zones, and any other relevant information that may be necessary for an appropriate response. Such information must be provided prior to the commencement of site operations. *Regardless of whether an emergency action plan or an emergency response plan is prepared, local response officials must be notified of site operations prior to the commencement of any site activities.*

Spill containment program (29 CFR 1910.120(j)(1)(viii)). In the event of a major spill or a release on-site, the spill containment program must be implemented to contain and isolate the hazardous substance release.

Responsibilities of the OSC/RPM

The OSC/RPM is responsible for reviewing the HASP for consistency with the workplan and accepting the HASP for the site. The HASP must accurately reflect the work being performed at the site, and must be reviewed and approved again when any additions or revisions are made to the HASP throughout the course of work at the site.

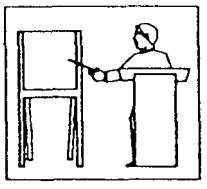
The OSC/RPM is also responsible for ensuring that employees are adequately informed of the procedures to report a health and safety violation, as well as the procedures for filing a workman's compensation report. Specifically, employees should be told that a health and safety complaint may be made either in writing or verbally, and that such complaints should be addressed to the OSC/RPM, the contractor's health and safety officer, and the EPA contract officer. The OSC/RPM should also ensure that workman compensation forms are available on-site. For additional information on employee rights, refer to Part 5 of this Fact Sheet.

Role of the Environmental Response Team (ERT)

If additional guidance is needed or desired, the OSC/RPM may submit the HASP to ERT for review or may request a site audit. It is important to note that ERT does not approve HASPs; ERT will only review them and provide recommendations. As soon as the HASP has been accepted by the OSC/RPM, covered operations at the site may commence; a plan may be implemented without ERT concurrence.

In general, it is the Agency's policy to encourage the development of an effective HASP and to assist the Regions with the task of reviewing and processing HASPs. As such, ERT will provide consultation and assistance if such assistance is requested. For further information on ERT assistance, contact the OSWER Health and Safety Manager in ERT in Edison, New Jersey, at

(FTS) 340-6740 or (908) 321-6740. Regional Health and Safety Officers may also be available for plan review and consultation. Refer to your Regional directory for the relevant addresses and telephone numbers.



PART 2: TRAINING REQUIREMENTS

This part of the Fact Sheet addresses the HAZWOPER training requirements that apply to employees engaged in hazardous waste operations and emergency response at uncontrolled hazardous waste sites and employees who perform corrective actions at RCRA TSD facilities.

General Training Requirements

Each employer at a site is responsible for ensuring that their respective employees are properly trained and equipped prior to commencing work at a site. The HAZWOPER training required for site workers must identify the hazards present on-site, the medical surveillance requirements, certain elements of the HASP, and operating practices and procedures, including the use of PPE and proper engineering controls. The specific issues and topics that are required to be addressed during training are specified at 29 CFR 1910.120(e)(2). The amount of training required for site workers is linked directly to an employee's potential for exposure to hazardous substances and to other health hazards at the site, and is specified at 29 CFR 1910.120(e)(3) and (4). *Employees may not participate in or supervise any site activity until they have been adequately trained.*

The HAZWOPER standards specify hourly requirements for four different categories of site workers. The amount of training a worker must receive is commensurate with the employee's potential for exposure; the hourly training requirements are described briefly below and summarized in Exhibit 6.

General site workers at an uncontrolled hazardous waste site include equipment operators and general laborers engaged in routine hazardous waste removal. These routine site workers must have a minimum of 40 hours of instruction off-site and 24 hours of field experience under the supervision of a trained and experienced supervisor.

EXHIBIT 6
Initial Training Requirements for Employees at Uncontrolled Hazardous Waste Sites (29 CFR 1910.120(e))

Routine Site Employees	40 Hours Off-Site 24 Hours Field Experience
Occasional Employees and Routine Site Employees Unlikely to be Exposed Above PELs	24 Hours Off-Site 8 Hours Field Experience
Supervisors	8 Hours of Specialized Training, in addition to the Requirements for the Employees they Supervise
Site Employees Assigned Site Emergency Response Duties	Trained to a Level of Competency in Addition to above Requirements
All Site Workers	8 Hours Annual Refresher Training

Workers who are on-site only occasionally to perform a specific job, such as groundwater monitoring, and who are unlikely to be exposed over PELs, are required to have a minimum of 24 hours of instruction off-site and a minimum of eight hours of supervised field experience.

Routine site workers who work only in areas where the exposure levels are monitored and determined to be below PELs are also required to receive 24 hours of instruction off-site and 8 hours of supervised field experience.

Supervisors of the three groups of employees described above are required to receive the same amount of initial training and field experience as the employees they supervise, plus 8 additional hours of specialized training in managing hazardous waste operations. For example, if a supervisor only manages employees who work on site occasionally, the supervisor must

have a minimum of 24 hours of instruction off-site and 8 hours of supervised field experience, plus an additional eight hours of specialized management training.

In addition to the requirements listed above, any worker who receives 24 hours of training and who then becomes a general site worker or whose job function requires that a respirator be worn, must have an additional 16 hours of instruction off-site and 16 hours of supervised field experience before commencing the new duties at the site.

Some of the training requirements specified above may be waived if the employee has had prior work experience or training. For example, certain training requirements may be waived if the employee has had experience working at an uncontrolled hazardous waste site or if the employee has participated in training courses offered by independent and federal organizations (e.g., EPA). If the employer believes that an employee has sufficient prior experience or training to waive some or all of the HAZWOPER training requirements, the employer must document the basis for his belief, denoting length and type of experience or training.

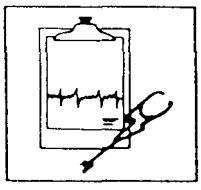
Although there are no specific additional training requirements for employees with emergency response duties at a site, such employees must be trained commensurate with the duties that will be assumed.

Refresher Training

All employees who perform clean-up operations at uncontrolled hazardous waste sites, including managers and supervisors, must receive a minimum of eight hours of annual refresher training. The purpose of refresher training is to maintain certain competencies. There are several ways to satisfy the annual refresher training requirement. For example, as explained on p. 7 of this Fact Sheet, the emergency response plan of the HASP must be rehearsed regularly. These rehearsals can be used to meet some of the annual refresher training requirements. Attendance at applicable seminars and critiques of actual responses are also acceptable methods of satisfying the annual refresher training requirements. Proper documentation of attendance, however, should be maintained.

Training Accreditation

On January 26, 1990, OSHA published a Notice of Proposed Rulemaking (NPRM) (55 FR 2776) that proposed accreditation procedures for programs to train employees engaged in clean-up operations at uncontrolled hazardous waste sites, and for employees engaged in certain hazardous waste operations at RCRA TSD facilities. The NPRM also proposed amendments to 29 CFR 1910.120 to include appropriate references to the provisions set forth in the proposed rule. If this regulation is promulgated as it was proposed, all employees subject to 29 CFR 1910.120 at uncontrolled hazardous waste sites will be required to attend an accredited training program or to document equivalent training and experience.



PART 3: MEDICAL SURVEILLANCE REQUIREMENTS

Part 3 of this Fact Sheet discusses the medical surveillance requirements in HAZWOPER that apply to employees engaged in hazardous waste operations and emergency response at uncontrolled hazardous waste sites, including employees who perform corrective actions at RCRA TSD facilities

General Medical Surveillance Requirements

The HAZWOPER medical surveillance requirements (29 CFR 1910.120(f)) provide the framework for a medical monitoring program for workers at uncontrolled hazardous waste sites. The standards contain provisions for baseline, periodic, and termination medical examinations.

A medical surveillance program must include monitoring for the following four groups of employees:

- Employees who are, or may be, exposed to PELs or health hazards for 30 or more days a year;
- Employees who wear a respirator for 30 or more days a year;
- Members of organized HAZMAT Teams; and

- Employees who are injured due to overexposure during an emergency incident, or who show symptoms of illness that may have resulted from exposure to hazardous substances.

If employees fall within the first three groups specified above, they must undergo a baseline medical examination prior to a site assignment. After this initial examination, employees must have a follow-up medical examination once a year; an attending physician may suggest a shorter or longer interval, but this period may not exceed two years. The content of these examinations should be determined by the attending physician, but certain key elements must be included. For example, the physician must complete a medical and work history and determine the employee's fitness for the type of duties to be assigned, including the employee's ability to wear PPE. Once the medical examination has been completed, the employer must obtain and furnish the employee with a copy of the physician's written opinion. The physician's written opinion must include the results of the medical examination and tests, any recommended work limitations, and the physician's opinion concerning the medical condition of the employee.

In addition to the initial and follow-up examinations, employees must receive a medical examination as soon as possible if they are injured or become ill from exposure to hazardous substances on-site or during an emergency, or they develop signs or symptoms that indicate a possible overexposure to hazardous substances. In addition, employees who are reassigned or terminate employment and, therefore, will no longer be exposed to hazardous substances must receive a final examination. This examination is only required if the employee has not had an examination within the past six months. All required medical examinations must be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

Additional guidance on these medical surveillance requirements can be found in:

- *U.S. EPA OERR Medical Monitoring Program Guidelines*, OSWER Directive 9285.3-04. To obtain a copy of these guidelines, contact the Environmental Response Team (ERT) of EPA in Edison, New Jersey. (Refer to Exhibit 8 for the appropriate address and telephone number.)

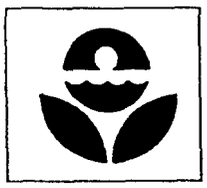
- *Standard Operating Safety Guides*, OSWER Directive 9285.1-OIC. To obtain a copy of this document, contact ERT in Edison, New Jersey.

- *Hazmat Team Planning Guidance*, Publication Number EPA/540/G-90/003. To obtain a copy of this document, contact the National Technical Information Service at (703) 487-4600.

- *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities* (Chapter 5 - Medical Monitoring), Publication Number 017-033-00419-6. To obtain a copy of this document, contact the Superintendent of Documents at the U.S Government Printing Office in Washington, D.C. 20402 ((202) 783-3238).

Medical Records

Medical records for employees must be maintained for a period of thirty years following termination of employment. These records must include the name and social security number of the employee; the physician's written opinions, including recommended occupational limitations and results of examinations and tests; any employee medical complaints related to exposure to hazardous substances; and a copy of the information provided to the examining physician by the employer. The employer is responsible for retaining the records if the employee or physician leaves the area, or the company goes out of business. For additional information on medical recordkeeping equirements, refer to 29 CFR 1910.20.



PART 4: OTHER REQUIREMENTS

This part of the Fact Sheet discusses other requirements in HAZWOPER that apply to employees engaged in hazardous waste operations and emergency response at uncontrolled hazardous waste sites. Specifically, this part outlines the requirements for: (1) handling drums and containers, (2) illumination and sanitation requirements, and (3) informational and new technology programs.

Requirements for Handling Drums and Containers (29 CFR 1910.120(j))

When performing site operations, HAZWOPER specifies some basic requirements for handling drums and containers on-site. In general, site operations should be organized to minimize the amount of drum and container movement. However, if drums or containers must be moved, the following are a few of the requirements that must be met.

- Drums and containers must be inspected prior to being moved. If this is not possible because the drums are buried beneath the earth or stacked several tiers high, the drums or containers should be moved to an accessible location and then inspected prior to further handling.

- Prior to the movement of drums, all employees who have a potential to be exposed to hazardous substances as a result of the transfer operation must be notified of the potential hazards associated with the contents of the drums or containers.

In addition to the above requirements, HAZWOPER provides specific procedures for: (1) opening drums and containers; (2) selecting and operating material handling equipment; (3) handling radioactive and shock-sensitive wastes and laboratory waste packs; (4) sampling the contents of drums or containers; (5) shipping and transporting drums or containers; and (6) handling tanks and vaults containing hazardous substances.

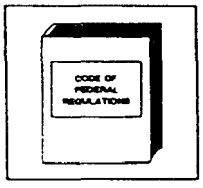
Illumination and Sanitation Requirements (29 CFR 1910.120(m) and (n))

The employer is responsible for ensuring that appropriate procedures exist at the site to maintain certain minimum illumination intensities and an adequate supply of water. There must be two separate systems for furnishing water: a potable and a nonpotable system. The potable system should provide drinking water only; the nonpotable system should provide water for fire fighting purposes. There are also requirements for toilet facilities, food handling, sleeping quarters, washing facilities, and shower/change rooms.

Informational and New Technology Programs (29 CFR 1910.120(i) and (o))

Two additional programs that must be developed, implemented, and included as part of the employer's safety and health program are the information and new technology programs. A program must be developed and implemented to inform employees of the nature, level, and degree of exposure that may occur as a result of performing hazardous waste operations. In developing this informational program, the employer should consult the Hazard Communications Standard (HCS) (29 CFR 1910.1200 and 29 CFR 1926.59). The HCS may contain information that would be useful to incorporate into the informational program or emergency response plan for a site.

In addition to developing an informational program, the employer must include as part of the safety and health program procedures for introducing new and innovative technologies into the work area. The purpose of the new technology program is to ensure that new and improved technologies and equipment are developed and introduced to provide for the improved protection of employees engaged in hazardous waste clean-up operations. As part of the new technology program, the employer must carefully evaluate new technologies, equipment, and control measures, such as absorbents and neutralizers, as they are introduced and made available on the market. The evaluation, which must be completed prior to using the new technology at the site, must identify the effectiveness of the new equipment, method, or material. Any data or information obtained during the evaluation must be made available to OSHA upon request.



PART 5: EMPLOYEE RIGHTS UNDER SECTION 8 OF THE OSH ACT

Section 8 of the OSH Act, *Inspections, Investigations, and Recordkeeping*, gives employees certain rights to inspect documents, and request and participate in inspections. Exhibit 7 provides a summary of the principle provisions of section 8 of the OSH Act.

OSHA has authority to inspect a site on their own initiative at any reasonable time. Under paragraph (f)(1) of section 8, however, an

EXHIBIT 7
Principal Provisions of
Section 8 of the OSH Act

Paragraph 8(c)(1):

- Employers are required to inform employees of their rights under the OSH Act

Paragraph 8(c)(3):

- Employees are entitled access to any required records that indicate the person's exposure to toxic materials

Paragraph 8(e):

- An employee and employer representative must be given the opportunity to accompany OSHA during any workplace inspection

Paragraph 8(f):

- An employee or employee representative may request an OSHA inspection if the person believes that there is a violation of a safety or health standard that threatens physical harm, or that causes an imminent danger

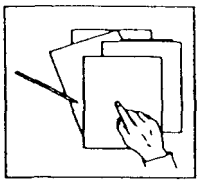
employee or employee representative also can request an OSHA inspection if the person making the request believes either that there is a violation of a safety or health standard that threatens physical harm, or that an imminent danger exists. The request must be written and signed, and must include a reasonable statement of the violation or danger. An employer is entitled to get a copy of the request, but the employee can ask OSHA not to disclose his name. When an employee makes a request under this provision, OSHA *must* conduct an inspection if they determine that there are reasonable grounds to believe a violation or danger exists. If OSHA makes a contrary determination, the person who made the request must be notified.

Under paragraph (f)(2), before or during an inspection, an employee or employee representative has the right to notify OSHA in writing of any violation of the OSH Act that the person has reason to believe exists in the workplace. If the person making the request asks, OSHA must explain any determination not to sanction the employer.

If there is an OSHA inspection, under section 8(e), an authorized employee representative must be given the chance to accompany OSHA during any inspection. If there is no authorized employee representative, the OSHA inspector has a further duty to consult with a reasonable number of employees on matters of health and safety. Under section 8(e), employers are also provided with the opportunity to designate a representative to accompany OSHA on the inspection. An important point to remember, however, is that under no circumstances may the employer designate the employee representative

Section 8 sets out three other important employee rights. Paragraph (c)(1) requires employers to post a notice or use some other appropriate means to inform employees of how the OSH Act protects them, as well as what employee obligations are. Further, where the OSH Act requires measuring or monitoring potentially toxic materials or harmful physical agents (e.g., Subpart Z, 29 CFR 1910.1000), paragraph (c)(3) gives an employee or an authorized employee representative the right to observe any such activity, and to have access to the records. This same paragraph states that an employee or former employee is entitled to have access to any required records that indicate the person's exposure to toxic materials or harmful physical agents. When an employee is so exposed, the employer must notify him of an exposure above levels prescribed by an applicable OSHA standard, and inform the employee of actions taken to correct the conditions that led to the impermissible exposure.

There are other provisions of the OSH Act that set forth employee rights. For additional information, consult the OSH Act. Another useful source to consult on this subject is the OSHA publication entitled *Employee Workplace Rights* (OSHA Publication No. 3021). To obtain a copy of this document, contact OSHA's Publications Office. (Refer to Exhibit 8 for the appropriate address and telephone number.) When ordering the document, be certain to specify the publication number.



PART 6: SOURCES OF ADDITIONAL INFORMATION AND REFERENCE MATERIALS

Part 6 of this Fact Sheet provides information on where you can obtain a copy of a generic HASP; describes a set of Guidelines that can help an OSC/RPM assess the efficacy of a HASP; and provides important addresses and telephone numbers for additional information on HAZWOPER requirements.

Generic HASPs

ERT has developed a computer software package to assist field personnel in preparing a site-specific health and safety plan, complete with all the elements required by HAZWOPER. You can obtain a copy of the generic HASP by contacting:

ERC - Health and Safety
U.S. EPA/ERT
2890 Woodbridge Avenue
Building 18 (MS-101)
Edison, NJ 08837-3679
Attention: Generic HASP

Single copies are available without charge. Requestors must specify their desired disk size (i.e., either 3 1/2 or 5 1/4 inch disk) and whether a high density or double density disk is preferred.

Health and Safety Audit Guidelines

ERT has developed step-by-step guidance for evaluating the comprehensiveness and efficacy of the preliminary evaluation and the HASP for activities at uncontrolled hazardous wastes sites. These "Health and Safety Audit Guidelines" may be used in conducting a health and safety site audit, or simply to assist OSC/RPMs in determining whether a HASP is *likely* to comply with the HAZWOPER requirements.

A copy of the "Health and Safety Audit Guidelines" (Publication Number EPA/540/G-89/010) may be obtained by calling the National Technical Information Service at (703) 487-4600.

Additional Sources of Information

The following is a brief summary of where to obtain additional information on the HAZWOPER standards. Please refer to Exhibit 8 for the appropriate addresses and telephone numbers of the contacts referenced below.

- If you have questions regarding the existing relationship between EPA and OSHA with respect to the implementation of the standards, contact the ERT in Edison, NJ.

- For information about EPA's training courses, contact ERT's Operations Section in Cincinnati, OH.

- For information and guidance on the substance of 29 CFR 1910.120, contact the appropriate OSHA Regional office. If additional information is needed, contact the OSHA Office of Health Compliance Assistance in Washington, D.C.

- For information on how to obtain technical assistance from OSHA, contact the appropriate OSHA Regional office. (Refer to Exhibit 8 for appropriate addresses and telephone numbers.)

- There are four other HAZWOPER Fact Sheets that are available:

  -- *Hazardous Waste Operations and Emergency Response: General Information and Comparison* (Pub. No. 9285.2-09FS) explains the scope of the HAZWOPER standards, and distinguishes them from regulations and consensus standards covering the same or similar subject matter;

  -- *Hazardous Waste Operations and Emergency Response: RCRA TSD and Emergency Response Without Regard to Location* (Pub. No. 9285.2-07FS) explains the principal HAZWOPER requirements for emergency response without regard to location and routine hazardous waste operations at RCRA TSD facilities.

- *Establishing Work Zones at Uncontrolled Hazardous Waste Sites* (Pub. No. 9285.2-06FS) describes the requirements and procedures for establishing support zones at uncontrolled hazardous waste sites.

- *Hazardous Waste Operations and Emergency Response: Available Guidance* (Pub. No. 9285.2-10FS) describes guidance materials developed by the Environmental Response Team of EPA to help workers engaged in hazardous waste operations and emergency response understand the HAZWOPER requirements.

Copies of these Fact Sheets may be obtained by calling or writing ERT in Edison, NJ. Please specify the title and directive number of the Fact Sheet(s). (Refer to Exhibit 8 for the appropriate address and telephone number.)

EXHIBIT 8
Important Telephone Numbers and Addresses

- U.S. EPA/ERT
  2890 Woodbridge Avenue
  Building 18 (MS-101)
  Edison, NJ 08837-3679
  (908) 321-6740 or (FTS) 340-6740

- U.S. EPA/ERT
  Operations Section
  26 West Martin Luther King
  Cincinnati, OH 45268
  (513) 569-7537 or (FTS) 684-7537

- U.S. Department of Labor, OSHA
  Office of Health Compliance Assistance
  200 Constitution Avenue, NW
  Washington, D.C. 20210
  (202) 523-8036 or (FTS) 523-8036

- U.S. Department of Labor, OSHA
  Publications Office
  Room N 3101
  200 Constitution Avenue, NW
  Washington, D.C. 20210
  (202) 523-9667

<u>OSHA Regional Offices</u>

- U.S. Department of Labor, OSHA
  Region 1
  133 Portland Street, 1st Floor
  Boston, MA 02114
  (617) 565-7164 or (FTS) 835-7164

- U.S. Department of Labor, OSHA
  Region 2
  201 Varick Street, Room 670
  New York, NY 10014
  (212) 337-2325 or (FTS) 660-2378

- U.S. Department of Labor, OSHA
  Region 3
  Gateway Building, Suite 2100
  3535 Market Street
  Philadelphia, PA 19104
  (215) 596-1201 or (FTS) 596-1201

- U.S. Department of Labor, OSHA
  Region 4
  1375 Peachtree Street, NE, Suite 587
  Atlanta, GA 30367
  (404) 347-3573 or (FTS) 257-3573

- U.S. Department of Labor, OSHA
  Region 5
  230 South Dearborn Street
  32nd Floor, Room 3244
  Chicago, IL 60604
  (312) 353-2220 or (FTS) 353-2220

- U.S. Department of Labor, OSHA
  Region 6
  525 Griffin Street, Room 602
  Dallas, TX 75202
  (214) 767-4731 or (FTS) 729-4731

- U.S. Department of Labor, OSHA
  Region 7
  911 Walnut Street
  Kansas City, MO 64106
  (816) 426-5861 or (FTS) 867-5861

EXHIBIT 8 (continued)
Important Telephone Numbers and Addresses

OSHA Regional Offices (continued)

- U.S. Department of Labor, OSHA
  Region 8
  1951 Stout Street
  Denver, CO 80204
  (303) 844-3061 or (FTS) 564-3061

- U.S. Department of Labor, OSHA
  Region 9
  71 Stevenson Street, Suite 415
  San Francisco, CA 94105
  (415) 744-6670 or (FTS) 484-6670

- U.S. Department of Labor, OSHA
  Region 10
  1111 Third Avenue, Suite 715
  Seattle, WA 98101-3212
  (206) 442-5930 or (FTS) 399-5930

EPA Regional Offices

- U S. Environmental Protection Agency
  Region 1
  John F. Kennedy Federal Building
  Room 2203
  Boston, MA 02203
  (617) 565-3715 or (FTS) 835-3715

- U.S. Environmental Protection Agency
  Region 2
  Jacob K. Javitz Federal Building
  26 Federal Plaza
  New York, NY 10278
  (212) 264-2657 or (FTS) 264-2657

- U.S. Environmental Protection Agency
  Region 3
  841 Chestnut Building
  Philadelphia, PA 19107
  (215) 597-9800 or (FTS) 597-9800

- U.S. Environmental Protection Agency
  Region 4
  345 Courtland Street, NE
  Atlanta, GA 30365
  (404) 347-4727 or (FTS) 257-4727

- U.S. Environmental Protection Agency
  Region 5
  230 South Dearborn Street
  Chicago, IL 60604
  (312) 353-2000 or (FTS) 353-2000

- U.S. Environmental Protection Agency
  Region 6
  1445 Ross Avenue, 9th Floor
  Dallas, TX 75202
  (214) 655-6444 or (FTS) 255-6444

- U.S. Environmental Protection Agency
  Region 7
  726 Minnesota Avenue
  Kansas City, KS 66115
  (913) 551-7000 or (FTS) 276-7000

- U.S. Environmental Protection Agency
  Region 8
  999 18th Street, Suite 500
  Denver, CO 80202-2405
  (303) 293-1603 or (FTS) 293-1603

- U.S. Environmental Protection Agency
  Region 9
  215 Fremont Street
  San Francisco, CA 94105
  (415) 556-6322 or (FTS) 556-6322

- U.S. Environmental Protection Agency
  Region 10
  1200 6th Avenue
  Seattle, WA 98101
  (206) 442-1200 or (FTS) 399-1200

- Call the Emergency Planning and Community Right-to-Know Information Hotline for the addresses and telephone numbers of state emergency response commissions and local emergency planning committees in your area. The telephone numbers for the Hotline are: toll-free 800-535-7672, or 202-475-9652 in the Washington, D.C. area.

SECTION 3

QUICK REFERENCE FACT SHEETS

PART 5

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE: GENERAL INFORMATION AND COMPARISON

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response

Publication 9285.2-09FS
April 1991

EPA

Hazardous Waste Operations and Emergency Response:

General Information and Comparison

Office of Emergency and Remedial Response
Emergency Response Division MS-101

Quick Reference Fact Sheet

INTRODUCTION

Under the authority of section 126 of the Superfund Amendments and Reauthorization Act of 1986 (SARA Title I), the U.S. Environmental Protection Agency (EPA) and the U.S. Occupational Safety and Health Administration (OSHA) issued *identical* health and safety standards to protect workers engaged in hazardous waste operations and emergency response. The OSHA regulations, codified at 29 CFR 1910.120, became effective on March 6, 1990 (54 FR 9294). Corrections to these regulations were published on April 13, 1990 (55 FR 14072) to clarify certain medical surveillance requirements and to identify which employers must comply with 29 CFR 1910.120(p). The EPA regulations, published on June 23, 1989 at 54 FR 26654, incorporate the OSHA standards by reference and are codified at 40 CFR Part 311.

The EPA and OSHA worker protection standards for hazardous waste operations and emergency response (HAZWOPER) affect employers whose employees are engaged in the following activities.

- Clean-up operations at uncontrolled hazardous waste sites when a government authority requires the cleanup (29 CFR 1910.120(a)(i));
- Corrective actions at treatment, storage, and disposal (TSD) facilities regulated under the Resource Conservation and Recovery Act (RCRA) (29 CFR 1910.120(a)(ii));
- Voluntary clean-up operations at uncontrolled hazardous waste sites (29 CFR 1910.120(a)(iii));
- Hazardous waste operations conducted at RCRA TSD facilities (29 CFR 1910.120(a)(iv)); and
- Emergency response operations without regard to location, where there is the release or a substantial threat of release of a hazardous substance (29 CFR 1910.120(a)(v)).

The purpose of this Fact Sheet is to explain the scope and purpose of the worker protection standards issued under SARA Title I, and to distinguish these standards from other regulations and consensus standards covering the same or similar subject matter. This Fact Sheet is also designed to facilitate compliance with the HAZWOPER requirements by helping employers and other interested readers to understand their special responsibilities under these worker protection standards. For a summary of the HAZWOPER requirements, refer to Exhibit 1.

This Fact Sheet is divided into five sections. Section one gives a brief legislative history of the EPA and OSHA worker protection standards for hazardous waste operations and emergency response, and explains the responsibilities of these two agencies in implementing the standards. Sections two, three, and four compare the 1910.120 standards with other programs governing the same kinds of activities. Finally, section five explains how to obtain the publications discussed in this Fact Sheet.

Printed on Recycled Paper

EXHIBIT 1
The Worker Protection Standards for Hazardous Waste Operations and Emergency Response (29 CFR 1910.120)

(a) Scope, application, and definitions

(b) Safety and health program

(c) Site characterization and analysis

(d) Site control

(e) Training

(f) Medical surveillance

(g) Engineering controls, work practices, and personal protective equipment for employee protection

(h) Monitoring

(i) Informational programs

(j) Handling drums and containers

(k) Decontamination

(l) Emergency response by employees at uncontrolled hazardous waste sites.

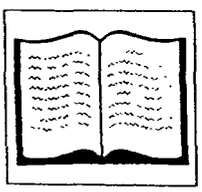
(m) Illumination.

(n) Sanitation at temporary workplaces

(o) New technology programs.

(p) Certain operations conducted under the Resource Conservation and Recovery Act of 1976.

(q) Emergency response to hazardous substance releases by employees not previously covered.



Overview of EPA and OSHA Worker Protection Authority

The Occupational Safety and Health Act of 1970, as amended, (OSH Act) established health and safety standards for the American workplace. Section 6 of the OSH Act established Federal authority to issue general health and safety standards for private industry; section 19 addresses standards for Federal government employees. Under the authority of section 6 of the OSH Act, OSHA promulgated general industry standards and standards that apply specifically to the construction industry; these standards are codified at 29 CFR 1910 and 1926, respectively. These standards set forth the minimum health and safety requirements necessary to ensure protection for all *private* sector employees in the United States. The scope of the coverage of the standards set forth in 29 CFR 1910 and 1926 changed dramatically on February 26, 1980, when President Jimmy Carter signed Executive Order 12196, requiring the *Federal government* to comply with the more stringent general industry standards issued under section 6 of the OSH Act.

SARA section 126(a) requires the Secretary of Labor to issue health and safety standards under section 6 of the OSH Act for the benefit of private sector employees -- and through the Executive Order, Federal employees -- engaged in hazardous waste operations and emergency response. Federal OSHA has no authority to enforce regulations protecting *state and local government employees*.

Under section 18 of the OSH Act, a state may elect to develop and implement its own occupational safety and health program if: (1) the state is willing to document its program in a state plan, and (2) the state's requirements are at least as stringent as the Federal regulations. Before a state program can become effective, however, OSHA must review and approve the state plan. Through its review and approval authority, OSHA requires states to extend occupational safety and health protection to state and local government employees, as well as to private sector employees, within the state's jurisdiction. Currently, there are 23 states and two territories with delegated OSHA programs. These state plans must be amended to incorporate the newly promulgated standards in 29 CFR 1910.120, to address the safety and health of employees engaged in hazardous waste operations and emergency response.

SARA section 126(f) requires the EPA Administrator to issue standards for hazardous waste operations and emergency response that are *identical* to OSHA's standards. Although the two sets of standards contain identical *substantive* provisions, EPA and OSHA address different *audiences*. EPA's authority extends to state and local government employers conducting hazardous waste operations and emergency response in states

that *do not* have in effect a delegated OSHA program. Currently, 27 states, one territory, and the District of Columbia fall under EPA's authority. The EPA regulations cover both compensated and uncompensated state and local government employees engaged in the covered activities. Therefore, the EPA standards protect volunteers, such as volunteer fire fighters who are responding to hazardous substance emergencies. Although Federal OSHA *recommends* that delegated state programs also cover uncompensated employees, not all states have followed this recommendation.

In summary, in states *without* an OSHA-approved plan, Federal OSHA standards protect all private sector and Federal employees engaged in hazardous waste operations and emergency response; the EPA worker protection standards protect all state and local government employees, including volunteer workers. In states *with* an OSHA-approved plan, the state program covers all private sector employees, as well as state and local government employees; Federal OSHA covers Federal employees in those states. The shaded area in Exhibit 2 shows jurisdictions without an OSHA-delegated program.

Inter-Agency Agreement

EPA and OSHA have an agreement to share responsibility for implementing the Title I worker protection standards. Under the terms of this agreement, OSHA performs the following activities:

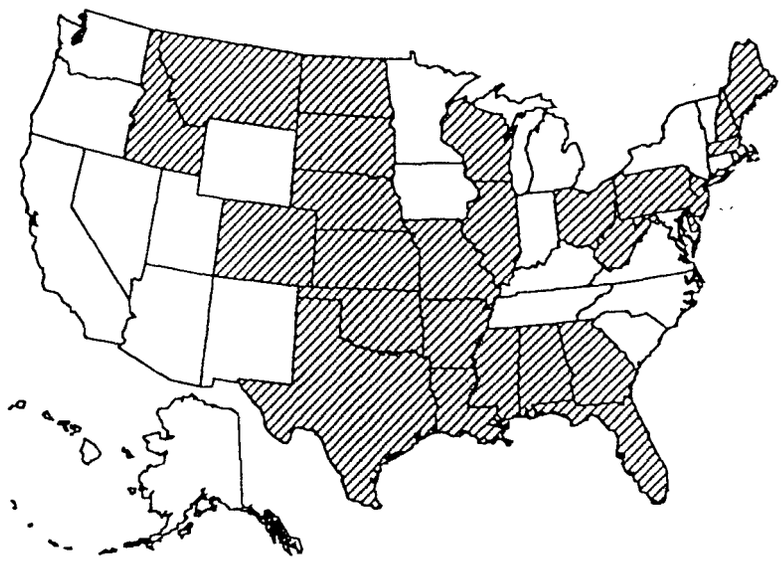
- *Support of the National Response Team and Regional Response Teams.*

- *Technical Assistance.* OSHA advises EPA on the types of actions EPA should take at uncontrolled hazardous waste sites to ensure full compliance with the HAZWOPER requirements. As an advisor, OSHA will identify problems that EPA may face and suggest appropriate solutions.

- *Compliance Activities.* OSHA conducts inspections and takes enforcement actions to ensure compliance with the worker protection standards at Superfund sites.

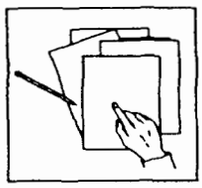
- *Implementation Activities.* OSHA supports EPA in conducting workshops to explain the requirements of the standards, and provides official interpretations of the health and safety requirements.

EXHIBIT 2
Shaded States Do Not Have Delegated OSHA Programs



If you have questions on the substance of the worker protection standards for hazardous waste operations and emergency response, contact an OSHA Regional Office or OSHA's Office of Health Compliance Assistance in Washington, D.C. Refer to Exhibit 4 for relevant addresses and telephone numbers.

The next three sections of this Fact Sheet compare OSHA's health and safety standards for hazardous waste operations and emergency response with several related regulations, standards, and guidelines developed by OSHA, EPA, and the National Fire Protection Association (NFPA). Be aware that in the context of this discussion, we will talk about "hazardous substances," "extremely hazardous substances" (EHSs), "hazardous materials," "hazardous wastes," and "highly hazardous chemicals." Each of these terms means something different, and the regulatory programs that employ them are intended to prevent or mitigate the effects from exposure to a distinct set of hazardous chemicals.



Comparing Regulatory Requirements Under SARA Title I, SARA Title III, and OSHA's Proposed Rule on Highly Hazardous Chemicals

SARA Title I

Under the authority of Title I, section 126 of SARA, EPA published worker protection standards for hazardous waste operations and emergency response (HAZWOPER). HAZWOPER specifies certain health and safety requirements to ensure the protection of employees engaged in hazardous waste operations and emergency response during five specified activities (see page 1 of this Fact Sheet). HAZWOPER *does not* address emergency responders who engage only in handling traditional fire and medical emergencies; other OSHA programs protect these employees. HAZWOPER, however, requires that an employer provide, among other things, proper emergency response planning, training, and medical surveillance. Affected workers must be protected during the entire remedial process, from the preliminary evaluation and initial site entry to final closure of the site.

Emergency Response Planning. An employer must develop an emergency response plan to protect workers in an emergency resulting from the release of all kinds of hazardous substances, including EHSs, CERCLA hazardous substances, RCRA hazardous wastes, and any substance listed by the U.S. Department of Transportation as a hazardous material.

Training. An employer also must ensure that workers receive the kind of training specified in the regulation. The standard reflects a tiered approach to training, linking the amount and type of training to an employee's potential for exposure to hazardous substances and to other health hazards during a hazardous waste operation or an emergency response. The greater the potential hazard, the more extensive and stringent are the training requirements.

Medical Surveillance. HAZWOPER establishes a framework for a medical monitoring program for certain workers engaged in hazardous waste operations and emergency response. The medical surveillance requirements include provisions for a baseline, periodic, and termination medical examination for specific groups of employees. HAZWOPER also requires that employees receive a medical examination as soon as possible if they are injured or become ill from exposure to hazardous substances on-site or during an emergency, or develop signs or symptoms that indicate a possible overexposure to hazardous substances. Although an attending physician may determine the content of medical examinations required under the standard, the examination must address key elements related to handling hazardous substances.

SARA Title III

SARA Title III, or the Emergency Planning and Community Right-to-Know Act, is a law enacted to improve state and local government capacity to respond to an emergency caused by an accidental release of an EHS; and to disseminate information to the public on dangerous chemicals made, used, or stored in their community.

Think of this law as having four main parts. The first part, sections 302 and 303, requires each state to create a State Emergency Response

Commission (SERC). In turn, these SERCs must create Local Emergency Planning Committees (LEPCs) that correspond to local emergency planning districts. LEPCs develop and update emergency response plans for accidents involving EHSs; and receive, manage, and provide public access to information about toxic and other hazardous substances in the district. SERCs review emergency response plans, and generally supervise and coordinate LEPC activities.

The second part of SARA Title III (section 304) sets out emergency release reporting requirements. Under this part of the law, the owner or operator of a facility from which an EHS or CERCLA hazardous substance is released at or above a reportable quantity (RQ) must notify SERCs and LEPCs in the affected area by telephone. There must be a written follow-up report to this immediate notification. Both the initial and follow-up reports must give details on known or anticipated health risks and advice regarding medical attention.

The third part of SARA Title III (sections 311 and 312) gives people the right to know what substances are being made, used, or stored in their communities. The OSHA Hazard Communication Standard (HCS) requires owners and operators to keep "material safety data sheets" (or MSDSs) with information about the health hazards of chemicals at the facility, and to make these MSDSs available to their employees. SARA Title III piggy-backs on the MSDS requirements in the HCS. Under SARA Title III, the owner or operator also must send copies of MSDSs, or lists of chemicals with MSDSs, to SERCs, LEPCs, and fire departments. LEPCs, in turn, make this information available to the public during normal business hours.

The final part of SARA Title III (section 313) requires certain owners and operators to report toxic substances released from their facility -- whether the release is routine or accidental; and to report toxic substances they transport to another site as waste.

Of these four parts, the one that most closely parallels the SARA Title I worker protection standards is the part dealing with emergency response planning (section 303). There are nine emergency response planning elements in section 303 of SARA Title III. Although these planning elements do not correspond point-for-point with the emergency response planning elements in the worker protection standards issued under SARA Title I, each program covers similar subjects. Title I (HAZWOPER) and Title III emergency response planning elements both:

- Highlight the need for planning *before* there is an emergency;
- Require planners to identify emergency response decision-makers and other personnel;
- Require planners to develop guidelines for recognizing and evaluating releases;
- Require evacuation planning;
- Require that the emergency response plan set out an orderly sequence of steps to follow in an emergency;
- Direct planners to specify equipment that may be needed for various levels and types of emergencies; and
- Require testing the plan and providing appropriate training for emergency responders.

On the other hand, there are some important differences in emergency response planning requirements under Title I and Title III. For example, a Title I plan must address a number of chemical hazards, while a Title III plan must cover only those emergencies arising from the release of an EHS. Further, a plan to protect employees under Title I may require far more specificity than a Title III plan. Although a Title III plan may be too general for use as an employer's Title I plan, the Title I plan may reference the Title III plan to avoid any unnecessary duplication of information. If a Title III plan is referenced, a copy of the referenced document must be kept with the Title I plan.

The most important thing to remember in distinguishing Title I and Title III emergency response planning is that Title I plans focus on worker safety; Title III plans focus on community safety. The similarities and differences between the Title I and Title III emergency response planning requirements are addressed in greater detail in a paper entitled "SARA Title I/Title III Emergency Response Planning Requirements." To obtain a copy of this document, contact the Environmental Response Team (ERT) of EPA in

Edison, New Jersey. (Refer to Exhibit 4 for the appropriate address and telephone number.)

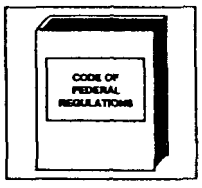
OSHA's Highly Hazardous Chemicals NPRM

On July 17, 1990, OSHA published a Notice of Proposed Rulemaking (NPRM), proposing a new regulation entitled "Process Safety Management of Highly Hazardous Chemicals" (55 FR 29150). The NPRM proposes requirements that will eliminate or mitigate the harm to employees as a consequence of chemical releases during the manufacturing or processing of highly hazardous chemicals. OSHA's proposed rule emphasizes management of hazards associated with highly hazardous chemicals, and defines a "highly hazardous chemical" as:

> *A substance possessing toxic, flammable, reactive, or explosive properties.*

The NPRM identifies 140 highly hazardous chemicals and proposes threshold quantities for each of the listed chemicals. The proposed requirements are similar to the worker protection standards issued under SARA Title I and the self-implementing provisions of SARA Title III in that each of these programs contains requirements for emergency response planning and employee training.

The NPRM requires an employer to establish and implement an emergency action plan under 29 CFR 1910.38(a). An emergency action plan must include an evacuation plan through which an employer identifies persons responsible for an orderly exit and work area check in the event of an emergency; and directs employees to leave an emergency incident site, maintain a safe distance, and call an appropriate emergency response organization. However, if an employer's highly hazardous chemical operation falls within one of the activities covered by HAZWOPER, the emergency response planning elements of 1910.120 apply. (Under HAZWOPER, an employer also may prepare a 1910.38(a) plan if the employer does not allow employees to respond to an emergency. If employees are allowed to respond, however, a more detailed emergency response plan is required.) Title I, Title III, and the Highly Hazardous Chemicals NPRM also require training for workers commensurate with their assigned duties.



Comparing General Requirements Under 29 CFR Parts 1910 and 1926 with the Particular Requirements of 29 CFR 1910.120

The occupational safety and health standards published in 29 CFR set out minimum requirements to ensure protection for all private sector employees in the United States. The general industry standards contained in Part 1910 of Title 29 were derived largely from standards developed by industry consensus organizations and non-OSHA Federal safety and health standards. The 1910 requirements reflect practices already recognized in most industrial sectors before there was an Occupational Safety and Health Administration. Part 1910, however, makes those practices mandatory.

Many of the Part 1910 standards set out generic specifications for worker tools, tolerances and specifications for industrial structures, requirements for installing equipment that make the workplace safer (e.g., sprinkler systems), rules for providing medical attention, and other general health and safety practices applicable to all types of employment. Other sections in Part 1910, however, are specific to an identified activity or industry; HAZWOPER is an example of the latter type of standard.

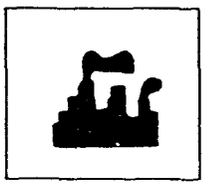
Section 1910.120 (HAZWOPER) contains specific requirements to minimize the health and safety hazards associated with conducting hazardous waste operations and emergency response at uncontrolled hazardous waste sites and RCRA TSD facilities, and performing emergency response operations without regard for location. In some instances, 1910.120 incorporates general worker protection provisions by reference. For example, 1910.120(g), *Engineering controls, work practices, and personal protective equipment for employee protection*, requires employers engaged in hazardous waste operations and emergency response to follow the provisions in 1910.94 through 1910.100 in setting up controls to protect employees from exposure to hazardous substances and safety and health hazards. Those referenced sections may apply to other industries and activities as well, but HAZWOPER applies only to hazardous waste operations and emergency

response during the covered activities and locations.

> If ever there appears to be a conflict between the general industry standards in 1910 or 1926 and HAZWOPER, the HAZWOPER requirements take precedent during the covered activities.

In addition to the requirements set forth under Part 1910, OSHA codified regulations in 29 CFR 1926 Subpart C that set forth safety and health standards specifically applicable to the construction industry. Part 1926 Subpart C includes safety standards for worker tools, and other standards relevant to health and safety in the construction environment (e.g., 29 CFR 1926.21 addresses programs for the education and training of employees and employers).

Parts 1910 and 1926 both require employers to provide whatever training and education is appropriate for employees to perform a given task safely. Appendix B in EPA's Health and Safety Audit Guidelines briefly summarizes the OSHA standards in 1910 and 1926 that may be most applicable to hazardous waste site activities; Exhibit 3 presents a list of these OSHA standards. For additional information on the standards listed in Exhibit 3 or on other OSHA standards, contact your local OSHA Regional Office. (Refer to Exhibit 4 for relevant addresses and telephone numbers.)



Comparing the Section 1910.120 Standards and the NFPA's Hazardous Materials Incidents Publications

Private organizations sometimes publish consensus documents addressing subject matter covered in Federal regulations. The National Fire Protection Association (NFPA) has published two highly relevant documents: *Recommended Practice for Responding to Hazardous Materials Incidents* (NFPA 471), and *Standard for Professional Competence of Responders to Hazardous Materials Incidents* (NFPA 472). The NFPA standards *are not* Federal regulations.

EXHIBIT 3
Other Potentially Applicable OSHA Standards (by section in 29 CFR)

1910.20	*Access to Employee Exposure and Medical Records*
1910.24	*Fixed Industrial Stairs*
1910.27	*Fixed Ladders*
1910.28	*Safety Requirements for Scaffolding*
1910.38	*Employee Emergency Plans and Fire Prevention Plans*
1910.57	*Ventilation*
1910.95	*Occupational Noise Exposure*
1910.101	*Compressed Gases*
1910.133	*Eye and Face Protection*
1910.134	*Respiratory Protection*
1910.135	*Occupational Head Protection*
1910.136	*Occupational Foot Protection*
1910.141	*Sanitation*
1910.151	*Medical Services and First Aid*
1910.165	*Employee Alarm Systems*
1910.181	*Derricks*
1910.252	*Welding, Cutting, and Brazing*
1910.307	*Hazardous Locations*
1910.1000	*Toxic and Hazardous Substances*
1910.1200	*Hazard Communication*
1926.20	*General Safety and Health Provisions*
1926.21	*Safety Training and Education*
1926.56	*Illumination*
1926.59	*Hazard Communication*
1926.151	*Fire Prevention*
1926.152	*Flammable and Combustible Liquids*
1926.200	*Accident Prevention Signs and Tags*
1926.301	*Hand Tools*
1926.651	*Specific Excavation Requirements*
1926.652	*Trenching Requirements*

NFPA 471 offers guidance in identifying the minimum competencies a responsible authority should attain before responding to a hazardous materials incident, and specifies operating guidelines for a response. Like HAZWOPER, NFPA 471 covers, among other things, planning for an emergency response, ensuring that responders have the proper equipment at their disposal, and conducting an emergency response.

NFPA 472 is a competency standard for workers who respond to hazardous materials incidents. NFPA 472 training criteria differ from the 1910.120 standards in that the former do not

establish specific hourly training requirements for emergency response personnel. There is no Incident Commander category in NFPA 472, but an Appendix to the standard does identify the role of an Incident Commander.

Indeed, the NFPA publications on hazardous materials incident response are similar in approach and breadth of coverage to HAZWOPER. In many instances, NFPA references the Federal standards. You must remember, however, that although the NFPA documents provide useful guidance to emergency response planners and responders, only the EPA and OSHA standards are *mandatory* Federal standards. If your organization falls within the scope of 29 CFR 1910.120, *you must comply.* Therefore, in any conflict between the NFPA Standard/Practice and the Title I worker protection standards, the Federal standards govern.

Where to Get Information and Publications

You can get any volume of the CFR by contacting the U.S. Government Printing Office (GPO) or any Federal Depository Library in your state. To contact GPO, call or write:

Superintendent of Documents
Government Printing Office (GPO)
Washington, D.C. 20402
(202) 783-3238

Many state college and university libraries are also Federal Depository Libraries. For a complete list of these libraries, ask GPO for *A Directory of U.S. Government Libraries.*

OSHA offers a catalogue listing Agency-issued publications and audiovisual aids that help employers and other interested persons to understand both the scope of OSHA regulations, and specific substantive provisions in health and safety standards. You can obtain a free copy of the catalogue, *OSHA Publications and Audiovisual Programs*, by sending your request with a self-addressed mailing label to:

U.S. Department of Labor, OSHA
Publications Office, Room N3101
200 Constitution Avenue, NW
Washington, D.C. 20210

To get a copy of the NFPA publications discussed in this Fact Sheet, or to obtain additional information on the substance of the publications, write:

National Fire Protection Association (NFPA)
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9904

For additional information on the SARA Title III requirements, contact the Emergency Planning and Community-Right-to-Know Hotline. The telephone numbers for the Hotline are: toll-free 800-535-7672, or 202-475-9652 in the Washington, D.C. area.

Currently, there are four other Fact Sheets that are available on the worker protection standards for hazardous waste operations and emergency response:

- *Hazardous Waste Operations and Emergency Response: Uncontrolled Hazardous Waste Sites and RCRA Corrective Action* (Pub. No. 9285.2-08FS) explains the specific requirements for hazardous waste operations conducted at uncontrolled hazardous waste sites, including corrective actions at RCRA TSD facilities.

- *Establishing Work Zones at Uncontrolled Hazardous Waste Sites* (Pub. No. 9285.2-06FS) describes the requirements and procedures for establishing support zones at uncontrolled hazardous waste sites.

- *Hazardous Waste Operations and Emergency Response: RCRA TSD and Emergency Response Without Regard to Location* (Pub. No. 9285.2-07FS) describes the principal requirements of the standards for hazardous waste operations at RCRA TSD facilities and emergency response operations without regard to location.

- *Hazardous Waste Operations and Emergency Response: Available Guidance* (Pub. No. 9285.2-10FS) describes guidance materials

developed by the Environmental Response Team to help workers engaged in hazardous waste operations and emergency response understand the HAZWOPER requirements.

Copies of these Fact Sheets may be obtained by calling or writing the Environmental Response Team of EPA in Edison, New Jersey. (Refer to Exhibit 4 for the appropriate address and telephone numbers.) Please specify the title and publication number of the Fact Sheet(s).

EXHIBIT 4
Important Telephone Numbers and Addresses

- U.S. EPA/ERT
  2890 Woodbridge Avenue
  Building 18 (MS-101)
  Edison, NJ 08837-3679
  (908) 321-6740 or (FTS) 340-6740

- U.S. Department of Labor, OSHA
  Office of Health Compliance Assistance
  200 Constitution Avenue, NW
  Washington, D.C. 20210
  (202) 523-8036 or (FTS) 523-8036

OSHA Regional Offices

- U.S. Department of Labor, OSHA
  Region 1
  133 Portland Street, 1st Floor
  Boston, MA 02114
  (617) 565-7164 or (FTS) 835-7164

- U.S. Department of Labor, OSHA
  Region 2
  201 Varick Street, Room 670
  New York, NY 10014
  (212) 337-2325 or (FTS) 660-2378

- U.S. Department of Labor, OSHA
  Region 3
  Gateway Building, Suite 2100
  3535 Market Street
  Philadelphia, PA 19104
  (215) 596-1201 or (FTS) 596-1201

- U.S. Department of Labor, OSHA
  Region 4
  1375 Peachtree Street, NE, Suite 587
  Atlanta, GA 30367
  (404) 347-3573 or (FTS) 257-3573

- U.S. Department of Labor, OSHA
  Region 5
  230 South Dearborn Street
  32nd Floor, Room 3244
  Chicago, IL 60604
  (312) 353-2220 or (FTS) 353-2220

- U.S. Department of Labor, OSHA
  Region 6
  525 Griffin Street, Room 602
  Dallas, TX 75202
  (214) 767-4731 or (FTS) 729-4731

- U.S. Department of Labor, OSHA
  Region 7
  911 Walnut Street
  Kansas City, MO 64106
  (816) 426-5861 or (FTS) 867-5861

- U.S. Department of Labor, OSHA
  Region 8
  1951 Stout Street
  Denver, CO 80204
  (303) 844-3061 or (FTS) 564-3061

- U.S. Department of Labor, OSHA
  Region 9
  71 Stevenson Street, Suite 415
  San Francisco, CA 94105
  (415) 744-6670 or (FTS) 484-6670

- U.S. Department of Labor, OSHA
  Region 10
  1111 Third Avenue, Suite 715
  Seattle, WA 98101-3212
  (206) 442-5930 or (FTS) 399-5930

EXHIBIT 4 (continued)
Important Telephone Numbers and Addresses

EPA Regional Offices

- U.S. Environmental Protection Agency
  Region 1
  John F. Kennedy Federal Building
  Room 2203
  Boston, MA 02203
  (617) 565-3715 or (FTS) 835-3715

- U.S. Environmental Protection Agency
  Region 2
  Jacob K. Javitz Federal Building
  26 Federal Plaza
  New York, NY 10278
  (212) 264-2657 or (FTS) 264-2657

- U.S. Environmental Protection Agency
  Region 3
  841 Chestnut Building
  Philadelphia, PA 19107
  (215) 597-9800 or (FTS) 597-9800

- U.S. Environmental Protection Agency
  Region 4
  345 Courtland Street, NE
  Atlanta, GA 30365
  (404) 347-4727 or (FTS) 257-4727

- U.S. Environmental Protection Agency
  Region 5
  230 South Dearborn Street
  Chicago, IL 60604
  (312) 353-2000 or (FTS) 353-2000

- U.S. Environmental Protection Agency
  Region 6
  1445 Ross Avenue, 9th Floor
  Dallas, TX 75202
  (214) 655-6444 or (FTS) 255-6444

- U.S. Environmental Protection Agency
  Region 7
  726 Minnesota Avenue
  Kansas City, KS 66115
  (913) 551-7000 or (FTS) 276-7000

- U.S. Environmental Protection Agency
  Region 8
  999 18th Street, Suite 500
  Denver, CO 80202-2405
  (303) 293-1603 or (FTS) 293-1603

- U.S. Environmental Protection Agency
  Region 9
  215 Fremont Street
  San Francisco, CA 94105
  (415) 556-6322 or (FTS) 556-6322

- U.S. Environmental Protection Agency
  Region 10
  1200 6th Avenue
  Seattle, WA 98101
  (206) 442-1200 or (FTS) 399-1200

- Call the Emergency Planning and Community Right-to-Know Information Hotline for the addresses and telephone numbers of state emergency response commissions and local emergency planning committees in your area. The telephone numbers for the Hotline are: toll-free 800-535-7672, or 202-475-9652 in the Washington, D.C. area.

SECTION 3

QUICK REFERENCE FACT SHEETS

PART 6

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE: AVAILABLE GUIDANCE

United States Environmental Protection Agency
Office of Solid Waste and Emergency Response
Publication 9285 2-10FS
April 1991

EPA

Hazardous Waste Operations and Emergency Response:
Available Guidance

Office of Emergency and Remedial Response
Emergency Response Division MS-101
Quick Reference Fact Sheet

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) and the U.S. Occupational Safety and Health Administration (OSHA) have issued identical health and safety standards to protect workers engaged in hazardous waste operations and emergency response (HAZWOPER). The EPA regulations are codified at 40 CFR Part 311 (54 FR 6654). The OSHA regulations are codified at 29 CFR 1910.120 (54 FR 9294 and 55 FR 14072).

The Environmental Response Team (ERT) at EPA developed this Fact Sheet to alert interested parties to the availability of guidance materials that will help employers, employees, On-Scene Coordinators (OSCs), and Remedial Project Managers (RPMs) to better understand and comply with the new HAZWOPER standards. This Fact Sheet is organized into four sections, representing the four distinct formats used to present information about the new requirements: (1) Software; (2) HAZWOPER Fact Sheets; (3) Guidance Documents; and (4) Training. Exhibit 1 presents at a glance the various guidance that is described in this Fact Sheet.

COMPUTER SOFTWARE

Two major ERT software systems are currently available for HAZWOPER. The topics addressed by these systems are discussed below and are listed in Exhibit 2.

Health and Safety Planner (U.S. EPA, 1990)

The Health and Safety Planner (HASP) — often called the generic health and safety plan — is a menu-driven computerized software system designed to assist health and safety officers in designing, implementing, and updating a site health and safety plan. HASP contains several valuable data bases that include information on chemical hazards associated with many of the chemicals typically found at an uncontrolled hazardous waste site. HASP allows the user to retrieve data on chemical hazards, suggests appropriate monitoring devices, identifies likely routes of exposure, and recommends levels of personal protective equipment based on those hazards and the tasks that will be performed at the site. HASP also includes standard protocols for typical assessment and remediation activities. Finally, HASP uses standard text components to actually produce a site-specific health and safety plan, addressing the potential hazards identified for the site. The health and safety plan format generated by HASP is consistent with OSHA's 29 CFR 1910.120 requirements. HASP is available on either 3½" or 5¼" diskettes, for either double density or high density disk drives; it runs on most IBM-compatible personal computers, and it comes with a User's Guide (OSWER Directive 9285.8-01).

Field Certification Tracking System (U.S. EPA, 1989)

The Field Certification Tracking System (FCTS) is a computerized software system that simplifies the recordkeeping associated with the health and safety requirements under HAZWOPER. The system creates personnel files, updates the personnel files, and produces personnel reports. FCTS is essentially a tracking system; it cannot be used to identify training and medical monitoring requirements, but rather allows the user to specify the requirements and to track the employee's fulfillment of those requirements. Employees working at a location, for example, may be grouped into categories, such as HAZMAT Team Member, routine site worker, or first responder, and then training and medical monitoring requirements for each worker or each category of workers

EXHIBIT 1
Available Guidance

Computer Software

- Health and Safety Planner (HASP)
- Field Certification Tracking System (FCTS)

Guidance Documents

- Hazmat Team Planning Guidance
- Occupational Medical Monitoring Program Guidelines for SARA Hazardous Waste Field Activity Personnel
- Health and Safety Audit Guidelines
- Standard Operating Safety Guides
- Field Standard Operating Procedures

HAZWOPER Fact Sheets

- Hazardous Waste Operations and Emergency Response General Information and Comparison
- Hazardous Waste Operations and Emergency Response Uncontrolled Hazardous Waste Sites and RCRA Corrective Action
- Hazardous Waste Operations and Emergency Response RCRA TSD and Emergency Response Without Regard to Location
- Establishing Work Zones at Uncontrolled Hazardous Waste Sites

Training

- Hazardous Materials Incident Response Training Program Course Schedule

EXHIBIT 2
Computer Software

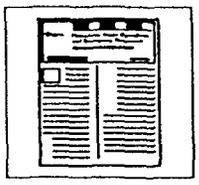
Health and Safety Planner

- Identification of chemical hazards
- Selection of monitoring devices
- Identification of likely routes of exposure
- Selection of personal protective equipment

Field Certification Tracking System

- Simplification of recordkeeping for field personnel
- Creation of personnel files for health and safety requirements
- Updating of personnel files

must be input into the FCTS system. The training and medical monitoring requirements entered for each employee may be more or less stringent than those specified in 29 CFR 1910.120. Thus, although all affected employees must comply with the training and medical monitoring requirements in 29 CFR 1910.120, FCTS provides the user with flexibility regarding the elements that will be tracked. Once a personnel file is created, the system can be used to list the required training for an employee's category, update an employee's file to reflect newly acquired training, and target personnel files to identify employees who are overdue for a particular type of training. FCTS is available on either 3½" or 5¼" diskettes, for either double density or high density disk drives, it runs on most IBM-compatible personal computers, and it comes with a User's Guide (OSWER Directive 9285.3-03).



HAZWOPER FACT SHEETS

Currently, there are four available ERT Fact Sheets (in addition to this one) that provide guidance on the HAZWOPER requirements. The topics addressed by these Fact Sheets are discussed below and are presented in Exhibit 3.

Hazardous Waste Operations and Emergency Response: General Information and Comparison **(U.S. EPA, 1991, Pub. No. 9285.2-09FS)**

This Fact Sheet explains the scope and purpose of the HAZWOPER standards, and distinguishes the Title I standards from regulations and consensus standards covering the same or similar subject matter. Specifically, this Fact Sheet provides a brief legislative history of HAZWOPER, and compares it with other programs governing the same kinds of activities, such as

EXHIBIT 3
HAZWOPER Fact Sheets

General Information and Comparison

- Overview of EPA and OSHA Authority
- Comparing Regulatory Requirements
- Comparing General Requirements
- NFPA's Hazardous Materials Incidents Publications
- Sources of Additional Information

Uncontrolled Hazardous Waste Sites and RCRA Corrective Action

- Planning Requirements
- Training Requirements
- Medical Surveillance Requirements
- Other Requirements
- Employee Rights
- Sources of Additional Information

RCRA TSD and Emergency Response Without Regard to Location

- Requirements for Planning, Training, and Medical Surveillance for Emergency Response Without Regard to Location
- Requirements for Planning, Training, and Medical Surveillance at RCRA TSD Facilities
- Sources of Additional Information

Establishing Work Zones at Uncontrolled Hazardous Waste Sites

- Definitions of Work Zones
- Data Collection Requirements
- Selection of Work Zones
- Ensuring Integrity of Work Zones
- Consultation and References

SARA Title III and OSHA's proposed rule on highly hazardous substances. This Fact Sheet also discusses how the HAZWOPER requirements relate to the industry-specific standards at 29 CFR 1910 and the standards applicable to the construction industry at 29 CFR 1926. Finally, this Fact Sheet describes relevant National Fire Protection Association (NFPA) publications and their relationship to HAZWOPER.

Hazardous Waste Operations and Emergency Response: Uncontrolled Hazardous Waste Sites and RCRA Corrective Action (U.S. EPA, 1991, Pub. No. 9285.2-08FS)

This Fact Sheet explains the principle HAZWOPER requirements as they apply to employees engaged in hazardous waste operations and emergency response at uncontrolled hazardous waste sites, including employees who perform corrective actions at RCRA TSD facilities. Specifically, this Fact Sheet describes the relevant planning, training, and medical surveillance requirements in HAZWOPER, including the site control and decontamination programs, the emergency response plan, the spill containment program, and the specific responsibilities of the OSC/RPM and ERT. Other requirements, such as the procedures for handling drums and containers, illumination and sanitation requirements, and the informational and new technology programs also are addressed. Finally, this Fact Sheet discusses employee rights under section 8 of the Occupational Safety and Health Act of 1970, as amended (OSH Act)

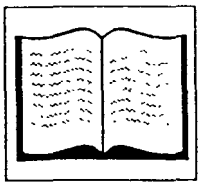
Hazardous Waste Operations and Emergency Response: RCRA TSD and Emergency Response Without Regard to Location (U.S. EPA, 1991, Pub. No. 9285.2-07FS)

This Fact Sheet describes the planning, training, and medical surveillance requirements in HAZWOPER as they apply to emergency responders regardless of location, and employees who perform routine hazardous waste operations at RCRA TSD facilities. The Fact Sheet explains the applicable HAZWOPER planning and medical monitoring requirements, as well as the five specific levels of training required for responders to emergencies that could occur at any location.

Establishing Work Zones at Uncontrolled Hazardous Waste Sites (U.S. EPA, 1991, Pub. No. 9285.2-06FS)

This Fact Sheet summarizes the requirements and procedures for establishing and maintaining Support Zones (i.e., Clean Zones) at hazardous waste sites The Fact Sheet defines the different work zones usually found at a hazardous waste site (i.e., Exclusion, Contamination Reduction, and Support), describes data collection and site characterization requirements for establishing a Support Zone (both prior to and during initial site entry), provides information on selecting and maintaining work zones (i.e., data compilation and evaluation), and provides information on maintaining the work zones (i.e., use of site controls, periodic monitoring of the support zone, and other considerations). This Fact Sheet also references a number of technical guidance documents

that address some of the activities that are conducted in establishing work zones (e.g., air monitoring).



GUIDANCE DOCUMENTS

Five major ERT guidance documents are currently available for HAZWOPER. The topics addressed by these documents are discussed briefly below and are presented in Exhibit 4.

***Hazmat Team Planning Guidance* (U.S. EPA, 1990, Pub. No. EPA/540/G-90/003)**

The *Hazmat Team Planning Guidance* document assists local fire departments and other response organizations in establishing a HAZMAT Team. The document identifies necessary equipment and suggests ways to acquire and maintain the equipment and to train personnel for the HAZMAT Team. The document offers guidance in determining actual HAZMAT response requirements, establishing the goals and levels of expertise needed to meet those requirements, and estimating the costs of meeting those goals. The document also provides assistance in preparing response plans and standard operating procedures (SOPs). The Appendices to the document provide a summary of how to begin the hazards analysis process and how to design a medical program. The Appendices also contain a list of EPA Regional Superfund training contacts and selected guidance and reference documents.

***Occupational Medical Monitoring Program Guidelines for SARA Hazardous Waste Field Activity Personnel* (U.S. EPA, 1990, Pub. No. OSWER Directive 9285.3-04)**

This summary document provides guidelines covering the requirements for a comprehensive occupational medical monitoring program for personnel involved in hazardous waste field activities. This document outlines general medical monitoring requirements such as the type of physician who must perform or supervise examinations, and the procedures required of the personnel who must undergo the monitoring. The four types of examinations — baseline, periodic, unscheduled, and termination — are described, as well as reporting requirements, special requirements (i.e., immunizations, research tests, and reproductive hazards), and the relationship between occupational medical monitoring and workers' compensation. The Appendices to the document address the minimum examination types and content, and provide guidelines for immunization requirements. References are also provided.

***EPA Health and Safety Audit Guidelines* (U.S. EPA, 1989, Pub. No. EPA/540/G-89/010)**

These Guidelines provide a representative sample of the HAZWOPER requirements at different stages of cleanup at an uncontrolled hazardous waste site, as well as during emergency response operations that occur without regard to location. It is in a workbook format that provides the user with space for notes regarding the comprehensiveness and efficacy of the written site-specific health and safety plan, as well as the health and safety measures being implemented in the field and during off-site emergency response operations. The Guidelines may be used to assist an auditor or site supervisor in obtaining a sense of the likely level of compliance with the HAZWOPER requirements; they, however, are not meant to be a comprehensive compilation of all requirements. If compliance with the specific elements in a subsection of these guidelines is excellent, then it is likely that all requirements under that subsection have been met. If, on the other hand, compliance is sketchy or weak, it is advisable to pursue additional questions and to further investigate compliance with that subsection. The EPA Audit Guidelines are in a simple, easy to follow, question and answer format. The Appendices to the document provide an incident safety check-off list, a description of levels of personnel protection, and a log and summary form for occupational injuries and illnesses.

***Standard Operating Safety Guides* (U.S. EPA, 1988, OSWER Directive 9285.1-OIC)**

The *Standard Operating Safety Guides* (SOSG) provide guidelines for use by any organization in developing its own specific operation safety procedures. These Guides should be adapted to address the safety criteria required for protection of response personnel from the hazards created by a specific operation or incident. This document is not meant to be a comprehensive safety manual, but rather it provides technical information that should be considered in developing instructions on how to accomplish specific hazardous waste operations in a safe manner.

Field Standard Operating Procedures (FSOPs)

EPA has published a series of FSOPs that provides procedures to minimize the risk of exposure to hazardous substances. These procedures were derived from early drafts of EPA's *Standard Operating Safety Guides* and are presented in a format that is more appropriate for use in the field. Five of the most relevant FSOPs are described below.

EXHIBIT 4
Guidance Documents

Hazmat Team Planning Guidance

- Do you need a hazmat team?
- Training and equipping your hazmat team
- Preparing response plans and standard operating procedures

Health and Safety Audit Guidelines

- Preliminary evaluation
- Written health and safety plan review
- Health and safety field review
- Off-site emergency response review

Occupational Medical Monitoring Program Guidelines for SARA Hazardous Waste Field Activity Personnel

- General requirements
- Baseline examination
- Periodic examination
- Unscheduled examination
- Termination examination
- Reporting requirements
- Special requirements
- Relationship between occupational medical monitoring and workers' compensation
- Minimum examination types and requirements
- Guidelines for immunization requirements

Standard Operating Safety Guides

- Environmental incidents
- Standard operating procedures
- Health and safety requirements
- Site safety plan
- Initial site survey and reconnaissance
- Levels of personal protective equipment
- Effects of stress
- Work zones
- Decontamination
- Air surveillance

Field Standard Operating Procedures

- Site entry
- Work zones
- Decontamination of response personnel
- Air surveillance
- Site safety plan

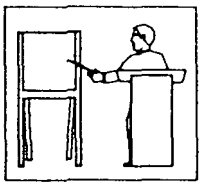
FSOP #4: Site Entry (U.S. EPA, 1985, OSWER Directive 9285.2-01). This document discusses site entry procedures, including proper selection, use, and decontamination of personal protective equipment; use of field equipment; activities conducted during initial site entry; and check-out procedures for a self-contained breathing apparatus.

FSOP #6: Work Zones (U.S. EPA, 1985, OSWER Directive 9285.2-04). This document discusses a number of topics related to work zones, including definitions of work zones, methodology for selecting work zone locations, personal protective levels, and air monitoring.

FSOP #7: Decontamination of Response Personnel (U.S. EPA, 1985, OSWER Directive 9285.2-02). This document provides flow charts for decontamination layouts, descriptions of personal protective equipment, procedures for decontamination, and lists of decontamination equipment.

FSOP #8: Air Surveillance (U.S. EPA, 1985, OSWER Directive 9285.2-03). This document describes the types and methods of air surveillance, procedures and equipment for air monitoring, and a method for analyzing organic solvents by gas chromatography

FSOP #9: Site Safety Plan (U.S. EPA, 1985, OSWER Directive 9285.2-05). This document describes the general requirements for a site safety plan, discusses development and implementation of a site safety plan, and provides sample plans and a checklist.



TRAINING

As part of EPA's comprehensive program for protecting the public and the environment from releases of hazardous materials, ERT developed the Hazardous Materials Incident Response Training (HMIRT) Program. A list of the HMIRT courses is provided in Exhibit 5 A schedule of these courses is available from ERT in Cincinnati, Ohio.

EXHIBIT 5
Training

Hazardous Materials Incident Response Training Program Schedule of Courses

- Personal Protection and Safety
- Hazardous Materials Treatment Technologies
- Air Surveillance for Hazardous Materials
- Hazardous Materials Incident Response Operations
- Risk Assessment Guidance for Superfund
- Introduction to Groundwater Investigations
- Safety and Health Compliance for Managers
- Sampling for Hazardous Materials
- Radiation Safety at Superfund Sites
- Emergency Response to Hazardous Materials Incidents
- Advanced Air Sampling for Hazardous Materials
- Removal Cost Management System

Hazardous Materials Incident Response Training Program Course Schedule

The HMIRT program is designed for emergency responders and for personnel who investigate and clean up uncontrolled hazardous waste sites. The HMIRT program currently has a curriculum of 12 courses. (See Exhibit 5.) The curriculum covers emergency operations, as well as the scientific and technical aspects of response to hazardous materials incidents. The courses provide specific training in worker health and safety and in various technical operations that must be performed by site personnel and emergency responders to identify, evaluate, and control releases of hazardous substances.

All HMIRT courses, which generally last from three to five days, emphasize the practical application of lecture material through problem solving, case studies, and demonstrations, along with actual exercises using response equipment and instruments. Many of the HMIRT courses are accredited by the American Council on Education. The program also offers continuing education units and American Board of Industrial Hygiene (ABIH) certificate maintenance credits for course participants. Tuition for HMIRT courses is free to any government worker, including federal, state, and local personnel, as well as to volunteer fire companies; however, there is a nominal tuition fee for members of industry.

WHERE TO OBTAIN GUIDANCE

The guidance described in this Fact Sheet can be obtained from the sources shown in Exhibit 6. When calling or writing, please be certain to specify the title and identification number (if available) of the guidance.

EXHIBIT 6
Where to Obtain Guidance

To Obtain:

- Computer Software
  - -- HASP (and User's Guide, 9285.8-01)
  - -- FCTS (and User's Guide, 9285 3-03)
- HAZWOPER Fact Sheets
  - -- General Information and Comparison (9285 2-09FS)
  - -- Uncontrolled Hazardous Waste Sites and RCRA Corrective Action (9285 2-08FS)
  - -- RCRA TSD and Emergency Response Without Regard to Location (9285.2-07FS)
  - -- Establishing Work Zones at Uncontrolled Hazardous Waste Sites (9285 2-06FS)
- Occupational Medical Monitoring Program Guidelines for SARA Hazardous Waste Field Activity Personnel (9285 3-04)
- Standard Operating Safety Guides (9285 1-01C)
- Field Standard Operating Procedures
  - -- FSOP #4 Site Entry (9285 2-01)
  - -- FSOP #6 Work Zones (9285 2-04)
  - -- FSOP #7 Decontamination of Response Personnel (9285 2-02)
  - - FSOP #8 Air Surveillance (9285 2-03)
  - -- FSOP #9 Site Safety Plan (9285 2-05)

Call or Write

- U S EPA/ERT ERC H&S
  2890 Woodbridge Avenue
  Building 18 (MS-101)
  Edison, NJ 08837-3679
  (908) 321-6740 or (FTS) 340-6740

To Obtain:

- Hazmat Team Planning Guidance (EPA/540/G-90/003)
- Health and Safety Audit Guidelines (EPA/540/G-89/010)

Call or Write.

- National Technical Information Service (NTIS)
  5285 Port Royal Road
  Springfield, VA 22161
  (703) 487-4600

To obtain:

- HMIRT Course Schedule

Call or Write:

- U.S. EPA/ERT
  26 West Martin Luther King
  Cincinnati, OH 45268
  (513) 569-7537 or (FTS) 684-7537

To Obtain:

- Other information on worker protection standards

Call or Write:

- Emergency Planning and Community Right-to-Know Information
  U.S EPA (OS-120)
  401 M Street, SW
  Washington, D.C. 20460
  (800) 535-0202 or (202) 479-2449
- Superfund Docket/U.S EPA
  401 M Street, SW
  Room 2427 SDIC
  Washington, D.C. 20460
  (202) 382-3046
- U.S Department of Labor
  Occupational Safety and Health Administration (OSHA)
  OSHA Publications Office, Room N3101
  200 Constitution Avenue, NW
  Washington, D.C. 20210
  (202) 523-9667
- National Institute of Occupational Safety and Health
  NIOSH Publications
  4676 Columbia Parkway
  Cincinnati, OH 45226
- Federal Emergency Management Agency (FEMA)
  P.O Box 70274
  Washington, D C. 20024
  (or contact FEMA Regional Office directly)
- Emergency Management Institute (EMI)/ National Fire Protection Academy (NFA)
  Federal Emergency Management Agency
  16825 South Seton Avenue
  Emmitsburg, MD 21727
  (301) 447-1122
- National Fire Protection Association (NFPA)
  1 Batterymarch Park
  P O Box 9101
  Quincy, MA 02269-9101
  (617) 770-3000
- Fire Protection Publications
  Oklahoma State University
  Stillwater, OK 74078-0118
  (405) 744-7576
- Superintendent of Documents
  U S Government Printing Office
  Washington, D.C. 20402
  (202) 783-3238
- National Technical Information Service (NTIS)
  5285 Port Royal Road
  Springfield, VA 22161
  (703) 487-4600

SECTION 4

AIR SURVEILLANCE

AIR SURVEILLANCE

SECTION OBJECTIVE

The objectives of this section are to:

- Discuss charactersics and types of air monitoring and sampling equipment.
- Provide students with a list of manufacturers and suppliers of air monitoring and sampling equipment.

STUDENT PERFORMANCE OBJECTIVES

After completing this section and related lesson(s), the student will be able to:

- Identify various types of air surveillance equipment.
- Discuss the basics of initial site survey and long term monitoring, and identify factors affecting an air surveillance plan.
- Compare and contrast available air surveillance techniques.
- Identify manufacturers and suppliers of air monitoring and sampling equipment.

SECTION 4

AIR SURVEILLANCE

PART 1

CHARACTERISTICS AND TYPES OF AIR SURVEILLANCE EQUIPMENT

I. INTRODUCTION

Airborne contaminants can present a significant threat to human health. Identifying and quantifying these contaminants by air monitoring is an essential component of a health and safety program at a hazardous waste site. Air monitoring data is useful for:

- Assessing the health risks to the public and response workers.
- Selecting personal protective equipment.
- Delineating areas where protection is needed.
- Determining actual or potential effects on the environment.
- Selecting actions to mitigate the hazards safely and effectively.

Direct-reading instruments were developed as early warning devices for use in industrial settings, where leaks or an accident could release a high concentration of a known chemical. Today, some direct reading instruments can detect low concentrations of contaminants as little as one part contaminant per million parts of air (ppm). Direct-reading instruments provide information at the time of sampling and do not require sending samples to a laboratory for subsequent analysis. This characteristic of direct-reading instruments enables rapid decision-making.

Many of the common types of monitoring equipment discussed in this part are listed in tabular form in **APPENDIX I**.

II. CHARACTERISTICS OF AIR MONITORING INSTRUMENTS

To be useful air monitoring instruments must be:

- Portable and rugged.
- Easy to operate.
- Inherently safe.
- Able to generate reliable and useful results.

A. Portability

A prime consideration for field instruments is portability. Transportation shock resulting from the movement from one place to another, together with unintentional abuse, shortens the usable life of an instrument. To reduce the effects of this trauma, instruments should be selected that have reinforced shells or frames, shock-mounted electronic packages, or padded containers for shipment.

Exposure to the elements and to the test atmosphere itself is of concern for those instruments repeatedly used in adverse conditions or as long-term monitors. Anodized or coated finishes, weather resistant packaging and remote sensors are effective in reducing downtime and increasing portability.

An internal power supply is important for portability. Some instruments use replaceable or rechargeable batteries and some do not require a power supply.

An instrument should not be so heavy or bulky that it is difficult for a response worker to carry.

B. Ease Of Operation

Because many of these instruments were designed for industrial use, allowances may not have been made for using the instrument while wearing protective equipment. One 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 use of the instrument should be short. Rapid warm-up, easy attachment of accessories, and quick instrument checks shorten preparation time.

C. Inherent Safety

The portable instrumentation used to characterize hazardous material spills or waste sites must be safe to use. Electrical devices, including instruments, must be constructed in such a fashion as to prevent the ignition of a combustible atmosphere. The sources of this ignition could be: an arc generated by the power source itself or the associated electronics, or a flame or heat source necessary for function of the instrument. Several engineering, insurance, and safety organizations have standardized test methods, established inclusive definitions, and developed codes for testing electrical devices used in hazardous locations. The National Fire Protection Association (NFPA) has created minimum standards in its National Electrical Code (NEC) published every 3 years. This code spells out types of areas in which hazardous atmospheres can be generated and the types of materials that generate these atmospheres, and design safeguards acceptable for use in hazardous atmospheres.

1. Hazardous Atmospheres

Depending upon the response worker's background, the term "hazardous atmosphere" conjures up situations ranging from toxic air contaminants to flammable atmospheres. For NEC purposes, an atmosphere is hazardous if it meets the following criteria:

- It is a mixture of any flammable material in air whose concentration is within the material's flammable range (i.e. between the material's lower flammable limit and its upper flammable limit).
- There is the potential for an ignition source to be present.
- The resulting exothermic reaction could propagate beyond where it started.

To adequately describe hazardous atmospheres, the NEC categories them according to their Class, Group, and Division.

a. Class and Group

Class is a category describing the type of flammable material that produces the hazardous atmosphere:

- Class I is flammable vapors and gases, such as gasoline and hydrogen. Class I is further divided into groups A, B, C, and D on the basis of similar flammability characteristics (**TABLE 1**).
- Class II consists of combustible dusts like coal or grain and is divided into groups E, F, and G (**TABLE 2**).
- Class III is ignitable fibers such as produced by cotton milling.

b. Division

Division is the term describing the "location" of generation and release of the flammable material.

- Division 1 is a location where the generation and release are continuous, intermittent, or periodic into an open, unconfined area under normal conditions.
- Division 2 is a location where the generation and release are only from ruptures, leaks or other failures from closed systems or containers.

TABLE 1
SELECTED CLASS I CHEMICALS BY GROUPS

Group A Atmospheres acetylene

Group B Atmospheres (not sealed in conduit 1/2 inch of larger)

1,3-butadiene
ethylene oxide
formaldehyde (gas)
hydrogen
manufactured gas (containing greater than 30% H_2 by volume)
propylene oxide
propyl nitrate
allyl glycidyl ether
n-butyl glycidyl ether

Group C Atmospheres (selected chemicals)

acetaldehyde	epichlorohydrin	tetrahydrofuran
carbon monoxide	ethylene	triethylamine
crotonaldehyde	ethyl mercaptan	ethylene glycol
dicyclopentadiene	hydrogen cyanide	monoethyl ether
diethyl ether	hydrogen selenide	hydrazine
di-isobutyl amine	hydrogen sulfide	chloroaldehyde
methylacetylene	morpholine	tetraethyl lead
ethylene glycol	monoethyl	(39 others)
ether acetate	nitropropane	

Group D Atmospheres (selected chemicals)

acetone	methane	acetonitrile
methanol	acrylonitrile	methyl ethyl ketone
ammonia	naphtha	benzene
propane	butane	styrene
chlorobenzene	vinyl chloride	

Source: Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (classified) Locations, 1986 National Fire Protection Association ANSI/NFPA 497M.

TABLE 2 SELECTED CLASS II CHEMICALS BY GROUPS
Group E Conductive Dusts Atmospheres containing metal dusts, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics.
Group F Semi-Volatile Dusts Atmospheres containing carbon black, coal or coke dust with more than 8% volatile material.
Group G Non-Conductive Dusts Atmospheres containing flour, starch, grain, carbonaceous, chemical thermoplastic, thermosetting and molding compounds.

Source: Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (classified) Locations, 1986 National Fire Protection Association ANSI/NFPA 497M.

2. Using this system

A hazardous atmosphere can be routinely and adequately defined. As an example, an abandoned waste site containing intact closed drums of methyl ethyl ketone, toluene and xylene would be considered a Class I, Division 2, Group D environment. However, when transferring of the flammable liquids takes place at the site, or if releases of flammable gases/vapors is considered normal, the areas would be considered Class I, Division 1.

3. Controls

The following three methods of construction exist to prevent a potential source from igniting a flammable atmosphere:

- Explosion-proof: Explosion-proof instruments allow the flammable atmosphere to enter. If an arc is generated, the ensuing explosion is contained within the specially built enclosure. Within it, any flames or hot gases are cooled prior to exiting into the ambient flammable atmosphere so that the explosion does not spread into the environment.

- Intrinsically Safe: The potential for arcing among components is reduced by encasing them in a solid insulating material. Also, reducing the instrument's operational current and voltage below the energy level necessary for ignition of the flammable atmosphere provides protection. An "intrinsically safe" device, as defined by the

National Electrical Code, is incapable "of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignited concentration. Abnormal conditions shall include accidental damage to any wiring, failure of electrical components, application of over-voltage, adjustment and maintenance operations and other similar conditions".

- Purged: The arcing or flame-producing device is buffered from the flammable atmosphere with an inert gas. In a pressurized or "purged" system, a steady stream of, nitrogen or helium is passed by the potential arcing device, keeping the flammable atmosphere from the ignition source. This type of control, however, does not satisfactorily control analytical devices that use flame or heat for analysis, such as a combustible gas indicator (CGI). It also requires a source of gas which would reduce instrument portability.

4. Certification

If a device is certified as explosion-proof,intrinsically safe, or purged for a given Class, Division, and Group, and is used, maintained, and serviced according to the manufacturer's instructions, it will not contribute to ignition. The device is not, however, certified for use in atmospheres other than those indicated. All certified devices must be marked to show Class, Division, and Group. (see **FIGURE 1**) Any manufacturer wishing to have an electrical device certified must submit a prototype to a laboratory for testing. If the unit passes, it is certified as submitted. However, the manufacturer agrees to allow the testing laboratory to randomly check the manufacturing plant at any time, as well as any marketed units. Furthermore, any change in the unit requires the manufacturer to notify the test laboratory, which can continue the certification or withdraw it until the modified unit can be retested. NFPA does not do certification testing. Testing is done by such organizations as Underwriters' Laboratory Inc. (UL) or Factory Mutual Research Corp. (FM). Currently, these are the only two testing labs recognized by OSHA.

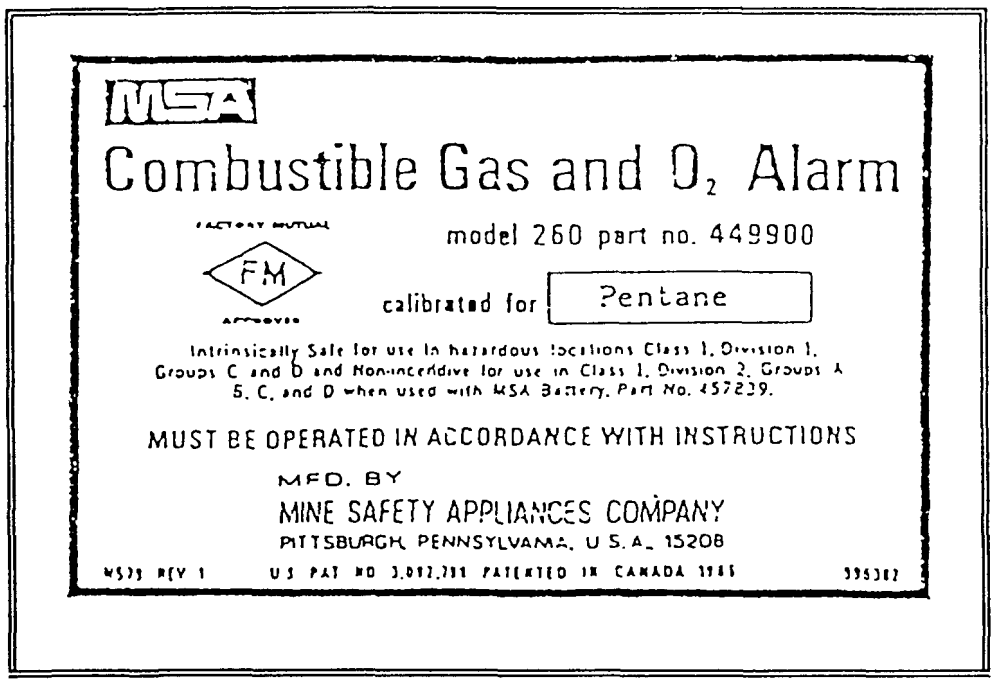


FIGURE 1
CERTIFICATION LABEL FROM MSA MODEL 260
COMBUSTIBLE GAS AND O_2 INDICATOR

To ensure personnel safety, it is recommended that only approved instruments be used on-site and only in atmospheres for which they have been certified. When investigating incidents involving unknown hazards, the monitoring instruments should be rated for use in the most hazardous locations. The following points will assist in selection of equipment that will not contribute to ignition of a hazardous atmosphere:

- The mention of a certifying group in the manufacturer's equipment literature does not guarantee certification.
- Some organizations test and certify instruments for locations different from the NEC classification. The Mine Safety and Health Administration (MSHA) tests instruments only for use in methane-air atmospheres and in atmospheres containing coal dust.
- In an area designated Division 1, there is a greater probability of generating a hazardous atmosphere than in Division 2. Therefore, the test protocols for Division 1 certification are more stringent than those for Division 2. Thus a device approved for Division 1 is also permitted for use in Division 2, but not vice versa. For most response work this means that devices approved for Class I (vapors, gases), Division 1 (areas of ignitable concentrations), Groups A, B, C, D should be chosen whenever possible. At a minimum, an instrument should be approved for use in Division 2 locations.
- There are so many Groups, Classes, and Divisions that it is impossible to certify an all-inclusive instrument. Therefore, select a certified device based on the chemicals and conditions most likely to be encountered. For example, a device certified for a Class II, Division 1, Group E (combustible metal dust) would offer little protection around a flammable vapor or gas.

D. Reliable and Useful Results

The response time, sensitivity, selectivity, accuracy and precision of an instrument are important in evaluating the reliability and usefulness of the data the instrument generates.

Response time, the interval between an instrument "sensing" a contaminant and generating data, is important to producing reliable and useful results in the field. Response time depends on: test(s) to be performed, dead time between sample periods (the time for analysis, data generation, and data display), and the sensitivity of the instrument. Response times for direct-reading instruments may range from a few seconds to several minutes.

Sensitivity is important when slight concentration changes can be dangerous. Sensitivity is defined as the ability of an instrument to accurately measure changes in concentration. Sensitive instruments can detect small changes in concentration. The lower detection limit is the lowest concentration to which instrument will respond to. The operating range is the lower and upper use limits of the instrument. It is defined by the lower detection limit at one end and the saturation concentration at the other end. It is important to use an instrument with an operating range that will accurately measure the concentration in the range of concern.

Amplification, a term often used synonymously (and incorrectly) with sensitivity, is the instrument's ability to increase very small electronic signals emanating from the detector to the readout. Changing the amplification of the detector does not change its sensitivity. However, it may be useful in calibration. Instruments with amplifier circuits can be effected by radio frequency from pulsed DC or AC power lines, transformers, generators, and radio wave transmitters.

Accuracy is defined as the relationship between a true value and the instrument reading. Precision is the indication of the reproducibility. These factors can be indicated by the error factor. For example, some detector tubes may have an error factor of $\pm 35\%$ of the true value; meaning the actual concentration of the chemical being measured is within a range of 35% higher and lower than the tube reading.

Selectivity is the ability of an instrument to detect and measure a specific chemical or group of similar chemicals. Additionally, selectivity is dependent upon interfering compounds which may produce a similar response. Selectivity and sensitivity must be reviewed and interpreted together. Interferences can effect the accuracy of the instrument reading.

Another consideration is that the instrument must give results that are immediately useful. Instruments should be direct reading, with little or no need to interpolate, integrate, or compile large amounts of data.

When selecting an instrument, compare the desired sensitivity, range, accuracy, selectivity, and ability to vary amplification of detector signals with the available instrument characteristics.

III. CALIBRATION AND RELATIVE RESPONSE

For an instrument to function properly in the field, it should be calibrated prior to use. Calibration is the process of adjusting the instrument readout so that it corresponds to the actual concentration. Calibration involves checking the instrument results with a known concentration of a gas or vapor to see that the instrument gives the proper response. For example, if a combustible gas meter is calibrated with a gas that is 20% of the lower explosive limit (LEL), then the instrument should read 20% of the LEL. If it does not read accurately, it is out of calibration and should be adjusted until accurate readings are obtained. Although an instrument is calibrated to give a one-to-one response for a specific chemical (the calibration gas), its response to other chemicals may be different. This variability is called relative response. A combustible gas indicator calibrated to pentane will give a higher instrument reading for methane than the actual concentration (see **TABLE 3**). The relative response of an instrument to different chemicals can be calculated by dividing the instrument reading by the actual concentration and is expressed as a ratio or a percent. Note that for the calibration standard the relative response should be 1.00 or 100%.

If the instrument is being used for a chemical that is not the calibration standard, then it may be possible to look at the manufacturer's information to get the relative response of that instrument for the chemical. Then the actual concentration can be calculated. For example, if the instrument's relative response for xylene is .27 (27%) and the reading is 100 ppm (parts per million), then the actual concentration is 370 ppm (.27 x actual concentration = 100 ppm, then actual concentration = 100/.27 = 370 ppm). If there is no relative response data for the chemical in question, it may be possible to recalibrate the instrument. If the instrument has adjustable settings and a known concentration is available, the instrument may be adjusted to read directly for the chemical. As recalibration takes time, this is usually done only if the instrument is going to be used for many measurements of the special chemical.

TABLE 3
RELATIVE RESPONSE FOR A COMBUSTIBLE GAS INDICATOR CALIBRATED TO PENTANE

Chemical	Concentration (% LEL)	Meter Response (% LEL)	Relative Response
Methane	50	85	170%
Acetylene	50	60	120%
Pentane	50	53	106%
1,4-Dioxane	50	37	74%
Xylene	50	27	54%

Source: Portable Gas Indicator, Model 250 & 260, Response Curves, Mine Safety Appliances Company, Pittsburgh, PA.

IV. TYPES OF DIRECT-READING INSTRUMENTS

A. Introduction

Many hazards may be present when responding to hazardous materials spills or uncontrolled waste sites. There are several types of instrumentation for detecting hazardous atmospheres. This section will discuss oxygen indicators, combustible gas indicators, and toxic atmosphere monitors.

B. Oxygen Indicators

Oxygen indicators are used to evaluate an atmosphere for the following:

- Oxygen content for respiratory purposes. Normal air is 20.9% oxygen. Generally, if the oxygen content decreases below 19.5% it is considered oxygen deficient and special respiratory protection is needed.
- Increased risk of combustion. Generally, concentrations above 25% are considered oxygen-enriched and increase the risk of combustion.
- Use of other instruments. Some instruments require sufficient oxygen for operation. For example, some combustible gas indicators do not give reliable results at oxygen concentrations below 10%. Also, the inherent safety approvals for instruments are for normal atmospheres and not for oxygen enriched ones.
- Presence of contaminants. A decrease in oxygen content can be due to the consumption (by combustion or a reaction such as rusting) of oxygen or the displacement of air by a chemical. If it is due to consumption then the concern is the lack of oxygen. If it is due to displacement then there is something present that could be flammable or toxic.

Oxygen deficient atmospheres may occur in unventilated areas or may by due to terrain variations in cases where heavier than air vapors may collect. Most indicators have meters which display the oxygen concentration from 0-25%. There are also oxygen indicators available which measure concentrations from 0-5% and 0-100%. The most useful range for response is the 0-25% oxygen content readout since decisions involving air-supplying respirators and the use of combustible gas indicators fall into this range.

Many instrument manufacturers make oxygen meters. They can be small hand-held units with or without pumps to draw the sample across the detector cell. Some pumps are single aspirating (hand-squeeze) bulbs, others are battery powered diaphragm pumps. Units that combine O_2 meters and combustible gas indicators into one instrument are available from a number of manufacturers. Also, flashing and audible alarms can be found on many instruments. These alarms go off at a pre-set oxygen concentration to alert the users even if they are not watching the meter. Manufacturers of oxygen indicators are found at the end of this manual section.

1. Principle of Operation

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

air is allowed to diffuse to the sensor. The oxygen detector uses an electrochemical sensor to determine the oxygen concentration in air. A typical sensor consists of: two electrodes; a housing containing a basic electrolytic solution; and a semipermeable Teflon membrane (**FIGURE 2**).

Oxygen molecules (O_2) diffuse through the membrane into the solution. Reactions between the oxygen, the solution and the electrodes produce a minute electric current proportional to the oxygen content. The current passes through the electronic circuit. The resulting signal is shown as a needle deflection on a meter or digital reading.

2. Limitations and Considerations

The operation of oxygen meters depends on the absolute atmospheric pressure. The concentration of natural oxygen (to differentiate it from manufactured or generated oxygen) is a function of the atmospheric pressure at a given altitude. While the actual percentage of oxygen does not change with altitude, at sea level the weight of the atmosphere above is greater, and more O_2 molecules (and the other components of air) are compressed into a given volume than at higher elevations. As elevation increases, this compression decreases, resulting in fewer air molecules being "squeezed" into a given volume. Consequently, an O_2 indicator calibrated at sea level and operated at an altitude of several thousand feet will falsely indicate an oxygen deficient atmosphere because less oxygen is being "pushed" into the sensor. Therefore, it is necessary to calibrate at the altitude the instrument is used.

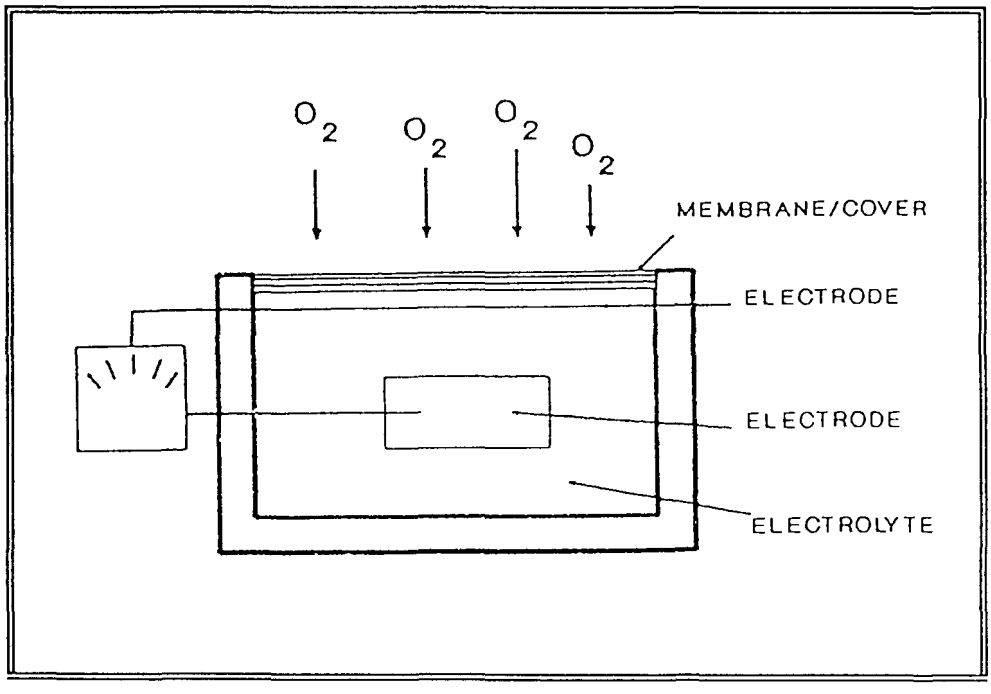


FIGURE 2
SCHEMATIC OF OXYGEN SENSOR

Selection from Product Literature, Rexnard Electronic Products Division, Biomarine Oxygen Sensor, by Rexnard, Inc., reprinted with permission of publisher.

High concentrations of carbon dioxide (CO_2) shorten the useful life of the oxygen sensor. As a general rule, the unit can be used in atmospheres greater than 0.5% CO_2 only with frequent replacing or rejuvenating of the sensor. Lifetime in a normal atmosphere (0.04% CO_2) can be from one week to one year depending on the manufacturer's design.

Temperature can affect the response of oxygen indicators. The normal operating range for them is between 32°F and 120°F. Between 0°F and 32°F the response of the unit is slower. Below 0°F the sensor may be damaged by the solution freezing. The instrument should be calibrated at the temperature at which it will be used.

Strong oxidizing chemicals, like ozone and chlorine, can cause increased readings and indicate high or normal O_2 content when the actual content is normal or even low.

C. Combustible Atmosphere Indicators

Combustible gas indicators (CGIs) measure the concentration of a flammable vapor or gas in air, indicating the results as a percentage of the lower explosive limit (LEL) of the calibration gas.

The LEL (or LFL - lower flammable limit) of a combustible gas or vapor is the minimum concentration of the material in air which will propagate flame on contact with an ignition source. The upper explosive limit (UEL) is the maximum concentration. Above the UEL, the mixture is too "rich" to support combustion so ignition is not possible. Below the LEL there is insufficient fuel to support combustion.

CGI's 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 square bulbs or automatic (battery-powered) diaphragm types. Many units are "combination meters". This means they have an O_2 meter and CGI (and sometimes one or two specific gas indicators) combined in the same instrument. Flashing and audible alarms are options on many units. The alarms go off at a pre-set concentration to warn the instrument operator of potentially hazardous concentrations. Other options such as larger sampling lines, moisture taps, all dust filters are also available. Manufacturers of CGIs are listed at the end of this manual section.

Concentrations between the LEL and the UEL are considered flammable.

1. Principle of Operation

Combustible gas indicators use a combustion chamber containing a filament that combusts the flammable gas. To facilitate combustion the filament is heated or is coated with a catalyst (like platinum or palladium), or both. The filament is part of a balanced resistor circuit called a Wheatstone Bridge. 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 causes an

imbalance in the Wheatstone Bridge. This is measured as the ratio of combustible vapor present compared to the total required to reach the LEL. For example, if the meter reads 0.5 (or 50%, depending upon the readout), this means that 50% of the concentration of combustible gas needed to reach a flammable or combustible situation is present. If the LEL for the gas is 5% then the meter indicates that a 2.5% concentration is present. Thus, the typical meter readout indicates concentration up to the LEL of the gas. See **FIGURE 3a**.

If a concentration greater than LEL and lower than the UEL is present, then the meter needle will stay beyond the 1.0 (100%) level on the meter. See **FIGURE 3b.** This indicates that the ambient atmosphere is readily combustible. When the atmosphere has a gas concentration above the UEL the meter needle will usually rise above the 1.0 (100%) mark and then return to zero. See **FIGURE 3c**. This occurs because the gas mixture in the combustion cell is too rich to burn. This permits the filament to conduct a current just as if the atmosphere contained no combustibles at all. Some instruments have a lock mechanism that prevents the needle from returning to zero when it has reached 100% and must be reset in an atmosphere below the LEL.

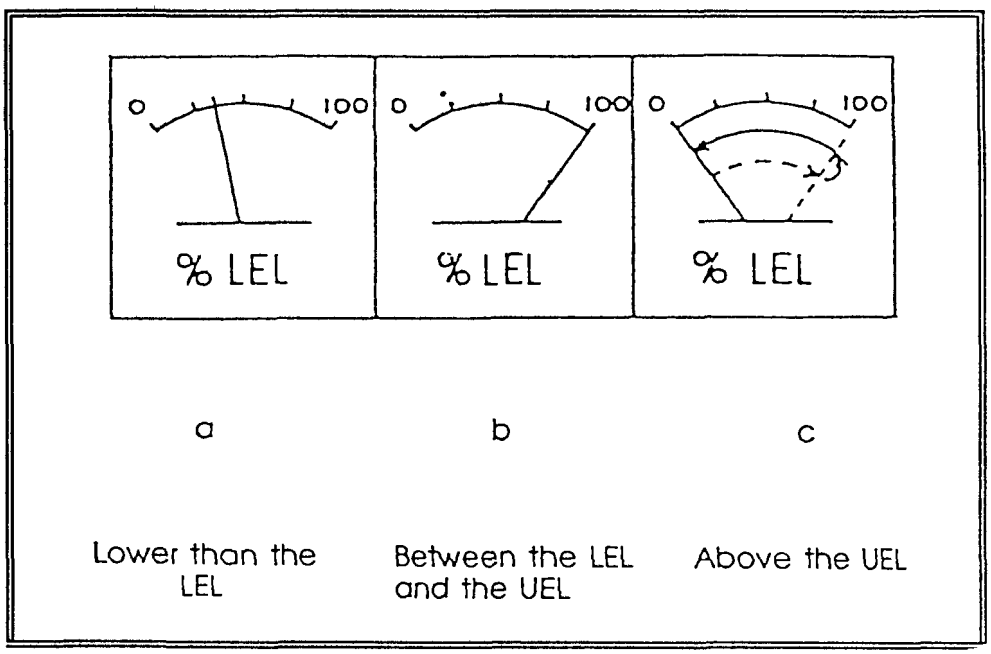


FIGURE 3
COMPARISON OF METER READINGS TO COMBUSTIBLE GAS CONCENTRATIONS

2. Limitations and Considerations

The response of the instrument is temperature dependent. If the temperature at which the instrument is zeroed differs from the sample temperature, the accuracy of the reading is affected. Hotter temperatures raise the temperature of the filament and produce a higher than actual reading. Cooler temperatures will reduce the reading. It works best to calibrate and zero the instrument at the sample temperature.

The instruments are intended for use only in normal oxygen atmospheres. Oxygen-deficient atmospheres will produce lowered readings. Also the safety guards that prevent the combustion source from igniting a flammable atmosphere are not designed to operate in an oxygen-enriched atmosphere.

Organic lead vapors (e.g. gasoline vapors), sulfur compounds, and silicone compounds will foul the filament. Acid gases (e.g. hydrogen chloride and hydrogen fluoride) can corrode the filament. Most units have an optional filter that protects the sensor from leaded vapors.

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 can't 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 (i.e. the contaminant) is present.

D. Toxic Atmosphere Monitors

Along with oxygen concentration and flammable gases or vapors, there is a concern about chemicals present at toxic concentrations.

This usually involves measurements at concentrations lower than would be indicated by oxygen indicators or combustible gas indicators. There is a need to determine if toxic chemicals are present and identify them so the environmental concentration can be compared to exposure guidelines. Toxic atmosphere monitoring is done to:

- identify airborne concentrations that could pose a toxic risk to response workers and the public.
- evaluate the need for and type of personal protective equipment.
- set up work zones or areas where contaminants are or are not present.

There are several different groups of instruments that can be used for these functions.

1. Colorimetric Indicator Tubes (Detector Tubes)

a. Principle of Operation

Colorimetric indicator tubes consist of a glass tube impregnated with an indicating chemical (**FIGURE 4**). The tube is connected to a piston- or bellows- type pump. A known volume of contaminated air is pulled at a predetermined rate through the tube by the pump. The contaminant reacts with the indicator chemical in the tube, producing a change in color whose length is proportional to the contaminant concentration.

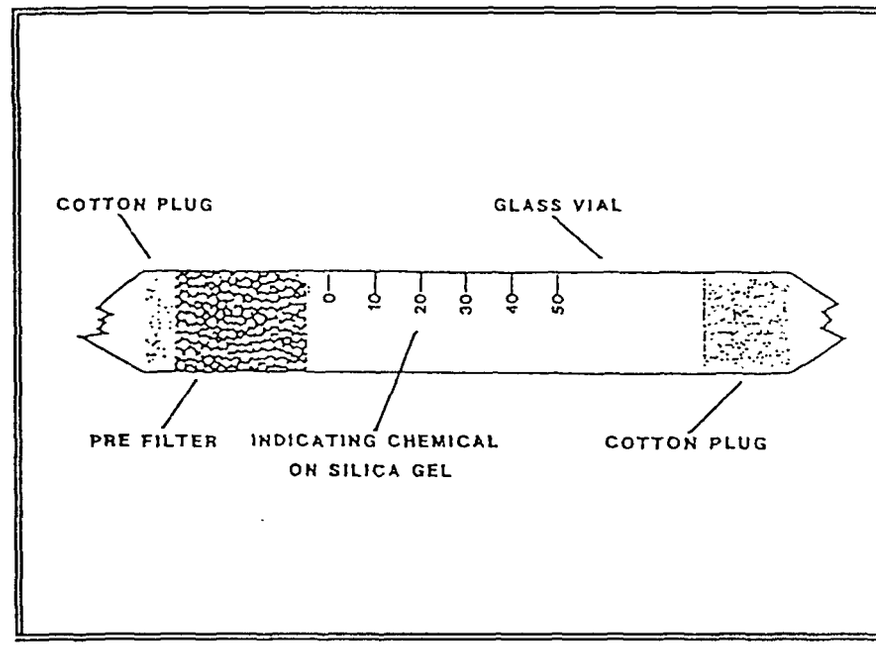


FIGURE 4
DIRECT-READING COLORIMETRIC INDICATOR TUBE

Detector tubes are normally chemical specific. There are different tubes for different gases; for example, chlorine detector tube for chlorine gas, acrylonitrile tube for acrylonitrile gas, etc. Some manufacturers do produce tubes for groups of gases, e.g. aromatic hydrocarbons, alcohols. Concentration ranges on the tubes may be in the ppm or percent range. A preconditioning filter may precede the indicating chemical to:

- remove contaminants (other than the one in question) that may interfere with the measurement. Many have a prefilter for removing humidity.
- react with a contaminant to change it into a compound that reacts with the indicating chemical.

"Haz-mat kits are available from at least two manufacturers. These kits identify or classify the contaminants as a member of a chemical group such as acid gas, halogenated hydrocarbon, etc. This is done by sampling with certain combinations of tubes at the same time by using a special multiple tube holder or by using tubes in a specific sampling sequence. Detector tube manufacturers are listed at the end of this manual section.

b. Limitations and Considerations

Detector tubes have the disadvantage of poor accuracy and precision. In the past, the National Institute for Occupational Safety and Health (NIOSH) tested and certified detector tubes that were submitted to them. For the tubes they tested they certified the accuracy to be $\pm 35\%$ at concentrations at 1/2 the OSHA Permissible Exposure Limit (PEL) and $\pm 25\%$ at 1 to 5 times the PEL. NIOSH has discontinued testing and certification. Special studies have reported error factors of 50% and higher 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. To reduce this problem it is recommended that the tubes be kept warm (for example, inside a coat pocket) until they are used if the measurement is done in cold weather. 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 during storage.

Some tubes do not have a prefilter to remove humidity and may be affected by high humidity. The manufacturer's instructions usually indicate if humidity is a problem and list any correction factors to use if the tube is affected by humidity.

The chemical used in the tubes deteriorates over time. Thus the tubes are assigned a shelf life. This varies from 1 to 3 years. Shelf life can be extended by refrigeration but the tube should equilibrate to ambient temperature before use.

An advantage that detector tubes have over some other instruments is that it is possible to select a tube that is specific to a chemical. However, some tubes will respond to interfering compounds. Fortunately, the manufacturers provide information with the tubes on interfering gases and vapors.

Interpretation of results can be a problem. Since the tube's 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; others may have an uneven endpoint. When in doubt use the highest value that would be obtained from reading the different aspects of the tube.

The total volume to be drawn through the tube varies with the tubes. The volume needed is given as the number of pump strokes needed, i.e. the number of times the piston or bellows is manipulated. Also, the air does not instantaneously go through the tube. It may take 1 to 2 minutes for each volume (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.

Due to these many considerations, it is very important to read the instructions that are provided with and are 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.

While there are many limitations and considerations for using detector tubes, 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.

2. Specific Chemical Monitors

There are several gas monitors which utilize electrochemical cells or metal oxide semi-conductors (MOS) for detecting specific chemicals. MOS detectors change conductivity when exposed to certain gases or vapors. They can be designed to respond to a large group of chemicals or to a specific chemical. The most common monitors are used to detect carbon monoxide or hydrogen sulfide but there are also monitors available for hydrogen cyanide, ammonia and chlorine. They are more accurate than detector tubes but there are only about a dozen different chemicals they can monitor.

3. Photoionization Detector (PID)

These instruments detect concentrations of gases and vapors in air by utilizing an ultraviolet light source to ionize the airborne contaminant. Once the gas or vapor is ionized in the instrument, it can be detected and measured.

a. Principle of Operation

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. The interaction of the oppositely charged particles and the laws of quantum mechanics keep the electrons in orbits outside the nucleus.

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 (see **TABLE 4**). Ionization potentials are measured in electron volts (eV). High frequency radiation (ultraviolet and above) is capable of causing ionization and is hence called ionizing radiation.

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. Since ions are charged particles, they may be collected on a charged plate and produce a current. The measured current will be directly proportional to the number of ionized molecules (see **FIGURE 5**).

The photoionization process can be illustrated as:

$$R + h \rightarrow R^{+} + e$$

where R is an organic or inorganic molecule and h represents a photon of UV light with energy equal to or greater than the ionization potential of that particular chemical species. R^{+} is the ionized molecule.

TABLE 4
IONIZATION POTENTIALS OF SELECTED CHEMICALS

Chemical	Ionization Potential (eV)
Hydrogen cyanide	13.9
Carbon dioxide	13.8
Methane	13.0
Hydrogen chloride	12.5
Water	12.6
Oxygen	12.1
Chlorine	11.5
Propane	11.1
Hydrogen sulfide	10.5
Hexane	10.2
Ammonia	10.1
Vinyl chloride	10.0
Acetone	9.7
Benzene	9.2
Phenol	8.5
Ethyl amine	8.0

PIDs use a fan or a pump to raw 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.

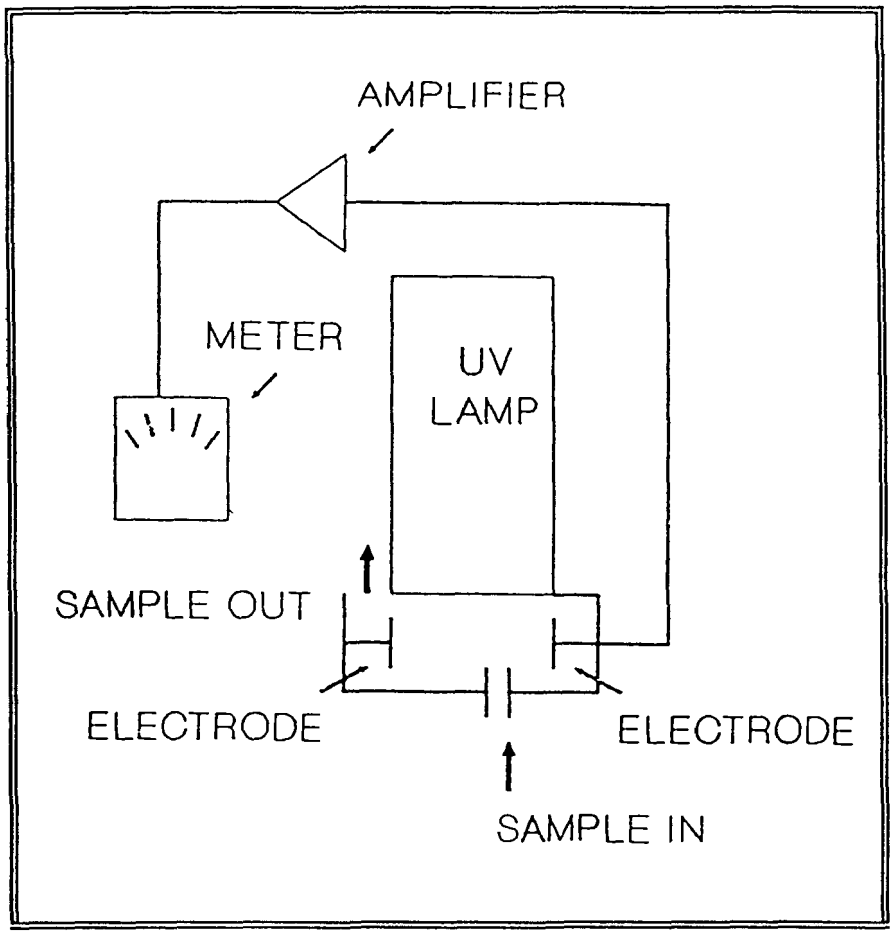


FIGURE 5
DIAGRAM OF PHOTOIONIZATION DETECTOR LAMP AND COLLECTING ELECTRODES

b. Photoionization Considerations and Limitations

Since the ability to detect a chemical depends on the ability to ionize it, the IP of a chemical to be detected must be compared to the energy generated by the UV lamp of the instrument. As can be seen from **TABLE 4** there is a limit imposed by the components of air. That is to say, the lamp cannot be too energetic or oxygen and nitrogen will ionize and interfere with the readings for contaminants. The energy of lamps available are 8.3, 8.4, 9.5, 10.2, 10.6, 10.9, 11.4, 11.7 and 11.8 eV. Not all lamps are available from a single manufacturer.

One use of the different lamps is for selective determination of chemicals. For example, if a spill of propane and vinyl chloride were to be monitored with a PID the first check would be to see if they 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 an energy greater than 11.1 eV is needed (like a 11.7 or 11.8). If vinyl chloride was the chemical of concern, then a lamp with an energy greater than 10.0 but less than 11.1 (such as 10.2 of 10.6) could be used. The propane would neither be 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. Dust in the atmosphere can collect on the lamp and block the transmission of UV light. This will cause a reduction in instrument reading. This problem will be detected during calibration and the lamp should be cleaned on a regular basis.

Humidity can cause two problems. When a cold instrument is taken into a warm moist atmosphere, the moisture can condense on the lamp. Like dust this will reduce the available light. Moisture in the air also reduces the ionization of chemicals and cause a reduction in readings.

Since an electric field is generated in the sample chamber of the instrument, radio-frequency interference from pulsed DC or AC power lines, transformers, generators, and radio wave transmission may produce an error in response.

As the lamp ages the intensity of the light decreases. It will still have the same ionization energy, but the response will decline. This will be detected during calibration and adjustments can be made. 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. **TABLE 5** shows the relative responses of several chemicals for a specific PID.

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.

Units which utilize photoionization include the Thermo Environmental Instruments Model 580A, the Photovac TIP and the HNU PI 101.

TABLE 5 RELATIVE RESPONSES FOR SELECTED CHEMICALS USING THE HNU MODEL PI 101 WITH 10.2 eV PROBE CALIBRATED TO BENZENE	
Chemical	Relative Response
m-Xylene	1.12
Benzene	1.00
Phenol	0.78
Vinyl chloride	0.63
Acetone	0.50
Hexane	0.22
Phosphine	0.20
Ammonia	0.03

Source: Instruction Manual for Model PI 101, Portable Photoionization Analyzer, HNU Systems, Inc., Newton, MA, 1986.

c. HNU PI 101 Photoionization Detector

The HNU PI 101 consists of two modules connected via a single power cord (**FIGURE 6**):

- A read-out unit consisting of a 4.5 inch analog meter, a rechargeable battery, and power supplies for operation of the amplifier and the UV lamp.
- A sensor unit consisting of the UV light source, pump, ionization chamber, and a preamplifier.

The unit has a separate sensor unit because the lamps available - 8.3, 9.5, 10.2 (standard) and 11.7 eV - require separate electronic circuits. To change the energy of ionization the whole sensor or probe has to be switched and not just the lamp. Lamps are replaceable.

d. Photovac TIP (Total Ionizables Present)

The TIP has components similar to those the HNU has, but they are all contained in an 18 inch long and 2.5 inch diameter unit. The standard lamp is 10.6 eV, but it can easily be replaced with a 8.4, 9.5, 10.2, or 11.7 eV lamp. A separate sensor is not used. The readout is digital with a range of 0 to 2000. The instrument also has a replaceable dust filter to eliminate collection on the lamp.

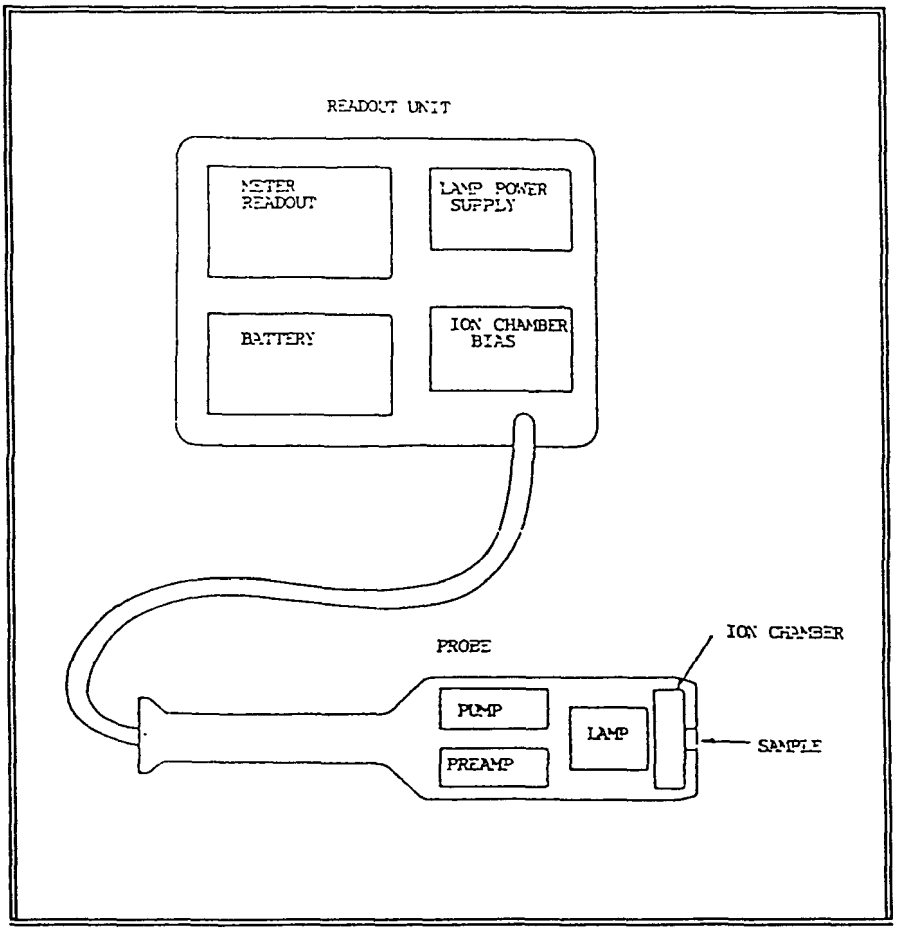


FIGURE 6
PORTABLE PHOTOIONIZATION DETECTOR

Selection from Instruction Manual for Model PI 101 Photoionization Detector, by HNU Systems, Inc., copyrighted 1975, by HNU Systems, Inc., reprinted with permission of Publisher.

e. (Organic Vapor Meter Model 580A) (Thermo Environmental Instrument)

The Organic Vapor Meter (OVM) is 5" by 5" by 10" with a handle on top and in the center. It can use any of four different lamps - 9.5, 10.0, 10.6 (standard), 11.8 eV. The instrument has a digital readout with a range of 0 to 2000. It has a maximum hold feature so that you can get two readings - the current concentration or the maximum concentration during the survey. The meter has a lock-out if the readout exceeds 2000 so that high concentrations are not missed. It must be reset in an area of low concentrations. The instrument has a microprocessor for assistance in calibration and lamp changing.

The unit also has connections and software for interfacing the unit with a personal computer and a data logger for recording readings at

coded locations so that the readings can be looked at later or unloaded into a computer.

Photoionization detectors are also used in gas chromatographs made by Photovac, HNU and Thermo Environmental Instruments. Gas chromatography will be discussed later in this part.

4. Flame Ionization Detector (FID)

These units utilize combustion as the means to ionize airborne contaminants. Once they are ionized, they can be detected and measured.

a. Principle of Operation

Flame ionization detectors use a hydrogen flame as the means to ionize organic (toxic) vapors. FID responds to virtually all organic compounds, that is, compounds that contain carbon-hydrogen or carbon-carbon bonds. The flame detector analyzes by the mechanism of breaking bonds as the following reaction indicates:

$$RH + 0 \rightarrow RHO^{+} + e- \rightarrow CO_2 + H_2O$$

Inside the detector chamber, the sample is exposed to a hydrogen flame which ionizes the organic vapors. When most organic vapors burn, positively charged carbon-containing ions are produced which are collected by a negatively charged collecting electrode in the chamber. An electric field exists between the conductors surrounding the flame and a collecting electrode. As the positive ions are collected, a current proportional to the hydrocarbon concentration is generated on the input electrode. This current is measured with a preamplifier which has an output signal proportional to the ionization current. A signal conducting amplifier is used to amplify the signal from the preamp and to condition it for subsequent meter or external recorder display.

Flame ionization detectors have a more generalized response in detecting organic vapors. This generalized sensitivity is due to the breaking of chemical bonds which require a set amount of energy and is a known reproducible event. When this is compared to Photoionization (PID), a major difference should be noted between the detectors. PID detection is dependent upon the ionization potential (eV) and the ease in which an electron can be ionized (displaced) from a molecule. This mechanism is variable, highly dependent on the individual characteristics of a particular substance. This results in a more variable response factor for the vast majority of organics that are ionizable. Therefore, in general, one does not see large sensitivity shifts between different substances when using

an FID as compared to a PID. Flame ionization detectors are the most sensitive for saturated hydrocarbons, alkanes and unsaturated hydrocarbons alkenes. Substances that contain substituted functional groups such as hydroxide (OH^-), and chloride (Cl^-), tend to reduce the detector's sensitivity; however, overall, the detectabilities remain good.

Companies that manufacture FIDs include Beckman Industrial, The Foxboro Company and Thermo Environmental Instruments. The Foxboro Century Organic Vapor Analyzer (OVA) will be discussed as an example later.

b. Flame Ionization Detector Considerations

Flame ionization detectors respond only to organic compounds. Thus, they do not detect inorganic compounds like chlorine, hydrogen cyanide, or ammonia.

As with all instruments, flame ionization detectors respond differently to different compounds. **TABLE 6** is a list of the relative responses of the Foxboro CENTURY OVA to some common organic compounds. Since that instrument is factory calibrated to methane, all responses are relative to methane and are given by percentage, with methane at 100%.

Thus with all survey-type instruments, the identity of the chemical of interest must be ascertained before its concentration can be determined. However, the CENTURY OVA can be purchased as a dual mode survey-gas chromatograph and can separate and define the components present in a gas mixture. As with all instruments, individuals should be trained for best operation and performance. Experience in gas chromatography is an important aspect to successful operation of the chromatographic option.

TABLE 6 RELATIVE RESPONSES FOR SELECTED CHEMICALS USING THE OVA CALIBRATED TO METHANE	
Compound	**Relative Response**
Methane	100
Ethane	90
Propane	64
n-Butane	61
n-Pentane	100
Ethylene	85
Acetylene	200
Benzene	150
Toluene	120
Acetone	100
Methyl ethyl ketone	80
Methyl isobutyl ketone	100
Methanol	15
Ethanol	25
Isopropyl alcohol	65
Carbon tetrachloride	10
Chloroform	70
Trichlorethylene	72
Vinyl chloride	35

Selection from Product Literature, The Foxboro Company, with permission of the Foxboro Company.

c. Foxboro CENTURY Organic Vapor Analyzer (OVA)

(The Foxboro CENTURY OVA consists of two major parts **(FIGURE 7)**

- A 12-pound package containing the sampling pump, battery pack, support electronics, flame ionization detector, hydrogen gas cylinder, and an optional gas chromatography (GC) column.
- A hand-held meter/sampling probe assembly.

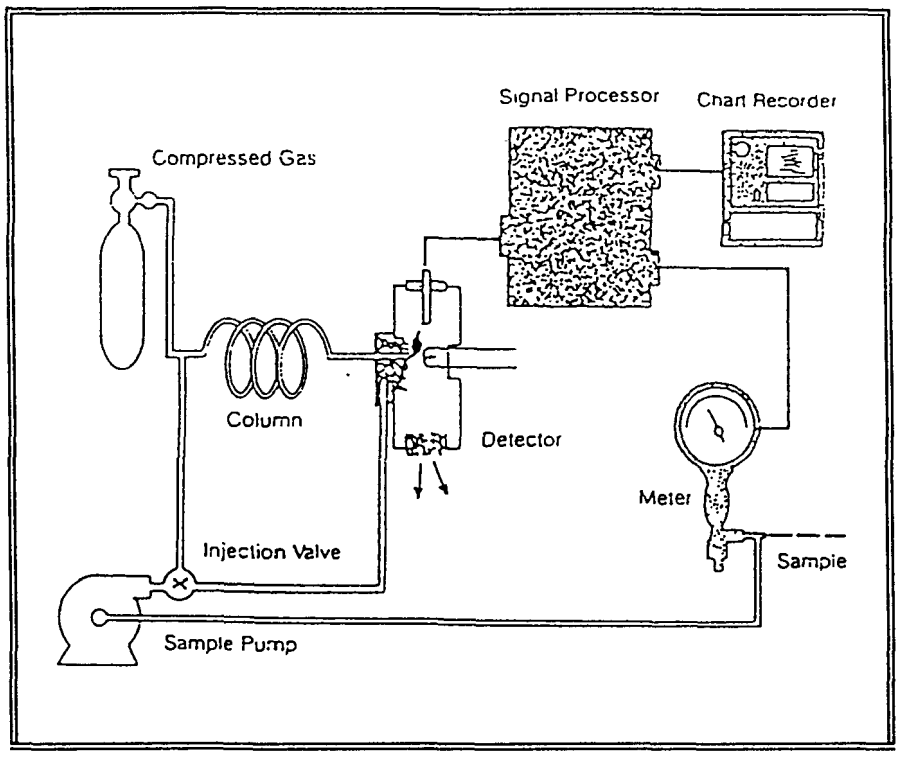


FIGURE 7
ORGANIC VAPOR ANALYZER SCHEMATIC

Selection from Product Literature, The Foxboro Company, with permission of the Foxboro Company.

The OVA is generally calibrated to methane, but can be calibrated to the species of interest.

The OVA can operate in two modes:

Survey mode: During normal survey mode operation, a sample is drawn into the probe and transmitted to the detector chamber by an internal pumping system. When the sample reaches the FID it is ionized as described before and the resulting signal is translated on the meter for direct-reading concentration as total organic vapors or recorded as a peak on a chart. The meter display is an integral part of the probe/readout assembly and has a scale from 0 to 10 which can be set to read 0-10, 0-100, or 0-1000 ppm.

Gas chromatography mode: Gas chromatography (GC) is a technique for separating components of a sample and qualitatively and quantitatively identifying them. The sample to be separated is injected into a column packed with an inert solid. As the carrier gas (for the OVA it is hydrogen) forces the sample through the column, the separate components of the sample are retained on the column for different periods of time. The amount of time a substance remains on the column, which is called its retention time, is a function of its

affinity for the column material, column length, column temperature, and flow rate of the carrier gas. Under preset instrumental conditions each component elutes from the column at a different but reproducible length of time. As the components elute from the column, they flow into the detector. Since the output of the detector can be connected to a strip chart recorder, separate peaks are recorded for each component. This readout is called a gas chromatogram (see Qualitative identification is made by measuring retention time. Retention time is defined as the period of time that elapses between the injection of the compound into the column and the elution of that compound as represented by a peak. Retention can be expressed as a function of either time or the measured distance between the injection point and the peak on the strip chart recorder. If the retention time of an unknown chemical agrees with the retention time of a known chemical recorded under the same set of analytical conditions, the unknown is tentatively identified. In addition, the area under the peak is proportional to the concentration of the corresponding sample component. If these areas are compared to the areas of standards, recorded under identical analytical conditions, the concentration of the sample components can be calculated. (See **FIGURE 8**)

5. Catalytic Combustion Detectors

There are toxic monitors which use the same detection system as CGIs but are more sensitive. In a sense they are super sensitive CGIs with readouts in ppm instead of %LEL. Since the detection method is similar, they have the same limitations and considerations as CGIs.

Some of these instruments, e.g. the Bacharach TLV Sniffer, give only readings in parts per million (ppm). There are combination units, e.g. Gastec Models 1238 and 1314, which give ppm readings along with %LEL and oxygen readings.

6. Infrared Spectrophotometer

a. Principle of Operation

The infrared spectrophotometer is a compound- specific instrument. Each compound being analyzed will absorb radiation at a discrete infrared wavelength. The unit measures how much of the infrared energy (IR) is absorbed and gives readings of percent IR absorbed or ppm of chemical.

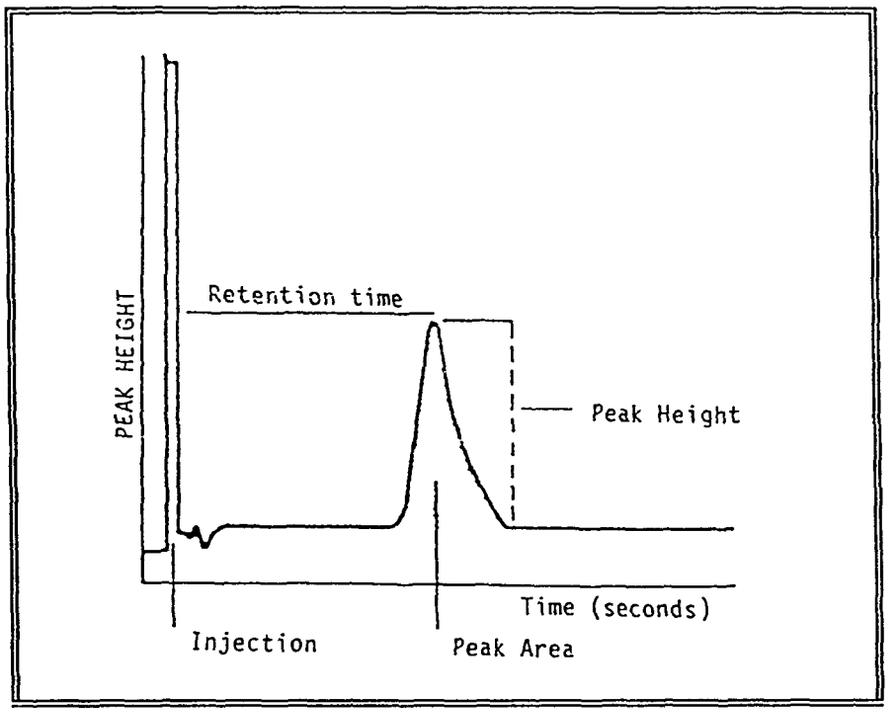


FIGURE 8
EXAMPLE OF A GAS CHROMATOGRAM

Selection from Product Literature, The Foxboro Company, reprinted with permission of The Foxboro Company.

Molecules are composed of atoms which are held together by bonds of various types and lengths. These arrangements, as in the ball and spring configurations presented in introductory chemistry, establish finite locations and discrete movements for each atom (ball) and bond (spring). These movements can be either vibrational, rotational, stretching, or bending of the chemical bonds. The frequencies of these movements are on the order of infrared radiation. A given bond movement can be initiated by stimulating the molecule with IR of varying frequency. As the bond moves, it absorbs the characteristic energy associated with that movement. The frequencies and intensity of IR absorbed are specific for a compound and its concentration, providing a "fingerprint" which can be used as an analytical tool.

Foxboro, Perkin-Elmer, and Beckman are producers of portable infrared spectrophotometers. The MIRAN is manufactured by Foxboro and is discussed below (**FIGURE 9**).

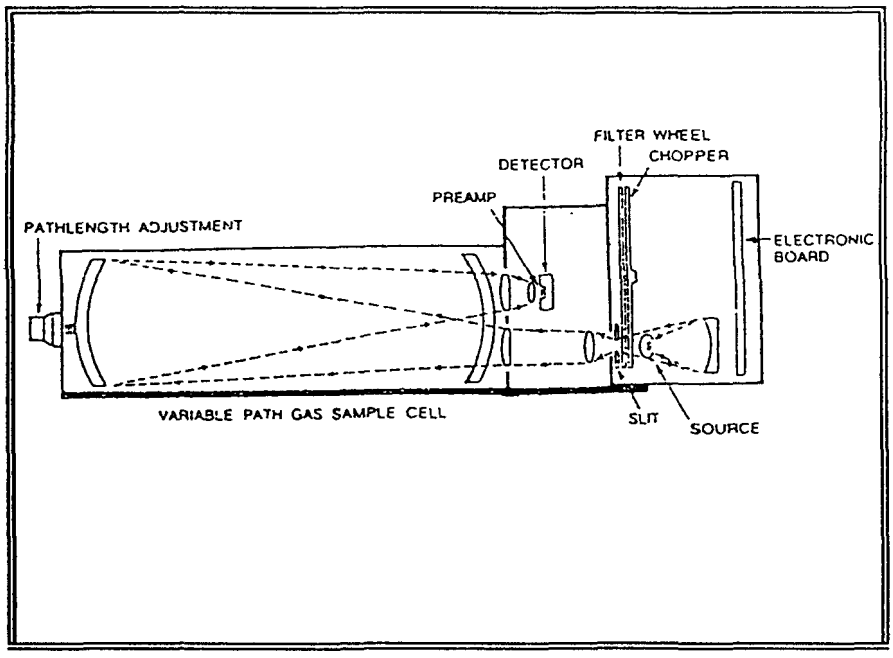


FIGURE 9
OPTICAL SCHEMATIC OF MIRAN ANALYZER

b. The MIRAN (miniature infrared analyzer) is a field IR spectrophotometer which uses a variable length gas cell to measure concentrations of vapors in ambient air. The air sample is drawn into a chamber for exposure to IR. Several movable mirrors permit repeated passes, producing paths from several centimeters to several meters. The longer the path length the better the detector response.

Field analysis presents problems not normally encountered with spectrophotometry in the laboratory. With lab instruments, the analyst can control the concentration of material entering the sample cell. Liquid or solid samples are preferable to gas samples because they possess more molecules than a gas of the same volume. Additionally, the spectra of analyses of the same chemical in the liquid phase and gaseous phase are markedly different. To analyze gas samples the IR beam in the MIRAN must make repeated passes to achieve reliable results. In the gaseous state, the molecules are free to rotate, and inter-molecular actions are at a minimum. The liquid state "locks" the molecules in a given structure.

c. Limitations and Considerations

The MIRAN is designed for industrial hygiene work in occupational settings where known types of materials are generated. Thus it is easy to select the IR frequency that is specific for the chemical in question.

If the contents of the atmosphere are not known, a full scan of the IR spectrum could be done to pick up any peaks. However, if many chemicals were present it would be difficult to identify a specific

chemical because of the many absorption peaks. If the instrument is just looking at a "fingerprint" peak, there is the possibility that a chemical could absorb at a peak that is not its "fingerprint" and cause a false indication.

The instrument needs a flat or level surface free from vibration so that the internal mirrors do not move and effect the light path.

7. Aerosol Monitors

Not all toxic materials dispersed in air are in the form of a gas or vapor. Solids and liquids can become suspended in air by combustion, splashing liquids or by disturbing soil.

There are direct-reading instruments that measure aerosols, i.e. dust, mist, fume, smoke, fog, spray. Most of them use a light source and a light sensor that measures the amount of light scattered by the aerosol. Readouts are in milligrams per cubic meter (mg/m^3). Some examples are MIE Incorporated RAM-1 and MINIRAM and TSI Incorporated's Model 5150.

Other methods of detection are the piezoelectric crystal mass monitor and beta attenuation. The piezoelectric crystal mass monitor uses a crystal that resonates at a certain frequency as electric current is applied to it. As particles collect on the crystal its resonant frequency changes and the change is measured. An instrument using this detector is TSI Incorporated's Model 3500.

Beta attenuation measures the attenuation of beta radiation by particles collected on a surface between the beta source and a beta detector. GCA Corporation's Model RDM-101 is an instrument using this type of detector.

Accessories for these types of instruments include; an attachment that only allows collection of "respirable" particles (i.e., ones that collect in the lungs) instead of the total particles in air; and integrators for giving average concentrations.

It is important to remember that these instruments give the total amount of particulate and not the type of particulate. Individual content, e.g., lead or arsenic, must be analyzed separately. However, if the content of the sample is known, then the direct-reading instrument could be used if content of the dust is assumed to remain constant. For example, if the dust being detected is 5% lead and 1% arsenic and the concentration of dust is 2 mg/m^3 then the concentration of lead and arsenic are 0.1 mg/m^3 and 0.02 mg/m^3 respectively ($0.05 \times 2\ mg/m^3 = 0.1\ mg/m^3$ and $0.01 \times 2\ mg/m^3 = 0.02\ mg/m^3$).

8. Accessories/Options

As mentioned earlier, instruments combining more than one detector can be found. For examples, "trimeters" and "quadmeters" combine an oxygen indicator, a combustible gas indicator and one or two toxic monitors. Also there are units with alarms that indicate readings that are above or below a concentration of concern, strip chart (printed) outputs, and electronic outputs for data storage.

Some instruments have an integrator that averages concentrations while the instrument is operating or over a specified time, e.g. 15 minutes. This permits use of the instrument as a long term monitor as well as a direct-reading instrument.

One of the more recent additions is the microprocessor. This can be used with a gas chromatograph so the microprocessor "reads" the output and compares it to calibration information in its memory. That way the instrument instead of the operator qualifies and quantifies the chemicals. In some cases the operator asks the microprocessor to check for a chemical and the unit uses its memory to match retention time and peak height. Microsensor's Micromonitor, the Photovac 10S50, and the Sentex Scentor use this capability. The MIRAN 1B uses the microprocessor to select the fingerprint frequency for the chemical requested. The main limitation with the microprocessors are the number of chemicals in their memory or "library". What the microprocessor doesn't recognize it can't identify. Most portable units have libraries for up to 100 chemicals. Also the detection method (PID, FID, etc.) used must be considered as that limits the number of chemicals that can be identified.

9. Programmed Thermal Desorber (PTD)

The Programmed Thermal Desorber (Foxboro PTD-132A) is not a detection system but does aid in on-site evaluation of air samples. It utilizes the principle of thermal desorption to extract contaminants from carbon or other sorbent tubes. The instrument performs this function automatically and has the ability to store the desorbed sample in a 300 ml chamber and to make replicate sample injections into a gas chromatograph or other analytical instrument. It allows rapid on-site analysis of collected air samples. Within the instrument is a small oven which is used to heat the sorbent tube to temperatures ranging from 100°-350°C depending upon the application. This heating has the effect of separating the sample from the sorbent, thus freeing it to be carried by a flow of clean carrier gas to the storage chamber. From there, the sample is released in carefully controlled amounts into the analytical instrument of choice. If the instrument is a gas chromatograph, the chromatogram is recorded in the normal fashion and the peaks are qualitatively and quantitatively determined. The calculations necessary to find the concentration of contaminant in the original air sample are simple volumetric ratios. While the PTD was designed to be used with the Foxboro CENTURY Organic Vapor Analyzer with a gas chromatograph accessory, it can be used with other instruments.

V. REFERENCES

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2. Cee, R.J., J.C. Septon, J.C. Ku and T. Wilczek: " An Evaluation of Commercial Detector Tube Systems." Paper presented at American Industrial Hygiene Conference, Montreal, Canada, June 1987.

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4. Clayton, G.D., and F.E. Clayton (ed.): Patty's Industrial Hygiene and Toxicology, 3rd review ed., Vol. I: General Principles, John Wiley and Sons, New York, NY, 1978.

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6. Klinsky, Joseph (ed.): Manual of Recommended Practice for Combustible Gas Indicators and Portable Direct-Reading Hydrocarbon Detectors, 1st ed., American Industrial Hygiene Association, Akron, OH, 1980.

7. National Fire Prevention Association: National Electrical Code, Vol. 70. 470 Atlantic Ave., Boston, MA 02210, 1986.

PART 1

DIRECT-READING INSTRUMENTS

APPENDIX I

DIRECT-READING INSTRUMENTS USED FOR EVALUATION

Hazard Monitored	Instrument	Application	Detection Method	Notes
Combustible Gas/Vapor	Combustible Gas Indicator	Measures the concentration of a combustible gas or vapor.	A filament is heated by burning the combustible gas/vapor. The increase in heat is measured.	Calibrated before use.
Oxygen Deficiency	Oxygen meter	Measures the percentage of oxygen in air.	Uses an electrochemical sensor to measure the partial pressure of oxygen in air.	Calibrated before each use in normal air.
Ionizing radiation	Geiger-Mueller (G-M) counter; Scintillator tube.	Environmental radiation monitor. Some monitors can distinguish among the types of ionizing radiation.	G-M: Ionizing radiation reacts with inert gas producing electric current. Scintillator: Ionizing radiation produces photons of light within a crystal. Crystals are specific to types of radiation e.g., sodium iodide crystal for gamma radiation.	Must be calibrated annually at a specialized facility.
Organics	1) Colorimetric tubes	Measure concentration of specific gases and vapors.	The substance reacts with the indicator chemical producing a stain whose length in the tube is proportional to the concentration of the substance.	Leak test before use. Check flow rate and volume periodically. Check shelf life of tubes before use.
	2) Flame Ionizing Detector (FID) with Gas Chromatograph (GC) Option	Measure total concentration of organics in survey mode; identifies and measures specific compounds in GC mode.	Gases and vapors are ionized in a flame. A current is produced in proportion to the number of carbon atoms present.	Requires experience to operate. Fuel source is hydrogen.

PART 1

DIRECT-READING INSTRUMENTS

APPENDIX I CONT'D

DIRECT-READING INSTRUMENTS USED FOR EVALUATION

Hazard Monitored	Instrument	Application	Detection Method	Notes
	3) Photoionizing Detectors	Measures total concentrations of substance(s). Some identification of compounds is possible if more than one probe is used.	Ultraviolet radiation ionizes molecules producing ions proportional to concentration.	Does not detect methane. Compounds have different ionization potentials.
	4) Portable infrared Spectrophotometer	Designed to quantify one or two component mixtures.	Infrared radiation (IR) is passed through a sample; each compound will absorb IR at a specific frequency. Amount of adsorption is proportional to concentration.	Requires knowledge of IR frequencies for chemicals. Short battery life. Needs to be operated at a stable location (table top).
	5) Catalytic Combustion Meters (Super Sensitive Combustible Gas Indicators).	Measures substances capable of being combusted.	Oxidation takes place on the surface of a heated catalytic bead element. Oxidation is proportional to concentration.	Similar to CGI, but used for ppm measurements.
Inorganics (Volatile)	1) Colorimetric tubes	Measure concentration of specific inorganic gases and vapors.	See previous description of detector tubes.	See previous note.
	2) Photoionizing Detectors	Measure total concentration of some inorganics.	See previous description of photoionization detectors.	See previous note. Detects limited number of inorganics.

PART 1

DIRECT-READING INSTRUMENTS

APPENDIX I CONT'D

DIRECT-READING INSTRUMENTS USED FOR EVALUATION

Hazard Monitored	Instrument	Application	Detection Method	Notes
	3) Portable Infrared Spectrophotometer	Designed to quantify one or two component mixtures. Will detect oxides of nitrogen, ammonia, hydrogen cyanide, hydrogen fluoride and sulfur dioxide.	See previous description of infrared spectrophotometer.	See previous note on IR.
	4) Specific Chemical Monitors	Measure concentration of specific gases and vapors.	Electrochemical sensor or metal oxide semi-conductor UV light absorption for mercury vapor detection.	Limited number of chemicals can be detected. Even though specific, there can interferences.
Aerosols/* Particulates	Direct-Reading Instruments for Analyzing Airborne Particulates.	Measures the concentration of aerosols in air. Can separate respirable from non-respirable aerosols.	Operates on one of three basic techniques 1) Optical 2) Piezoelectric 4) Beta Attenuation	Individual instruments have specific notes. Instruments are available to measure fibers.

* These direct-reading instruments will readout total or respirable aerosol matter, not the composition of the aerosols. The content, e.g., lead, pesticides, of a dust, fume, mist, fog, spray or smoke must be determined by specific analysis.

SECTION 4

AIR SURVEILLANCE

PART TWO

MANUFACTURERS AND SUPPLIERS OF AIR MONITORING AND SAMPLING EQUIPMENT

I. AIR MONITORING/SAMPLING EQUIPMENT

A. Aerosol/Particulate Monitors:

- Andersen Samplers Incorporated
- Air Techniques Incorporated
- California Measurements, Inc.
- General Metal Works Inc.
- HUND Corporation
- MDA Scientific, Inc.
- Met One Inc.
- MIE, Inc.
- Pacific Scientific (HIAC/ROYCO Instrument Division)
- Particle Measuring Systems Inc.
- Products Production Marketing, Inc.
- TSI Incorporated
- Wedding & Associates, Inc.

B. Calibration Gases: (many manufacturers of instruments provide calibration gases for use with their instruments)

- Airco Industrial Gases
- Alphagaz
- Digicolor
- Environics Inc.
- GC Industries
- Liquid Air Corporation
- National Specialty Gases
- Scott Specialty Gases
- VICI Metronics

C. Canister Samplers:

- Andersen Samplers Incorporated
- Nutech Corporation
- Scientific Instrumentation Specialists (SIS)
- Wedding & Associates, Inc.

D. Collection Media:

- Ace Glass Incorporated
- BGI Incorporated
- DACO Products
- Gelman Sciences
- Gilian Instrument Corp.
- Hi-Q Environmental Products Company
- LaMotte Chemical Products Company
- Micro Filtration Systems.
- Millipore Corporation
- Mine Safety Appliances Co.
- Nuclepore Corporation
- Schleicher & Schuell
- Sipin, Anatole J., Co., Inc.
- SKC Inc.

E. Combustible Gas Meters:

- Bacharach Instruments
- Biosystems Inc.
- Dynamation Incorporated
- Enmet Corporation
- GasTech Inc.
- GfG America Gas Detection Ltd.
- Grace Industries, Inc.
- Heath Consultants Incorporated
- Industrial Scientific Corporation
- J and N Enterprises, Inc.
- Lumidor Safety Products e.s.p. inc.
- Mine Safety Appliances Co.
- National Draeger, Inc.
- Neotronics N.A., Inc.
- Rexnord Safety Products
- Scott Aviation
- Sierra Monitor Corporation
- Texas Analytical Controls, Inc.

F. Detector/Colormetric Tubes:

- Enmet Corporation
- Matheson Safety Products
- Mine Safety Appliances Co.
- National Draeger, Inc.
- Sensidyne

G. Gas Bags:

- AeroVironment Inc.
- The Anspec Company, Inc.

- BGI Incorporated
- Calibrated Instruments, Inc.
- Digicolor
- Nutech Corporation
- Plastic Film Enterprises
- Pollution Measurement Corporation
- SKC Inc.

H. Gas Chromatographs:

- Bruker Instruments
- CMS Research Corporation
- The Foxboro Company
- HNU Systems, Inc.
- Microsensor Technology, Inc.
- Photovac Incorporated
- S-Cubed
- Sentex Sensing Technology, Inc.
- Summit Interests
- Thermo Environmental Instruments Inc.
- Varian
- XonTech, Inc.

I. Oxygen Meters:

- Bacharach Inc.
- Biosystems Inc.
- Dynamation Incorporated
- Enmet Corporation
- GC Industries
- GfG America Gas Detection Ltd.
- GasTech Inc.
- Industrial Scientific Corporation
- Lumidor Safety Products e.s.p., Inc.
- MDA Scientific, Inc.
- Metrosonics, Inc.
- Mine Safety Appliances Co.
- National Draeger, Inc.
- Neotronics N.A., Inc.
- Rexnord Safety Products
- Scott Aviation

- Sensidyne
- Sierra Monitor Corporation
- Teledyne Analytical Instruments

J. Passive Dosimeters:

- Advanced Chemical Sensors
- Air Quality Research, Inc.

R.S. Landauer, Jr. & Co.
Glenwood Science Park
Glenwood, IL 60425-1586
312/755-7000

Ludlum, Inc.
P.O. Box 248
Sweetwater, TX 79556
915/235-5494

Lumidor Safety Products e.s.p., Inc.
5364 NW 167th Street
Miami, FL 33014
305/625-6511

MDA Scientific, Inc.
405 Barclay Blvd.
Lincolnshire, IL 60069
312/634-2800
800/323-2000

MG Industries
175 Meister Avenue
North Branch, NJ 08876
201/231-9595

MIE, Inc.
213 Burlington Road
Bedford, MA 01730
617/275-5444

Macurco, Inc.
3946 S. Mariposa Street
Englewood, CO 80110
303/781-4062

Mast Development Company
Air Monitoring Division
2212 East 12th Street
Davenport, IA 52803
319/326-0141

Mateson Chemical Corporation
1025 E. Montgomery Avenue
Philadelphia, PA 19125
215/423-3200

Matheson Safety Products
P.O. Box 85
East Rutherford, NJ 07073
201/933-2400

Met One, Inc.
481 California Avenue
Grants Pass, OR 97526
503/479-1248

Metrosonics, Inc.
P.O. Box 23075
Rochester, NY 14692-3075
800/654-7778

Micro Filtration Systems
6800 Sierra Court
Dublin, CA 94568
415/828-6010

Microsensor Technology, Inc.
47747 Warm Springs Blvd.
Fremont, CA 94539
415/490-0900

Millipore Corporation -
Lab Products Division
80 Ashby Road
Bedford, MA 01730
800/225-1380

Mine Safety Appliances
P.O. Box 426
Pittsburgh, PA 15230
412/967-3000

National Draeger, Inc.
101 Technology Drive
Pittsburgh, PA 15230
412/787-8383

National Specialty Gases
630 United Drive
Durham, NC 27713-9985

Neotronics N.A., Inc.
P.O. Box 370
411 North Bradford Street
Gainesville, GA 30503
404/535-0600

Spectrex Corporation
3594 Haven Avenue
Redwood City, CA 94063
415/365-6567

Staplex Company
Air Sampler Division
777 Fifth Avenue
Brooklyn, NY 11232-1695
212/768-3333
800/221-0822

Summit Interests
P.O. Box 1128
Lyons, CO 80540
303/823-5303

Sybron Corporation
Analytical Products Division
221 Rivermoor Street
Boston, MA 02132
617/469-3300

3M/Occupation Health & Safety
Products Division 3M Center
Building 220-3E
St Paul, MN 55144
800/328-1667

TIF Instruments Inc.
9101 NW 7th Avenue
Miami, FL 33150
305/757-8811

TSI Incorporated
500 Cardigan Road
P.O. Box 43394
St Paul, MN 55164
612/483-0900

Tekmar Company
P.O. Box 371856
Cincinnati, OH 45222
800/543-4461

Teledyne Analytical Instruments
16830 Chestnut Street
City of Industry, CA 91749
213/283-7181

Terradex Corporation
460 N. Wiget Lane
Walnut Creek, CA 94598
415/938-2545

Texas Analytical Controls, Inc.
P.O. Box 42520
Houston, TX 77242
713/240-4160

Thermo Environmental Instruments
108 South Street
Hopkinton, MA 01748
617/435-5321

Thompson & Nielsen Electronics Ltd.
303-4019 Carling Avenue
Kanata, Ontario, Canada
613/592-3019

VICI Metronics
2991 Corvin Drive
Santa Clara, CA 95051
408/737-0550

Victoreen Instrument Inc.
10101 Woodland Avenue
Cleveland, OH 44104
216/795-8200

Warrington Laboratories, Inc.
P.O. Box 15147
7801 N. Lamar, D-111
Austin, TX 78752
512/452-2590

Wedding & Associates, Inc.
P.O. Box 1756
Fort Collins, CO 80522
303/221-0678

Whatman Paper Division
9 Bridewell Place
Clifton, NJ 07014
201/773-5800

Wheaton Scientific
1000 North 10th Street
Millville, NJ 08332
609/825-1400

B. Aerosols

Aerosol is a term used to describe fine particulates (solid or liquid) suspended in air. Particulates ranging in diameter from 5 to 30 microns are deposited in the nasal and pharyngeal passages. The trachea and smaller conducting tubes collect particulates 1-5 microns in diameter. For particulates to diffuse from the bronchioles into alveoli they must be less than 0.5 microns in diameter. Larger particles do reach the alveoli due to gravity. The smallest particulates may never be deposited in the alveoli and so may diffuse back into the conducting tubes to be exhaled.

Aerosols can be classified in two ways: by their physical form and origin and by the physiological effect on the body.

1. Physical Classification Examples:

   - Mechanical dispersoid: liquid or solid particle mechanically produced.
   - Condensation dispersoid: liquid or solid particle often produced by combustion.
   - Spray: visible liquid mechanical dispersoid.
   - Fume: extremely small solid condensation dispersoid.
   - Mist: liquid condensation dispersoid.
   - Fog: mist dense enough to obscure vision.
   - Smoke: liquid or solid organic particles resulting from incomplete combustion.
   - Smog: mixture of smoke and fog.

2. Physiological Classification Examples:

   - Nuisance: no lung injury but proper lung functioning inhibited.
   - Inert pulmonary reaction causing: non-specific reaction.
   - Pulmonary fibrosis causing: effects ranging from nodule production in lungs to serious diseases such as asbestosis.
   - Chemical irritation: irritation, inflammation, or ulceration of lung tissue.

- Systemic poison: diseases in other parts of the body.

- Allergy-producing: causes allergic hyper sensitivity reactions such as itching or sneezing.

C. Gaseous Contaminants

Gases and vapors are filtered to some degree on their trip through the respiratory tract. Soluble gases and vapors are absorbed by the conducting tubes in route to the alveoli. Not all will be absorbed so that along with insoluble gases, they finally diffuse into the alveoli where they can be directly absorbed into the bloodstream.

Gaseous contaminants can be classified as chemical and physiological hazards.

1. Chemical

- Acidic: acids or react with water to form acids.

- Alkaline: bases or react with water to form bases.

- Organic: compounds which contain carbon; may range from methane to chlorinated organic solvents.

- Organometallic: organic compounds containing metals.

- Hydrides: compound in which hydrogen is bonded to another metal.

- Inert: no chemical reactivity.

2. Physiological

- Irritants: corrosive substances which injure and inflame tissue.

- Asphyxiants: substances which displace oxygen or prevent the use of oxygen in the body.

- Anesthetics: substances which depress the central nervous system, causing a loss of sensation or intoxication.

- Systemic poisons: substances which can cause disease in various organ systems.

IV. RESPIRATORY PROTECTION DEVICES

The basic function of a respirator is to reduce the risk of respiratory injury due to breathing airborne contaminants. A respirator provides protection by removing the contaminants from ambient air or by supplying the wearer with an alternate source of clean breathing air.

All respiratory apparatus are composed of two main parts: (1) the device which supplies or purifies air, and (2) the facepiece which covers the nose and mouth and seals out the contaminants. The first component defines what class of respirator the device is; the second determines the relative measure of protection afforded by that respirator.

A. Classes of Respirators

Respirators are divided into two major classifications according to their mode of operation:

1. Air Purifying Respirators (APR's) remove contaminants by passing the breathing air through a purifying element. There are a wide variety of APR's available to protect against specific contaminants, but they all fall into two subclasses: (1) particulate APR's which employ a mechanical filter element, and (2) gas and vapor APR's that utilize chemical sorbents contained in a cartridge or canister.

   It is important to realize that there are limitations on the applications of APR's. These devices are specific for certain types of contaminants, so the identity of the hazardous agent must be known. There are maximum concentration limits; this requires a knowledge of the ambient concentration of the contaminant, as well as the Maximum Use Limit (MUL) of the respirator. Since APR's only clean the air, the ambient concentration of oxygen must be sufficient ($\geq$ 19.5%) for the user.

2. Atmosphere - Supplying Respirators (ASR's) provide a substitute source of clean breathing air. The respirable air is supplied to the worker from either a stationary source through a long hose, or from a portable container. The first type are called supplied-air respirators and the latter are known as self-contained breathing apparatus (SCBA).

   These devices can be used regardless of the type of airborne contaminant or oxygen concentration. However, the contaminant concentration limits vary for the different types of ASR's and the wearer must be aware of the limitations of his/her respirator.

B. Respiratory Protection

The protection provided the respirator wearer is a function of how well the facepiece (mask) fits. No matter how efficient the purifying element or how clean the supplied air, there is little protection afforded if the respirator mask does not provide a leak-free facepiece-to-face seal. Facepieces are available in three basic configurations (see **FIGURE 2**) which relate to their protective capacity.

-- Quarter-Mask (Type B Half-Mask) fits over the bridge of the nose, along the cheek, and across the top of the chin. The headbands which hold the respirator in place are attached at two or four places of the mask (i.e. two- or four-point suspension). Limited protection is expected because the respirator can be easily dislodged, creating a breach in the seal.

-- Half-Mask (Type A Half-Mask) fits over the bridge of the nose, along the cheek, and under the chin. Headbands have a fourpoint suspension. Because they maintain a better seal and are less likely to be dislodged, half-masks give greater protection than quarter-masks.

-- Full-Facepiece fits across the forehead, down over the temples and cheeks, and under the chin. They typically have a head harness with a five or six-point suspension. These masks give the greatest protection because they are held in place more securely and because it is easier to maintain a good seal along the forehead than it is across the top of the nose. An added benefit is the eye protection from the clear lens in the full-facepiece.

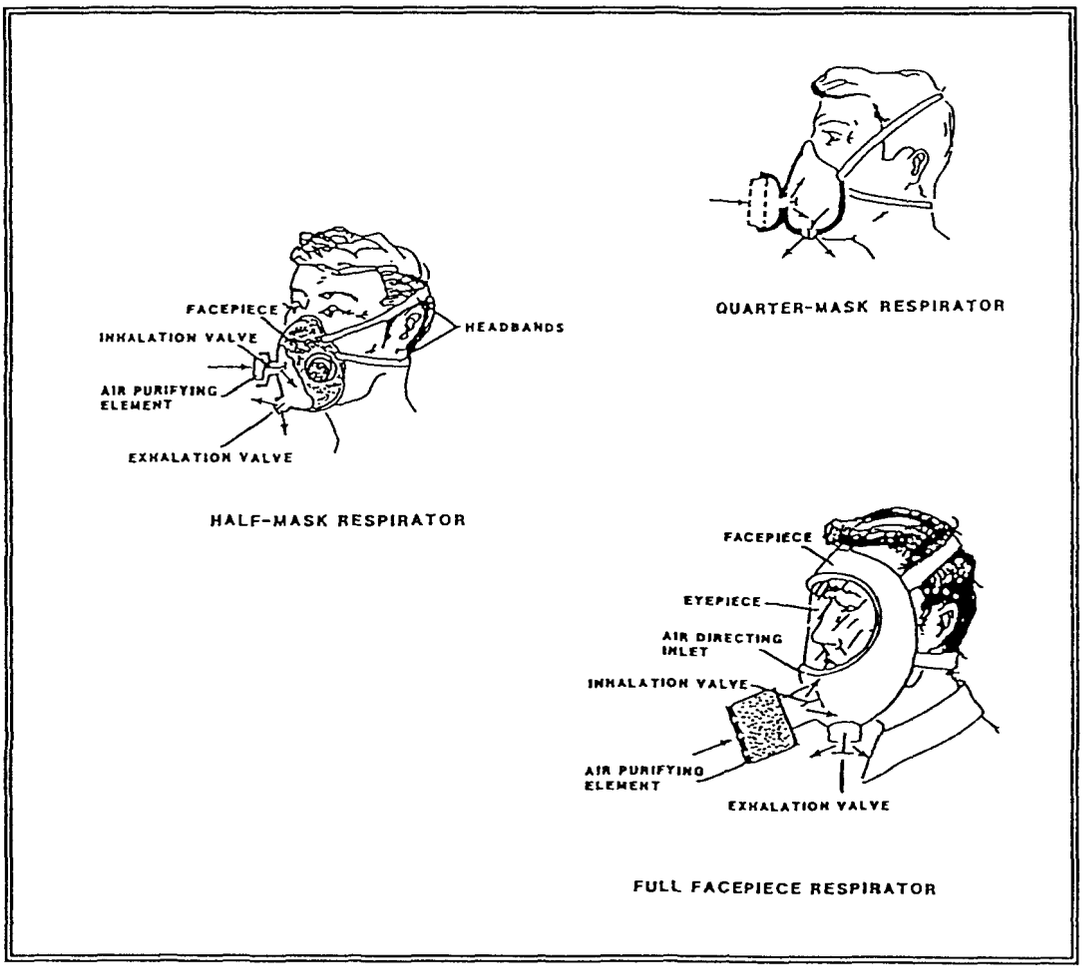

FIGURE 2

TYPES OF RESPIRATOR FACEPIECES

Not all respirators fit everyone, so each individual must find out which manufacturer's masks he/she can properly wear. At best, any given respirator will fit 60% of the working population. But with the large number of respirators available, at least one type should be found to fit an individual.

The use of respirators is prohibited when conditions prevent a good facepiece-to-face seal. Some examples of these conditions are facial hair, skullcaps, long hair, make-up, temple pieces on eyeglasses. Because maintaining a leak-free seal is so important, personnel required to wear respirators must successfully pass a fit-test designed to check the integrity of the seal.There are two types of fit-tests: quantitative and qualitative. The quantitative test is an analytical determination of the concentration of a test agent inside the facepiece compared to that outside the mask. This concentration ratio is called the Assigned Protection Factor (APF) and is a measure of the relative protection offered by a respirator. For example, if the ambient concentration of the test agent is 1000 and the concentration inside the mask is 10 ppm, the respirator gives the tested individual an APF of 100. So:

$$\text{APF} = \frac{\text{Concentration outside mask}}{\text{Concentration inside mask}}$$

Because quantitative tests are expensive and tedious, qualitative tests are most often performed to check respirator fit. A qualitative fit-test is not an analytical measurement. It is a subjective test where an irritant or aroma is used to determine if there is a good facepiece-to-face seal. If the test subject does not respond (by smelling, tasting, coughing, etc.) to the test agent, he/she can wear the tested respirator with the APF for that type of mask. **Table 2** lists several types of respirators and their APFs.

A Protection Factor is used to determine the Maximum Use Limit (MUL) of a successfully fit-tested respirator. The MUL is the highest concentration, not exceeding IDLH concentration, of a specific contaminant in which a respirator can be worn:

$$\text{MUL} = \text{APF} \times \text{TLV}$$

For example, if a contaminant has a TLV-TWA of 10 ppm, then the MUL for any half-mask respirator is 100 ppm; the MUL for a full-facepiece APR or demand SCBA is 1000 ppm. If the ambient concentration is greater than 1000 ppm, then a pressure demand SCBA is required.

Fit testing and Assigned Protection Factors are only two of the several considerations for selecting the proper respirator. Much more detailed information on the types and applications of APR's and ASR's is covered in the other Parts of this Section.

TABLE 2	
RESPIRATOR ASSIGNED PROTECTION FACTORS*	
Type of Respirator	**NIOSH APF (Qualitative Test)**
Air-purifying quarter-mask half-mask	5 10
Air-line quarter-mask half-mask	10 10
Hose mask full facepiece	10
SCBA, demand quarter-mask half-mask	10 10
Air-purifying full facepiece	50
Air-line, demand full facepiece	50
SCBA, demand full facepiece	50
Airline, pressure-demand, with escape provision full facepiece (no test required)	10,000
SCBA, pressure-demand or positive pressure full facepiece (no test required)	10,000

* For more detailed information consult Table 5, "Respirator Protection Factors" in ANSI Z88.2-1980.

V. RESPIRATOR USE AND SELECTION

A. User Requirements

The health of a respirator wearer is based on how the respirator is used. The American National Standards Institute (ANSI) has prepared the "American National Standard Practices for Respiratory Protection", and updates it periodically. The

rescinded. This is intended to protect the respirator user. Also, any unauthorized changes or hybridization of a respirator by the user invalidates the respirator approval and all the guarantees understood with the approval.

Appendix I presents the approval schedules for specific types of respirators. The schedule number came from the original Bureau of Mines respirator approval requirements. The Bureau of Mines preceded the Mining Enforcement and Safety Administration (NESA), which eventually became MSHA.

Many agencies were responsible for respirator certification at one time or another. Thus respirators in use today may bear approval numbers issued to the manufacturers by the Bureau of Mines, MESA, and MSHA. The approval number must be displayed on the respirator or its container. It consists of the prefix TC (Testing and Certification), the schedule number, followed by the approval number. For example in TC-13F-69, "13" is the schedule for self-contained breathing apparatus, "F" indicates the number of revisions to the schedule, and 69 is the consecutive approval number. Also, the approval label includes the certifying agencies.

Periodically, NIOSH publishes a list of all approved respirators and respirator components. The current edition, issued in 1988, is entitled the NIOSH Certified Equipment List as of September, (DHHS [NIOSH] Publication No. 87-102). This document is used to answer two basic questions about respiratory protection:

-- Is this respirator appropriate (approved) for the existing work conditions?

-- Is this respirator (mask and purifying-elements) an approved assembly?

If the answer to either of these questions is "no", then the worker is prohibited from using that respirator (or type of respirator). **Table 3** in Appendix I presents an example of the "NIOSH Certified Equipment List".

VII. RESPIRATOR CARE AND CLEANING

Once a respirator has been used it must be cleaned. All detachable parts such as straps, valves, and gaskets are removed. Cartridges cannot be cleaned. They can be used again if their service life has not been exhausted and they are stored properly. The facepiece and other parts can be washed separately in sanitizer solution. The parts should go through two water rinses and be left to air dry. When dry, the parts are reassembled and the respirator is put in a clean plastic bag and stored where it will be protected from high temperatures, very dusty environments or conditions that could alter the shape of the mask. Additional details are provided in Part 2, Appendix IV.

APPENDIX I

NIOSH CERTIFIED EQUIPMENT LIST

I. RESPIRATOR SELECTION

The selection of an appropriate respirator for use in a given situation can only be made by carefully considering a number of interrelated environmental, equipment, work situation, and human factors.

Once a type of respirator is selected, then the user can refer to appropriate table for a list of all approved devices of that type:

RESPIRATOR TYPE	APPROVED SCHEDULE
Self-Contained Breathing Apparatus	TC-13F-
Gas Masks	TC-14G-
Supplied-Air Respirators	TC-19C-
Dust, Fume, and Mist Respirators	TC-21C-
Chemical Cartridge Respirators	TC-23C-
Vinyl Chloride Respirators	TC-11-

Also, if the user chooses a specific respirator, he/she can look up the approval number for that device and determine the type of respirator protection it provides. For example, if you were to choose an MSA half-mask respirator with organic vapor cartridges, you would first find the approval number on the cartridge label. Next you look under the schedule for chemical cartridge respirators organic vapor until you find the correct listing, in this case TC-23C-201. From **TABLE 3** (next page), it can be seen that this respirator can be used for organic vapors, paints-lacquers-enamels, and dusts or mists under specified conditions.

The difference in applications is the Maximum Use Concentration (MUC) for which the cartridge or canister can be used in accordance with its NIOSH/MSHA approval. For example, organic vapors can be removed by the appropriate cartridges, chin canister, or gas-mask canister. Cartridges are approved for use in atmospheres up to 1,000 ppm (0.1%) organic vapors, chin style canisters up to 5000 ppm (0.5%), and gas mask canisters up to 20,000 ppm (2.0%). However, no air-purifying respirator is permitted in an IDLH atmosphere.

2. Service Life

Each sorbent has a finite capacity for removing contaminants and when this limit is reached the cartridge or canister is said to be saturated. At this point the element will allow the contaminant to pass through and enter the facepiece. The length of time a cartridge or canister will effectively sorb the contaminant is known as the service life of the element. Service life of a type of cartridge or canister is dependent on several factors: the breathing rate of the wearer; contaminant concentration; and sorption efficiency.

a. Breathing Rate

If the breathing rate of the user is rapid, the flow rate of the contaminated air drawn through the cartridge is greater than it is at a moderate or slow respiration rate. A higher flow rate brings a larger amount of contaminant in contact with the sorbent in a given period of time which, in turn, increases the rate of sorbent saturation and shortens service life.

b. Contaminant Concentration

The expected service life of an organic vapor cartridge decreases as ambient contaminant concentration increases. As concentration goes up, the mass flow rate increases, bringing more contaminant in contact with the sorbent in a given period of time. For example, at any constant breathing rate, ten times as much contaminant contacts the element when the concentration is 500 ppm compared to 50 ppm.

c. Cartridge Efficiency

Chemical sorbents vary in their ability to remove contaminants from air. **Table 5** compares the efficiency of organic vapor cartridges for a number of solvents by recording the amount of time until a 1% breathrough concentration was measured in the cartridge-filtered air. The initial test concentration is 1000 ppm of solvent vapor; the breathrough concentration is 10 ppm. From the table it can be seen that it takes 107 minutes for chlorobenzene to reach a 1% breakthrough, while it only takes 3.8 minutes for vinyl chloride. The sorbent (activated carbon) in the organic vapor cartridge is much better for removing chlorobenzene than vinyl chloride under the test conditions. Cartridge efficiencies need to be considered when selecting and using APR's. References for cartridge efficiency studies can be found in Appendix I.

TABLE 5

EFFECT OF SOLVENT VAPOR ON RESPIRATOR CARTRIDGE EFFICIENCY[1]

SOLVENT	TIME TO REACH 1% BREAKTHROUGH (10 ppm) MINUTES (2)
Aromatics[3]	
Benzene	73
Toluene	94
Ethyl benzene	84
m-Xylene	99
Cumene	81
Mestiylene	86
Alcohols[3]	
Methanol	0.2
Ethanol	28
Isopropanol	54
Allyl alcohol	66
n-Propanol	70
sec-Butanol	96
Butanol	115
2-Methoxyethanol	116
Isoamyl alcohol	97
4-Methyl-2-pentanol	75
2-Ethoxyethanol	77
Amyl alcohol	102
2-Ethyl-1-butanol	76.5
Monochlorides[3]	
Methyl chloride	0.05
Vinyl chloride	3.8
Ethyl chloride	5.6
Allyl chloride	31
1-Chloropropane	25
1-Chlorobutane	72
Chlorocyclopentane	78

TABLE 5 CONT'D EFFECT OF SOLVENT VAPOR ON RESPIRATOR CARTRIDGE EFFICIENCY[1]	
SOLVENT	**TIME TO REACH 1% BREAKTHROUGH (10 ppm) MINUTES (2)**
Monochlorides[3]	
Chlorobenzene	107
1-Chlorohexane	77
o-Chlorotoluene	102
1-Chloroheptane	82
3-(Choromethyl heptane)	63
Dichlorides[3]	10
Dichloromethane	33
trans-1,2-Dichloroethylene	23
1,1-Dichloroethane	30
cis-1,2-Dichloroethylene	54
1,2-Dichloroethane	65
1,2-Dichloropropane	108
1,4-Dichlorobutane	109
o-Dichlorobenzene	
Trichlorides[3]	
Chloroform	33
Methyl chloroform	40
Trichloroethylene	55
1,1,2-Trichlorethane	72
1,2,3-Trichloropropane	111
Tetra- anmd Pentachlorides[3]	
Carbon tetrachloride	77
Perchloroethylene	107
1,1,2,2-Tetrachloroethane	104
Pentachloroethane	93
Acetates[3]	
Methyl acetate	33
Vinyl acetate	55
Ethyl acetate	67
Isopropyl acetate	

TABLE 5 CONT'D EFFECT OF SOLVENT VAPOR ON RESPIRATOR CARTRIDGE EFFICIENCY[1]	
SOLVENT	**TIME TO REACH 1% BREAKTHROUGH (10 ppm) MINUTES (2)**
Acetates[3] Cont'd	
Isopropenyl acetate	83
Propyl acetate	79
Allyl acetate	76
sec-Butyl acetate	83
Butyl acetate	77
Isopentyl acetate	71
2-Methoxyethyl acetate	93
1,3-Dimethylbutyl acetate	61
Amyl acetate	73
2-Ethoxyethyl acetate	80
Hexyl acetate	67
Ketones[4]	37
Acetone	82
2-Butanone	104
2-Pentanone	94
4-Methyl-2-pentanone	96
Mesityl oxide	122
Cyclopentanone	141
3-Hepanone	91
2-Heptanone	101
Cyclohexanone	126
5-Methyl-3-heptanone	86
3-Methylcyclohexanone	101
Diisobutyl ketone	71
4-Methylcyclohexanone	111
Alkanes[4]	
Pentane	61
Hexane	52
Methylcyclopentane	62
Cyclohexane	69
2,2,4-Trimethylpentane	68
Heptane	78
Methylcyclohexane	69
5-Ethylidene-2-norbornene	87
Nonane	76
Decane	71

TABLE 5 CONT'D EFFECT OF SOLVENT VAPOR ON RESPIRATOR CARTRIDGE EFFICIENCY[1]	
SOLVENT	**TIME TO REACH 1% BREAKTHROUGH (10 ppm) MINUTES (2)**
Amines[4]	
Methyl amine	12
Ethyl amine	40
Isopropyl amine	66
Propyl amine	90
Diethyl amine	88
Butyl amine	110
Triethyl amine	81
Dipropyl amine	93
Diisopropyl amine	77
Cyclohexyl amine	112
Ditbutyl amine	76
Miscellaneious materials[4]	
Acrylonitrile	49
Pyridine	119
1-Nitropropane	143
Methyl iodide	12
Dibromomethane	82
1,2-Dibromoethane	141
Acetic anhydride	124
Bromobenzene	142

1 Nelson, G. O., and C. A. Harder. Respirator Cartridge Efficiency Studikes, University of California, Livermor. 1976.

2 Cartridge pairs tested at 1000 ppm, 50% relative humidity, 22°C, and 53.3 liters/minute (equivalent to a moderately heavey work rate). Pair cartridges preconditioned at room temperature and 50% relative humidity for at least 24 hours prior to testing.

3 Mine Safety Appliances Cartridges.

4 American Optical Cartridges.

3. Warning Properties

A warning property is used as a sign that a cartridge or canister in use is beginning to lose its effectiveness. A warning property can be detected as an odor, taste, or irritation. At the first such signal, the old cartridge or canister must be exchanged for a fresh one. Without a warning property, respirator efficiency may drop without the knowledge of the wearer, ultimately causing a health hazard.

Most substances have warning properties at some concentration. A warning property detected only at dangerous levels -- that is, greater than EL--is not considered adequate. An odor, taste, or irritation detected at extremely low concentrations is also not adequate because the warning is being given all the time or long before the filter begins to lose its effectiveness. In this case, the wearer would never realize when the filter actually becomes ineffective.

The best concentration for a warning property to be first detected is around the EL. For example, toluene has an odor threshold of 40 ppm and an EL of 100 ppm. This is usually considered an adequate warning property. Conversely, dimethylformamide has an EL of 10 ppm and an odor threshold of 100 ppm. An odor threshold ten times the EL is not an adequate warning property. Adequate warning properties are discussed in more detail in the NIOSH/OSHA Respirator Decision Logic (**Section 5, Part 4**, I of this manual). A list of warning properties is found in **Section 5, Part 2**, Appendix V.

If a substance causes rapid olfactory fatigue (that is, the sense of smell is no longer effective), its odor is not an adequate warning property. For example, upon entering an atmosphere containing hydrogen sulfide, the odor is quite noticeable, After a short period of time, it is no longer detectable.

V. REQUIREMENTS FOR RESPIRATOR USE

The use of an air-purifying respirator is contingent upon a number of criteria. If the conditions spelled-out in this section of the text cannot be met, then use of an APR is prohibited. Figure 2-2 illustrates the selection criteria in a flow diagram.

A. Oxygen Content

The normal atmosphere contains approximately 21% oxygen. The physiological effects of reduced oxygen begin to be evident at 16%. Without regard to contaminants, the atmosphere must contain a minimum of 19.5% oxygen to permit use of an air-purifying respirator. This is a legal requirement of 30 CFR Part 11 and a recommendation of ANSI Z88.2 - 1980. Below 19.5% oxygen, atmosphere-supplying respirators must be used instead.

B. Identification of Contaminants

It is absolutely imperative that the contaminant(s) be known so that:

- the toxic effects of inhaling the contaminant can be determined;
- appropriate particulate filters or cartridges/canisters can be chosen;

- it can be determined that adequate warning properties exist for the contaminant;

- the appropriate facepiece be selected (full-face mask is necessary if the agent causes eye irritation).

C. Known Contaminant Concentration

The maximum concentration depends on the contaminant and the respirator.

- concentration must not exceed IDLH;

- the Maximum Use Limit of the respirator cannot be exceeded (MUL=APF x EL);

- the Maximum Use Concentration of a particular type and size cartridge or canister must not be surpassed;

- expected service life (cartridge/canister efficiency) should be determined, if possible.

D. Periodic Monitoring of Hazards

Because of the importance of knowing the identity and concentration of the contaminant(s), monitoring of the work area with appropriate equipment must occur at least periodically during the work day. This is done to ensure that no significant changes have occurred and the respirators being used are adequate for the work conditions.

E. Approval of Respirators

The respirator assembly (facepiece and air-purifying elements) is approved for protection against the contaminant at the concentration which is present in the work area. The concentration must not exceed the NIOSH/MSHA designated MUC for that type and size cartridge or canister.

F. Fit-test

The wearer must pass a qualitative fit-test for the make, model, and size of air-purifying device used (Appendices II and III) provide instructions for the qualitative tests. The OSHA regulations, in 29 CFR 1910.1345 (e) (5) (i), state: "Every respirator wearer shall receive fitting instructions including demonstrations and practice in how the respirator is worn, how to adjust it, and how to determine if it fits properly. Respirators shall not be worn when conditions prevent a good face seal. Such conditions may be growth of beard, sideburns, a skull cap that projects under the facepiece, or temple pieces on glasses. Also, the absence of one or both dentures can seriously affect the fit of a facepiece. The worker's diligence in observing these factors shall be evaluated by periodic check. To assure proper protection, the facepiece fit shall be checked by the wearer each time he puts on the respirator. This may be done by giving fiting instructions".

APPENDIX I

REFERENCE FOR RESPIRATOR CARTRIDGE EFFICIENCIES STUDIES

Ruch, W.E., G.O. Nelson, C.L. Lindeken, R.E. Johjnsen, and D.J. Hodgkins. "Respirator Cartridge Efficiency Studies: 1. Experimental Design." American Industrial Hygiene Association j.33, 105 (1972)

Nelson, G.O., and D.H. Hodgkins. "Respirator Cartridge Efficiency Studies: II. Preparation of Test Atmospheres." American Industrial Hygiene Association J. 33, 110 (1972).

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Nelson, G.O., C.A. Harder. "Respirator Cartridge Efficienty Studies: IV. Effects of Steady-State and Pulsating Flow." American Industrial Hygiene Association J. 33, 797 (1972).

Nelson, G.O., C.A. Harder, and B.E. Bigler. "Respirator Cartridge Efficiency Studies: VI. Effect of Concentration". Lawrence Livermore Laboratory, Rept. UCRL-76184 (November, 1974).

Nelson, G.O., and C.A. Harder. "Respirator Cartridge Efficiency Studies: V. Effect of Solvent Vapor." American Industrial Hygiene Association J. 35, 391 (1974).

Nelson, G.O., C.A. Harder, and B.E. Bigler. "Respirator Cartridge Efficiency Studies: VII. Effect of Relative Humidity and Temperature." Lawrence Livermore Laboratory, Rept. UCRL-77390 (August, 1975).

Nelson, G.O., and A.N. Correia. "Respirator Cartridge Efficiency Studies: VIII. Summary and Conclusions." American Industrial Hygiene Association J. 37,9 (1976).

APPENDIX II

RESPIRATOR FIT-TESTING

I. INTRODUCTION

All users of potential users of demand-type respiratory protection devices should be fit tested to ensure a proper facepiece-to-face seal. Either isoamyl acetate or irritant smoke should be used with one of the four methods described below. A selection of respirators should be tested, with users allowed to choose the most comfortable from those that fit satisfactorily.

II. METHODS

A. Method No 1 - Swab or Brush (Organic Vapors)

- Use only facepieces equipped with organic vapor cartridges.
- Perform the test in area with no noticeable air movement.
- Saturate a tissue, cloth, or brush with isoamyl acetate.
- Prior to testing, expose subject to a very low concentration of isoamyl acetate to assure that he/she can detect the odor.
- After subject dons the respirator, tester visually inspects facepiece-to-face seal. If seal obviously leaks, test ends and mask is recorded as unsatisfactory. If subject is uncomfortable, test ends.
- Move saturated material slowly around entire sealing surface of the respirator at a distance of 3 to 6 inches. Perform first with test subject sedentary, then with subject moving head and face (i.e., talking, moving head side to side and up and down). End test if any leakage occurs.
- If the subject detects the odor during fitting, record that respirator as unsatisfactory, remove it from the subject, and visually inspect the facepiece-to-face seal. If any doubt exists about the respirator or cartridges, test a duplicate to assure that the leakage was due to facepiece-to-face seal.

B. Method No. 2 - Around Seal (Particulates)

- Use respirators equipped with high-efficiency filters (HEPA)
- Perform test in area with no noticeable air movement.

- Break both ends of a ventilation smoke tube. Insert one end into the tube connected to the positive-pressure end of a two-way aspirator bulb and cover the other end with 1- to 2 inch length of Tygon, surgical, or rubber tubing. Squeeze the aspirator bulb to generate the test aerosol.

- After subject dons the respirator, tester visually inspects facepiece-to-face seal. If seal obviously leaks, test ends and mask is recorded as unsatisfactory. If subject is uncomfortable, test ends.

- Direct the smoke around entire sealing surface of the respirator at a distance of 3 to 6 inches. Instruct subject to breathe shallowly during initial test around surface and normally thereafter if no leakage is detected. If a half-mask is being tested, instruct subject to close his/her eyes for the duration of the test. Perform the test first with subject sedentary, then with subject moving head and face (i.e., talking, moving head side to side and up and down). End test if any leakage occurs.

- If the subject detects the odor during fitting, record that respirator as unsatisfactory, remove it from the subject, and visually inspect the sealing surface. If any doubt exists about the respirator or cartridges, test a duplicate to assure that the leakage was due to the facepiece-to-face seal.

C. Method No. 3 - Enclosure in Plastic Bag (Organic Vapors)

- Use facepieces equipped with organic vapor cartridges.

  - Saturate a tissue or cloth with isoamyl acetate and suspend it inside the top of a plastic garbage bag or harvard hood.

  - Prior to testing, expose subject to a very low concentration of the isoamyl acetate to assure that he/she can detect the odor.

  - After subject dons the respirator, tester visually inspects facepiece-to-face seal. If seal obviously leaks, test ends and mask is recorded as unsatisfactory. If subject is uncomfortable, test ends.

  - Instruct subject to put his/her head into the bag or hood and breathe normally during a short (30-60 seconds) sedentary period. If no leakage is detected, instruct the subject to perform various exercises simulating, as nearly as possible, work conditions (i.e., talking, running in place, head movements, bending over). End test if any leakage occurs.

  - If the subject detects the odor during fitting, record that respirator as unsatisfactory, remove it from the subject, and visually inspect the sealing surface. If any doubt exists about the respirator or cartridges, test a duplicate to assure that leakage was due to the facepiece-to-face seal.

D. Method No. 4 - Enclosure in Plastic Bag (Particulates)

  - Use respirators equipped with high-efficiency filters (HEPA).

- Break both ends of a ventilation smoke tube. Insert one end into the tube connected to the positive-pressure end of a two-way aspirator bulb and cover the end with 1- to 2-inch length of Tygon, surgical, or rubber tubing. Squeeze the aspirator bulb to generate the test aerosol.

- After subject dons the respirator, tester visually inspects facepiece-to-face seal. If seal obviously leaks, test ends and mask is recorded as unsatisfactory. If subject is uncomfortable, test ends.

- Generate smoke into a hole punched in the top of the closed plastic bag until smoke can be visually detected throughout the bag or hood.

- Instruct subject to put his/her head into the bag or hood and breath shallowly during a short (30-60 seconds) sedentary period. If a half-mask is being tested, instruct subject to close his/her eyes before entering and keep them closed until exiting. If no leakage is detected during sedentary period, instruct subject to perform various exercises simulating, as nearly as possible, work conditions (i.e., talking, running in place, head movements, bending over) while breathing normally. End test if any leakage occurs.

- If the subject detects the odor during fitting, record that respirator as unsatisfactory, remove it from the subject, and visually inspect the sealing surface. If any doubt exists about the respirator or cartridges, test a duplicate to assure that leakage was due to the facepiece-to-face seal.

APPENDIX III

RESPIRATOR NEGATIVE AND POSITIVE PRESSURE TEST

I. FITTING

Place the respirator over the face and draw the straps evenly and securely. The mask should not be so tight as to cause discomfort or a headache. Secure bottom straps first, progressing to the top straps.

II. NEGATIVE PRESSURE TEST

This test (and the positive pressure test) should be used only as a very gross determination of fit. The wearer should use this test just before entering the hazardous atmosphere. In this test, the user closes off the inlet of the canister, cartridge(s), or filter(s) by covering with the palm(s), inhales gently so that the facepiece collapses slightly; and holds breath for about 10 seconds. If the facepiece remains slightly collapsed and no inward leakage is detected, the respirator is probably tight enough.

Although this test is simple, it has drawbacks; primarily that the wearer must handle the respirator after it has been positioned on his face. This handling can modify the facepiece seal.

III. POSITIVE PRESSURE TEST

This test, similar to the negative pressure test, is conducted by closing off the exhalation valve and exhaling gently into the facepiece. The fit is considered satisfactory if slight positive pressure can be built up inside the facepiece without any evidence of outward leakage. For some respirators, this method requires that the wearer remove the exhalation valve cover; this often disturbs the respirator fit even more than does the negative pressure test. Therefore, this test should be used sparingly if it requires removing and replacing a valve cover. The test is easy for respirators whose valve cover has a single small port that can be closed by the palm or a finger.

APPENDIX IV

CARE AND CLEANING OF RESPIRATORS

I. GENERAL REQUIREMENTS

Any organization using respirators on a routine basis should have a program for their care and cleaning. The purpose of a program is to assure that all respirators are maintained at their original effectiveness. If they are modified in any way, their Protection Factors may be voided. Usually one person in an organization is trained to inspect, clean, repair, and store respirators.

The program should be based on the number and types of respirators, working conditions, and hazards involved. In general, the program should include:

- Inspection (including a leak check)
- Cleaning and disinfection
- Repair
- Storage

II. INSPECTION

Inspect respirators after each use. Inspect monthly a respirator that is kept ready for emergency use to assure it will perform satisfactorily.

On air-purifying respirators, thoroughly check all connections for gaskets and "O" rings and for proper tightness. Check the condition of the facepiece and all its parts, connecting air tube, and headbands. Inspect rubber or elastomer parts for pliability and signs of deterioration.

Maintain a record for each respirator inspection, including date, inspector, and any unusual conditions or findings.

III. CLEANING AND DISINFECTION

Collect respirators at a central location. Brief employees required to wear respirators on the respirator program and assure them that they will always receive a clean and sanitized respirator. Clean and disinfect respirators as follows:

- Remove all cartridges, canisters, and filters, plus gaskets or seals not affixed to their seats.
- Remove elastic headbands.
- Remove exhalation cover.

- Remove speaking diaphragm or speaking diaphragm-exhalation valve assembly.

- Remove inhalation valves.

- Wash facepiece and breathing tube in cleaner/sanitizer powder mixed with warm water, preferably at 120° to 140° F. Wash components separately from the facemask, as necessary. Remove heavy soil from surfaces with a hand brush.

- Remove all parts from the wash water and rinse twice in clean warm water.

- Air dry parts in a designated clean area.

- Wipe facepieces, valves, and seats with a damp lint-free cloth to remove any remaining soap or other foreign materials.

NOTE: Most respirator manufacturers market their own cleaners/sanitizers as dry mixtures of a bactericidal agent and a mild detergent. One-ounce packets for quantity use are usually available.

IV. REPAIRS

Only a trained person with proper tools and replacement parts should work on respirators. No one should ever attempt to replace components or to make adjustments or repairs beyond the manufacturer's recommendations.

Make repairs as follows:

- Replace all faulty or questionable parts or assemblies. Use parts only specifically designed for the particular respirator.

- Reassemble the entire respirator and visually inspect the completed assembly.

- Insert new filters, cartridges, or canisters, as required. Make sure that gaskets or seals are in place and tightly sealed.

V. STORAGE

Follow manufacturers' storage instructions, which are always furnished with new respirators or affixed to the lid of the carrying case. In addition, these general instructions may be helpful:

- After respirators have been inspected, cleaned, and repaired, store them so as to protect against dust, excessive moisture, damaging chemicals, extreme temperatures and direct sunlight.

- Do not store respirators in clothes lockers, bench drawers, or tool boxes. Place them in wall compartments at work stations or in a work area designated for emergency equipment. Store them in the original carton or carrying case.

- Draw clean respirators from storage for each use. Each unit can be sealed in a plastic bag, placed in a separate box, and tagged for immediate use.

APPENDIX V

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. Exposure limits, where they exist, are included so that a comparison can be made to determine if a chemical has adequate warning properties. A material has adequate warning properties if the effects (odor, taste, irritation) are detectable and persistent at concentrations "at" or "below" the exposure limit. Please note that some sources give a statement like "adequate" or "inadequate" for the warning properties. Since the statement may be used in conjunction with a different exposure limit than is used in this table, it should be used with caution. 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 end points 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 on 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.

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Acetaldehyde	0.0001 - 2.3 (50)	100/150		100/150	10000
Acetamide	"odorless when pure"				
Acetic acid	0.1 - 24 (10 - 15)	10		10/15	1000
Acetic anhyride	0.1 - 81.2 (5)	C-5		C-5	1000
Acetone	0.1 - 699	750/1000	250	750/1000	20000
Acetonitrile	40 - 170	40/60	20	40/60	4000
Acetophenone	0.002 - 0.60	WEEL - 10			
Acetyl bromide	5.0×10^{-4}				
Acetyl chloride	1				
Acrolein	0.05 - 16.6 (0.21 - 0.5)	0.1/0.3		0.1/0.3	5
Acrylamide	"odorless"	0.3 mg/m^3	0.3 mg/m^3	0.3 mg/m^3,A2	N.A.
Acrylic acid	0.1 - 1	10		10	
Acrylonitrile	1.6 - 100, fatigue	2	1	2,A2	Ca
		C-10	C-10		
Akrol	10				
Aldrin	0.2536 - 0.4027 mg/m^3	0.25 mg/m^3	LD	0.25 mg/m^3	Ca
Allyl alcohol	0.08 - 7.2, (0.75 - 25)	2/4		2/4	150
Allylamine	6.3 - 28.7				
Allyl chloride	0.1 - 10 (50 - 100)	1/2	1	1/2	300
			C-3		
Allyl chloroformate	1.4				
Allyl disulfide	0.0012				
Allyl glycidyl ether	<10	5/10	C-9.6	5/10	270
Allyl isocyanide	0.018				
Ally isothiocyanate	0.15 - 0.42	WEEL -/1			

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Allyl mercaptan	0.00005 - 0.21				
Allyl sulfide	0.000014 - 0.01				
Ammonia	0.04 - 55 (55 - 140)	-/35	C-50	25/35	500
Ammonium hydroxide	50				
Ammonium sulfamate	"odorless"	10 mg/m^3 (Total dust)		10 mg/m^3	5000 mg/m^3
		5 mg/m^3 (Respirable fraction)			
n-Amyl acetate	0.00090 - 10 (200)	100		100	4000
sec-Amyl acetate	0.0017 - 0.082	125		125	9000
tert-Amyl acetate	0.0017				
n-Amyl alcohol					
(1-Pentanol)	0.0065 - 35				
Amylene	0.0022 - 2.3				
(2-Methyl-2-Butene)					
Amyl isovalerate	0.11				
n-Amyl mercaptan	0.07				
n-Amyl Methyl Ketone	0.0009 - 0.35				4000
Amyl Sulfide	0.0030 - 0.005				
Anethole	0.003				
Aniline	0.5 - 70	2		2	100
Apiol	0.0063				
Arsenic anhydride	1	0.01 mg/m^3	C-0.002 mg/m^3	0.2 mg/m^3	Ca
(Arsenic pentoxide)		(as As)	(as As)	(as As)	
Arsine	0.21 - 0.63	0.05	C-0.002 mg/m^3	0.05	Ca
			(as As)		
Benzaldehyde	0.003 - 0.69 (4.6)	WEEL - 2/4			

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Benzene	1.4 - 120 (2817)	1/5	0.1 C-1	10,A2	Ca
Benzoyl peroxide	"odorless"	5 mg/m^3	5 mg/m^3	5 mg/m^3	7000 mg/m^3
Benzyl alcohol	5.5				
Benzyl chloride	0.01 - 0.31 (8)	1	C-5 mg/m^3	1	10
Benzyl mercaptan	0.00019 - 0.04 (4.5)		0.1		
Benzyl sulfide	0.0021 - 0.07				
Bornyl acetate	0.0078				
Boron oxide	"immediate irritation"	10 mg/m^3 (Total dust) 5 mg/m^3 (Respirable fraction)		10 mg/m^3	N.A.
Boron trifluoride	1 - 1.5	C-1	NE	C-1	100
Bromine	0.05 - 3.5 (0.6 intolerable)	0.1/0.3		0.1/0.3	10
Bromoacetone	0.090				
Bromoacetophenone	0.015 - 0.17 (0.04)				
Bromoform	1.3 - 530	0.5		0.5	N.A.
1,3-Butadiene	0.16 - 1.8 (>8000)	1000	LL	10,A2	
n-Butane	5.5 - 5000	800		800	
2-Butoxyethanol	0.1 - 60 (100 - 195)	25		25	700
Butyl acetate	0.037 - 20 (300)	150/200		150/200	10000
sec-Butyl acetate	3 - 7	200		200	10000
tert-Butyl acetate	0.004 - 47	200		200	10000
Butyl acrylate	0.04 - 0.9	10		10	
Butyl alcohol	0.1 - 20 (25 - 100)	C-50		C-50	8000
sec-Butyl alcohol	0.1 - 43	100		100/150	10000
tert-Butyl alcohol	0.1 - 73 (100)	100/150		100/150	8000

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Butylamine	0.1 - 5 (10 - 15)	C-5		C-5	2000
sec-Butylamine	0.24 (as n-Butylamine)	C-5		C-5	
tert-Butylamine	0.24 (as n-Butylamine)	C-5		C-5	
Butyl cellosolve (see 2-Butoxyethanol)					
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	5		5	n-Butyl
mercaptan	0.00082 - 0.38	0.5	C-0.5	0.5	2500
tert-Butyl mercaptan	0.00009 - 0.06				
Butyl sulfide	0.015 - 0.18				
p-tert-Butyltoluene	5 (5 - 8)	10/20		10/20	1000
n-Butyraldehyde	0.0046 - 0.039				
Butyric acid	0.00056 - 0.001				
Cadmium dust	"inadequate"	0.2 mg/m^3 C-0.6 mg/m^3	LL	0.05 mg/m^3	Ca
Cadmium fume	"inadequate"	0.1 mg/m^3 C-0.3 mg/m^3	LL	C-0.05 mg/m^3	Ca
Calcium dodecylbenzene sulfonate	0.3				
Calcium hydroxide	"odorless"			5 mg/m^3	

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Calcium hypochlorite	3.5 (as Chlorine)				
Calcium phosphide	0.13 - 13.4				
Camphor-synthetic	0.003 - 200 (1.77)	2 mg/m^3		12/18 mg/m^3	200 mg/m^3
Caprolactam	0.001 - 0.065	Dust - 1/3 mg/m^3 Vapor 5/10		Dust 1/3 mg/m^3 Vapor 5/10	
Carbaryl (Sevin®)	"essentially odorless"	5 mg/m^3	5 mg/m^3	5 mg/m^3	600 mg/m^3
Carbitol acetate	0.157 - 0.263				
Carbon dioxide	"odorless"	10,000/30,000	10000 C-30000	5000/30000	50000
Carbon disulfide	0.0011 - 7.7	4/12	1 C-10	10	500
Carbon monoxide	"odorless"	35	35 C-200	50/400	1500
Carbon tetrachloride	2 - 700	2	C-2	5,A2	Ca
Cavacrol	0.0023				
Chloral	0.047				
Chlordane	"odorless"	0.5 mg/m^3		0.5/2.0 mg/m^3	500 mg/m^3
Chlorine	0.01 - 5 (1 - 6)	0.5/1	C-0.5	1/3	30
Chlorine dioxide	0.1 (5.0)	0.1/0.3		0.1/0.3	10
Chloroacetaldehyde	0.93 (0.01 - 1)	C-1		C-1	250
Chloracetic acid	0.045	WEEL - 0.3/1			
Chloroacetophenone (CN, Tear Gas)	0.01 - 1.35 (0.024 - 0.063)	0.05		0.05	100 mg/m^3
Chlorobenzene	0.1 - 60	75		75	2400

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
o-Chlorobenzylidene malononitrile	(0.2)	C-0.05		C-0.05	2 mg/m^3
Chlorobromomethane	100 - 400	200		200/250	5000
Chloroform	50 - 307, fatigue (>4096)	2	C-2	10,A2	Ca
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)	0.1		0.1/0.3	4
B-Chloroprene	0.1 - 138	10	C-1	10	Ca
Chlorosulfonic acid	1 - 5 (from HC1 produced)	WEEL - 0.3			
o-Chlorotoluene	0.32	50		50/75	
Chlorovinyl arsine	1.6				
Cinnamaldehyde	0.0026				
Citric acid	"odorless"				
Cobalt, Metal Fume & Dust	(>1 mg/m^3)	0.05 mg/m^3		0.05 mg/m^3	20 mg/m^3
Coumarin (Coumaphos, Baymix)	0.0033 - 0.2				
Crag® Herbicide	"none"	10 mg/m^3 (Total dust) 5 mg/m^3 (Respirable fraction)			5000 mg/m^3
m-Cresol	0.25 - 0.68	5	2.3	5	250
o-Cresol	0.26 - 0.68	5	2.3	5	250
p-Cresol	0.00047 - 0.0455	5	2.3	5	250
Crotonaldehyde	0.01 - 7.35 (45)	2		2	400
Crotyl Mercaptan	0.00016 - 0.0099				

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
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	50		50	8000
Cyanogen chloride (CNCL)	1 C-0.3		C-0.3	50 mg/m^3	(as CN)
Cyclohexane	0.1 - 300 (300)	300		300	10000
Cyclohexanol	0.06 - 160 (100)	50		50	3500
Cyclohexanone	0.01 - 4	25	25	25	5000
Cyclohexene	0.18 - 300	300		300	10000
Cyclohexylamine	2.6	10		10	
Cyclopentadiene	0.01 - 250	75		75	2000
2,4-D esters	0.02 - 0.1	10 mg/m^3		10 mg/m^3	500 mg/m^3
DDT (Dichlorodiphenyl trichloroethane)	2.9 mg/m^3	1 mg/m^3	LD	1 mg/m^3	Ca
Decaborane	0.05 - 0.35 (fatigue)	0.05/0.15		0.05/0.15	20
Decanoic acid	0.0020 - 0.35				
Decanal	0.0064 - 0.168				
1-Decylene	0.12				
Diacetone alcohol	0.1 - 1.7	50	50	50	2100
Diacetyl	0.025				
Diallyl ketone	9.0				

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Diazomethane	"inadequate"	0.2		0.2	10
Diborane	1.8 - 4, "not reliable"	0.1		0.1	40
Di-N-Butyl amine	0.08 - 0.48				
Dibutyl phosphate	"inadequate"	1/2		1/2	125
Dichlorobenzene	0.005	(see o-, p-)			
o-Dichlorobenzene	0.3 - 50 (20 - 30)	C-50		C-50	1700
p-Dichlorobenzene	0.18 - 30 (80 - 160)	75/110		75/110	1000
Dichlorodiethyl sulfide (Mustard Gas)	0.0023-0.19				
Dichlorodifluoromethane	"odorless"	1000		1000	50000
1,3-Dichloro-5,5-dimethyl hydatoin	"adequate", 0.01 (1.14)	0.2/0.4 mg/m^3		0.2/0.4 mg/m^3	5 mg/m^3
1,1-Dichloroethane	50 - 1350, "adequate"	100	HWC	200/250	4000
1,2-Dichloroethylene	0.085 - 500	200		200	4000
Dichloroethyl ether	0.0005 - 35 (100-200)	5/10		5/10	250
bis-a-Dichloroethyl sulfide	0.0023				
Dichloroispropyl ether	0.32				
Dichloromethane (see Methylene chloride)					
Dichloromonofluoromethane	"nearly odorless"	10		10	50000
2,4-Dichlorophenol	0.21 - 0.008				
1,2-Dichloropropane	0.1 - 70	75/110		75/110	
2,2-Dichloropropionic acid (Dalapon)	428	1		1	
Dichlorotetrafluoroethane	"nearly odorless"	1000		1000	50000
Dicyclopentadiene	0.003 - 0.020	5		5	

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Dieldrin	0.041	0.25 mg/m^3	LD	0.25 mg/m^3	Ca
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	3		3	
Diethylamine	0.01 - 38 (50, animals)	10/25		10/25	2000
Diethylaminoethanol	0.01 - 0.25	10		10	500
Diethylene glycol	"almost odorless"	WEEL - 50 ppm, Total - 10 mg/m^3, Aerosol only			
Diethylene triamine	10	1		1	
Diethyl ketone	1 - 10	200		200	
Diethyl selenide	0.00014	0.2 mg/m^3 (as Se)	0.2 mg/m^3 (as Se)	0.2 mg/m^3 (as Se)	
Diethyl succinate	0.021				
Difluorodibromomethane	"inadequate"	100		100	2500
Diglycidyl ether	5	0.1		0.1	Ca
Diisobutyl carbinol	0.048 - 0.160				
Diisobutyl ketone	0.11 - 0.31 (25.8)	25	25	25	2000
Diisopropylamine	0.1 - 4 (25 - 50, injury)	5		5	1000
Dimethyl acetamide	21 - 47	10		10	400
Dimethylamine	0.01 - 6 (97 - 183, animals)	10		10	2000
Dimethylaminoethanol	0.015 - 0.045				
Dimethylaniline	0.001 - 0.2	5/10		5/10	100
Dimethyl ether	0.3 - 9	WEEL - 500			
Dimethylformamide	0.1 - 100	10		10	3500
1,1-Dimethylhydrazine	1 - 14	0.5	0.06	0.5,A2	Ca

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Dimethyl sulfate	"nearly odorless"	0.1		0.1,A2	10
Dimethyl sulfide	0.001 - 0.020				
Dimethyl sulfoxide	"practically no odor"				
Dimethyl trithiocarbonate	0.0058 - 0.18 mg/m^3				
Dinitro-o-cresol	"odorless"	0.2 mg/m^3	0.2 mg/m^3	0.2 mg/m^3	5 mg/m^3
2,6-Dinitrophenol	0.21 (as phenol)				
Dinitrotoluene	"inadequate"	1.5 mg/m^3	LL	1.5 mg/m^3	Ca
Dioxane	0.003 - 278 (200 - 300)	25	C-1	25	Ca
Dioxolane	64 - 128				
Diphenyl (Biphenyl)	0.0008 - 0.06 (3 - 4)	0.2		0.2	300 ms/m^3
Diphenylamine chlorarsine	0.22				
Diphenyl chloroarsine	0.030				
Diphenylcyanoarsine	0.3				
Diphenyl ether (see Phenyl ether)					
Diphenyl sulfide	0.00034 - 0.0047				
Diphosgene (Trichloro-methyl chloroformate)	1.2				
Dipropylamine	0.02 - 55				
Dipropylene glycol	"practically odorless"				
Dipropylene glycol methyl ether	34.7 - 1000 (74.3)	100/150		100	N.A.
Dithioethylene glycol	0.031				
Dodecanol	0.0064				
Dodecylbenzene sulfonic acid	0.4 - 8				

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Epichlorohydrin	0.1 - 16 (100)	2	ME	2	Ca
EPN	"inadequate"	0.5 mg/m^3		0.5 mg/m^3	50 mg/m^3
Ethane	150 - 899			(a)	
1,2-Ethanedithiol	0.0042			0.5	
Ethanol	1 - 5100 (5041)	1000		1000	
Ethanolamine	2 - 4	3/6		3/6	1000
2-Ethoxy-3,4-dihydro-1, 2-pyran	0.10 - 0.60				
2-Ethoxyethanol (Cellosolve solvent)	0.55 - 50	200	LL	5	NN
2 Ethoxyethyl acetate (Cellosolve acetate)	0.056 - 50 (600, animals)	100		5	2500
Ethyl acetate	0.01 - 50 (200 - 400)	400		400	10000
Ethyl acrylate	0.00024 - 1 (75)	5/10		5/25	2000
Ethylamine	0.01 - 1 (100, delayed)	10		10	4000
Ethyl benzene	0.1 - 200 (200)	100/125		100/125	2000
Ethyl bromide	3.1 - 200 (6500)	200/250		200/250	3500
2-Ethylbutanol	0.07 - 0.77				
Ethyl butyl ketone	0.1 - 10	50		50	3000
Ethyl butyrate	0.0082 - 0.015				
Ethyl chloride (Chloroethane)	4.2	1000	HWC	1000	20000
Ethyl disulfide	0.0028				
Ethylene	261 - 4010			(a)	
Ethylene bromide (see Ethylene dibromide)					

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Ethylene chloride (see Ethylene dichloride)					
Ethylene chlorohydrin	"odorless", 0.4	C-1		C-1	10
Ethylene diamine	1 - 11.2 (100)	10		10	2000
Ethylene dibromide	10 - 25	20	0.045	A2	Ca
		C-30	C-0.13		
		P-50			
Ethylene dichloride	6.2 - 185	1/2	1	10	Ca
			C-2		
Ethylene glycol	0.08 - 40	C-50		C-50	
Ethylene imine	"inadequate" 1 - 100+	LL	LL	0.5	Ca
Ethylene oxide	0.1 - 700	1	0.1	1,A2	Ca
			C-5		
Ethyl ether	0.1 - 9 (200)	400/500		400/500	19000
Ethyl formate	18 - 33 (330)	100		100	8000
Ethyl glycol	25				
Ethyl hexanol	0.075 - 0.138				
Ethyl hexanoate	0.0056				
Ethyl hexyl acetate	0.073 - 0.21				
Ethyl hexyl acrylate	0.18				
Ethylidene norbornene	0.007 - 0.073	C-5		C-5	
Ethyl isothiocyanate	1.6 - 10.7				
Ethyl mercaptan	0.00051 - 0.075	0.5	C-0.5	0.5	2500
Ethyl methacrylate	0.0067				
n-Ethylmorpholine	0.1 - 25, fatigue (40 - 100)	5		5	2000
Ethyl pelargonate	0.0014				

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Ethyl phthalate	"odorless"				
Ethyl selenide	0.0003 - 0.014 mg/m^3	0.2 mg/m^3 (as Se)	0.2 mg/m^3 (as Se)	0.2 mg/m^3 (as Se)	
Ethyl selenomercaptan	0.0003	0.2 mg/m^3 (as Se)	0.2 mg/m^3 (as Se)	0.2 mg/m^3 (as Se)	
Ethyl silicate	17 - 85 (250)	100		10	1000
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	(5.0mg/m^3)	2.5 mg/m^3	2.5 mg/m^3 (as F)	2.5 mg/m^3	500 mg/m^3
Fluorine	0.035 - 3 (25 - 100)	0.1		1/2	25
Fluorotrichloromethane	5 - 100, "odorless"	C-1000		C-1000	10000
Formaldehyde	0.01 - 60 (0.25 - 2)	3	0.016	1/2, A2	Ca
		C-10	C-0.1		
Formic acid	0.024 - 340 (15)	5		5	100
Fuel Oil #1	0.082 - 1				
(Kerosene, Jet Fuel)					
Fuel Oil #2	0.082				
(Diesel Oil)					
Fuel Oil #4	0.5				
Fuel Oil #6 (Bunker-C)	0 - 13				
Furfural	0.006 - 5 (12.2 - 50)	2		2	250
Furfuryl alcohol	8	10/15	50	10/15	250

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Fumaric acid (trans-Butenedioic)	"odorless"				
Gasoline	0.005 - 10	300/500		300/500	
Glutaraldehyde	0.04	C-0.2		C-0.2	
Glycol diacetate	0.077 - 0.312				
Halothane	33			50	
n-Heptal chloride	0.060				
Heptachlor	0.306 mg/m^3	0.5 mg/m^3		0.5 mg/m^3	100 mg/m^3
Heptaldehyde	0.050				
n-Heptane	0.5 - 329	400/500	85 C-440	400/500	5000
Heptanol	0.057 - 20				
HETP (see TEPP)					
Hexachlorocyclopentadiene	0.03 - 0.33	0.1		0.01	
Hexachloroethane	0.15	1	LL	10	Ca
Hexamethlyenediamine	0.0009	WEEL - 5 mg/m^3			
n-Hexane	65 - 248 (1400 - 1500)	500/100	100 C-510	50	5000
Hexanoic acid	0.0061				
Hexanol	0.0050 - 0.09				
Hexanone (see Methyl Butyl Ketone)					
sec-Hexyl acetate	0.1 - 100 (100)	50		50	400
Hexylene glycol	50	C-25		C-25	
Hydrazine	3 - 4	0.1	C-0.03	0.1,A2	Ca

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Hydrocinnamyl alcohol	0.00027				
Hydrogen bromide	2 (3 - 6)	C-3		C-3	50
Hydrogen chloride	1 - 10 (35)	C-5		C-5	100
Hydrogen cyanide	0.00027 - 5, fatigue	-/4.7	C-4.7	C-10	50
Hydrogen fluoride	0.04 - 0.163	3/6	3 C-6	C-3	30
Hydrogen peroxide	"odorless" (100)	1		1	75
Hydrogen selenide	0.0005 - 3.6, fades fast (1.5)	0.05		0.05	2
Hydrogen sulfide	0.00001 - 1.4 (50 - 100) (fatigue at high concentration)	10/15	C-10	10/15	300
2-Hydroxpropyl acrylate	0.05	0.5		0.5	
Indene	0.02	10		10	
Iodine	1.73 (1.63 - disappears within 2 minutes)	C-0.1		C-0.1	10
Iodoform	0.0004 - 0.5	0.6		0.6	
Ionone	5.9×10^{-8} - 73				
Isoamyl acetate	0.001 - 1	100		100	3000
Isoamyl alcohol	0.01 - 35 (100 - 150)	100/125		100/125	8000
Isoamyl mercaptan	0.0043 - 0.7				
Isobutyl acetate	0.002 - 7 (<150)	150		150/187	7500
Isobutyl alcohol	0.0009 - 74 (99)	50		50	8000
Isobutyl acrylate	0.009 - 0.012				
Isobutyl cellosolve	0.114 - 0.191				
Isobutyl mercaptan	0.00054 - 0.00097				
Isobutyraldehyde	0.047 - 0.336				

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
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)	4	4	C-5	800
Isoprene (2-Methylbutadiene)	0.005	WEEL - 50			
Isopropanolamine dodecylbenzene sulfate	0.3				
Isopropyl acetate	0.5 - 400 (200)	250/310		250/310	16000
Isopropyl alcohol	7.5 - 300 (400)	400/500	400 C-800	400/500	12000
Isopropylamine	0.1 - 10 (10 - 20)	5/10		5/10	4000
Isopropyl ether	0.02 - 300 (800)	500		250/310	10000
Isopropyl glycidyl ether	300	50/75	C-50	50/75	1500
Isopropyl Mercaptan	0.00025				
Kerosene	0.082 - 1		100 mg/m^3		
Ketene	(23)	0.5/1.5		0.5/1.5	50
Kuwait-Crude	0.1 - 0.5				
Lactic acid	4×10^{-7}				
Lauric acid	0.0034				
Lauryl mercaptan	4 mg/m^3				
Light Gasoline	800			300/500	

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Lindane	"practically odorless"	0.5 mg/m^3		0.5 mg/m^3	1000 mg/m^3
	3.9 mg/m^3 - 21.3 mg/m^3				
Linoleyl acetate	0.0016				
Lithium hydride	(0.1 mg/m^3)	0.025 mg/m^3		0.025 mg/m^3	55 mg/m^3
LPG	20,000 (propane)	1000		1000	19000
Magnesium dodecyl sulfate	0.2				
Malathion	10 - 13.5 mg/m^3	10 mg/m^3 (Total dust)	15 mg/m^3	10 mg/m^3	5000 mg/m^3
		5 mg/m^3 (Respirable fraction)			
Maleic anhydride	0.1 - 0.5 (0.25 - 1.83)	0.25		0.25	500
Menthol	1.5				
2-Mercaptoethanol	0.12 - 0.64				
Mercury, Inorganic (except Mercury pernitrate)	"odorless"	C-0.1 mg/m^3 (as Hg)	0.05 mg/m^3 (as Hg)	0.1 mg/m^3	28 mg/m^3
Mercury, vapor	"odorless"	0.05 mg/m^3		0.05 mg/m^3	28 mg/m^3
Mesitylene (see Trimethybenzene)					
Mesityl oxide	0.017 - 25	15/25	10	15/25	5000
Methoxynaphthalene	0.00012				
3-Methoxypropylamine	0.2 - 42	WEEL-10			
Methyl acetate	0.2 - 300 (10,000)	200/250		200/250	10000
Methyl acetylene-Propadiene Mixture	100	1000/1250		1000/1250	20000
Methyl acrylate	0.0005 - 20 (75)	10		10	1000
Methylacrylonitrile	2 - 14 (fatigue)	1		1	
Methyl alcohol	10 - 20482 (7500-69000)	200/250	200	200/250	25000
		C-800			

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Methylamine	0.001 - 10, fatigue (20 - 100)	10		10	100
Methyl amyl acetate	0.002 - 1048 (1048)				
Methyl amyl alcohol (Methyl isobutyl carbinol)	0.01- 50 (24 - 50)	25/40		25/40	2000
n-Methylaniline	1.6 - 2	0.5		0.5	100
Methyl anthranilate	0.00066 - 0.06				
Methyl bromide	20.6 - 1030	5	LL	5	Ca
2-Methyl-2-butanol (tert-Amyl alcohol)	0.23 - 2.3				
Methyl n-butyl ketone	0.07 - 0.09	5	1	5	5000
Methyl n-butyrate	0.0026				
Methyl cellosolve	0.0925 - 92.5 (118)	25	LL	5	NN
Methyl cellosolve acetate	0.64 - 50	25		5	4000
Methyl chloride	10 - 250, "no odor" (500 - 1000)	50/100	LL	50/100	Ca
Methyl chloroform	20 - 714 (500 - 1000)	350/450		350/450	1000
Methyl 2-cyanoacrylate	1 - 3	2/4		2/4	
Methylcyclohexane	500 - 630	400		400	10000
Methylcyclohexanol	500 (500)	50		50	10000
Methyl dichloroarsine	0.11				
Methyl bisphenyl isocyanate (MDI)	0.39 (0.05 - 0.1)	C - 0.02	0.005 C-0.02	0.005	10
Methylene choride (Dichloromethane)	"can adapt to odor" 25 - 227 (5000)	500 C-1000 P-2000	LL	50/175, A2	Ca

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Methyl ethanol amine	3.4				
Methyl ethyl ketone (MEK)	0.25 - 85 (200)	C - 0.7	200	200/300	3000
Methylethyl pyridine	0.006 - 19				
Methyl formate	204 - 3000, fatigue (3563)	100/150		100/150	5000
Methyl glycol (1,2-propylene glycol)	60 - 90				
5-Methyl-3-heptanone (Ethyl amyl ketone)	6 (50)	25		25	3000
Methyl hydrazine	1 - 3	C-0.2	C-0.04	C-0.2,A2	Ca
Methyl iodide	(4300)	2	LL	2,A2	Ca
Methyl isoamyl alcohol	0.20				
Methyl isoamyl ketone	0.01 - 0.28	50	100	50	
Methyl isobutyl ketone	0.01 - 47 (100)	50/175	50	50/75	3000
Methyl isocyanate	2.0 (2)	0.02		0.02	20
Methyl isopropyl ketone	0.1 - 4.8	200		200	
Methyl mercaptan	0.0001 - 1.1	0.5	0.5	0.5	400
Methyl methacrylate	0.01 - 1 (170 - 250)	100		100	4000
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)	50/100		50/100	5000
Methyl sulfide (see Dimethyl Sulfide)					
Methyl thiocyanate	0.25 - 3.2				

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Methyltrichlorosilane	1				
Methyl vinyl ketone	0.2				
Methylvinyl pyridine	0.040				
Mineral spirits	30				
Morpholine	0.01 - 0.14	20/30		20/30	8000
Musk (Synthetic)	4.0×10^{-7}				
Naptha - coal tar	4.68 - 100 (200 - 300)	100			10000
Naptha - petroleum (rubber solvent)	<500				
Naphthalene	0.001 - 0.8 (15)	10/15		10/15	500
2-Napthol	1.3				
Nickel carbonyl	1 - 3	0.001	0.001	0.05 (as Ni)	Ca
Nitric acid	0.3 - 1.0 (62)	2/4	2	2/4	100
Nitric oxide	"odorless", 0.3 - 1, "poor"	25		25	100
p-Nitroaniline	"odorless"	3 mg/m^3		3 mg/m^3	300 mg/m^3
Nitrobenzene	0.001 - 6	1		1	200
o-Nitrochlorobenzene	0.002				
Nitroethane	2.1 - 200 (100 - 500)	100		100	10000
Nitrogen dioxide	0.1 - 5.3 (5 - 20)	-/1	C-1	3/5	50
Nitrogen tetroxide	5				
Nitrogen trifluoride	"no odor-warning properties at potentially dangerous levels"	10		10	2000
Nitromethane	3.5 - 100 (200 - 500)	100		100	1000
1-Nitropropane	11 - 300 (99 - 150)	25		25	2300
2-Nitropropane	48 - 300	10	LL	C-10,A2	Ca

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Nitrotoluene (m,o,p isomers)	0.05 - 1.74	2		2	200
Nitrous oxide	"poor"		25		
Nonane	0.1 - 47	200		200	
n-Octane	0.5 - 235	300/375	75 C-385	300/375	5000
Octanoic Acid	0.0014				
1-Octanol	0.0021 - 0.31	WEEL - 50			
2-Octanol	0.0026				
Oenanthic acid (Heptanoic acid)	0.015				
Oxygen difluoride	0.1 - 0.5, (fatigue)	C-0.05	C-0.5	C-0.05	0.5
Ozone	0.0005 - 0.5 (1 - 3.7)	0.1/0.3		0.1/0.3	10
Parathion	0.48 mg/m^3	0.1 mg.m^3	0.05 mg/m^3	0.1 mg/m^3	20 mg/m^3
Pelargonic acid (Nonyl Alcohol)	0.00086				
Pentaborane	0.8 (1)	0.005/0.015		0.005/0.015	3
Pentachlorophenol	9.3 mg/m^3 (0.3 - 10.9 mg/m^3)	0.5 mg/m^3		0.5 mg/m^3	150 mg/m^3
n-Pentane	2.2 - 1100	600/750	120 C-610	600/750	15000
2,4-Pentanedione	0.01 - 0.024				
2-Pentanone (Methyl propyl ketone)	3 - 14	200	150	200/250	5000
Pentanol (see amyl alcohol)					
Pentene (n-Amylene)	2.2				
n-Pentyl acetate (see n-Amyl acetate)					

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
1-Pentyl mercaptan	0.00021				
Perchloroethylene (see Tetrachloroethylene)					
Perchloromethyl mercaptan	0.001	0.1		0.1	10
Perchloryl fluoride	10 (but not reliable)	3/6		3/6	385
Pero-Klean-No-818	0.005				
Petroleum distillates (Petroleum naptha)	<500	400			10000
Phenol	0.005 - 5 (48)	5	5.2 C-15.6	5	250
Phenyl ether	0.001 - 0.10 (3 - 4)	1		1/2	N.A.
Phenyl ether-biphenyl mixture	0.1 - 1 (3-4)	1			N.A.
Phenyl isocyanide	0.029 mg/m^3				
Phenyl isothiocyanate	0.43				
Phosgene	0.125 - 6 (dulls senses) (1-2)	0.1	0.1 C-0.2	0.1	2
Phosphine	0.01 - 5 (7.7)	0.3/1		0.3/1	200
Phosphorous pentasulfide	"fatigue", 0.0047 (as H_2S)	1 mg/m^3		1/3 mg/m^3	750 mg/m^3
Phosphorous trichloride	0.7 (2 - 4)	0.2/0.5		0.2/0.5	50
Phthalic anhydride	0.05 - 0.12 (30 mg/m^3)	1		1	16700
2-Picoline	0.023 - 0.046	WEEL - 2/5			
Propane	1000 - 20,000	1000		(a)	20000
Propionaldehyde	0.04 - 1				
Propionic acid	0.001 - 20	10		10/15	

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
n-Propyl acetate	0.05 - 200	200/250		200/250	8000
Propyl alcohol	0.01 - 200 (5500)	200/250		200/250	4000
Propylene	23 - 67.6			(a)	
Propylene diamine	0.014 - 0.067				
Propylene dichloride	0.25 - 130	75/110		75/110	2000
Propylene glycol	"odorless"	WEEL - 500 ppm, Total; 10 mg/m^3 Aerosol only			
Propylene glycol dinitrate	0.24	0.05			0.05
Propylene glycol monomethyl ether	10	100/150		100/150	
Propylene oxide	10 - 210 (457 - 473, animals)	100		20	2000
Propyl mercaptan	0.00075 - 0.02				
n-Propyl nitrate	50 - 90	25/40		25/40	2000
Propyl sulfide	0.011 - 0.17				
Pyridine	0.001 - 5 (fatigue at 5, but taste remains)	5		5	3600
Pyrolgallo (1,2,3-trihydroxybenzene)	20				
Quinoline	0.16 - 71	WEEL - 0.1			
Quinone	0.08 - 0.5, fatigue (0.1 - 0.5)	0.1		0.1	75
Resorcinol (1,3-dihydroxylbenzene)	40	10/20		10/20	
Rotenone	"odorless", 222 mg/m^3	5 mg/m^3		5 mg/m^3	5000 mg/m^3
Safrole	0.0032				

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Selenium oxide	0.0002 mg/m^3	0.2 mg/m^3 (as Se)		0.2 mg/m^3 (as Se)	100 mg/m^3
Silver Cyanide	"odorless"	0.01 mg/m^3 (as Ag)		0.01 mg/m^3 (as Ag)	50 mg/m^3 (CN)
Silver Nitrate	"odorless"	0.01 mg/m^3 (as Ag)		0.01 mg/m^3 (as Ag)	N.A.
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 dodecylbenzene sulfonate	0.5 (as alky aryl sulfonate)				
Sodium hydroxide	"odorless"	C-2 mg/m^3	C-2 mg/m^3	C-2 mg/m^3	250 mg/m^3
Sodium nitrochlorobenzene sulfonate	0.5 (as alky aryl sulfonate)				
Sodium octyl sulfate	0.2				
Sodium sulfate	"odorless"				
Sorbitol	"odorless"				
Stoddard solvent	1 - 30 (400)	100	350 mg/m^3	100	5000
Strychnine	"odorless"	0.15 mg/m^3		0.15 mg/m^3	3 mg/m^3
Styrene	0.001 - 200 (200 - 400)	50/100	50 C-100	50/100	5000
Styrene oxide	0.40				
Sulfoxide	91				
Sulfur dichloride ($SC1_2$)	0.001				
Sulfur dioxide	0.3 - 5 (6 - 20)				

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
	0.3-taste	2/5	0.5	2/5	100
Sulfuric Acid	0.6 - 2.4 mg/m^3	1 mg/m^3	1 mg/m^3	1 mg/m^3	80 mg/m^3
Sulfur monochloride (Sulfur chloride, S_2C1_2)	0.001 (2 - 9)	C-1		C-1	10
Sulfuryl fluoride	"odorless"	5/10		5/10	1000
Tannic acid	2 - 4				
TEPP (HETP, Bladex, Vapotone)	"odorless"	0.05 mg/m^3		0.004 mg/m^3	10 mg/m^3
Terphenyls	> 1	C - 0.5		C-0.5	3500 mg/m^3
1,1,2,2-Tetrachloroethane	0.2 - 8	1	LL	1	Ca
Tetrachlorethylene (Perchloroethylene)	2 - 50 (106 - 690)	25	ME	50/200	Ca
Tetraethyl-o-silicate	5.0 - 7.2				
Tetrahydrofuran	0.1 - 60	200/250		200/250	20000
Tetramethylbenzene	0.0029				
Tetranitromethane	(0.40)	1		1	5
Thiocresol (Toluenethiol)	0.0027 - 0.02				
Thiophenol (Phenyl mercaptan)	0.0001 - 85	0.5		0.5	
Thymol	0.00086				
Toluene	0.02 - 70, fatigue (300 - 400)	100/150	100 C-200	100/150	2000 C-200
Toluene diisocyanate (TDI)	0.2 - 2.14	0.005/0.02	0.005 C-0.02	0.005/0.02	10

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
Toxaphene (Phenatox)	2.4 mg/m^3	0.5/1 mg/m^3		0.5/1 mg/m^3	200 mg/m^3
1,2,4-Trichlorobenzene	1.4 - 3	C-5		C-5	
1,1,2-Trichloroethane	0.5 - 167	10	LL	10	Ca
o-Tolidine	0.0048 - 20	5	C-0.02 mg/m^3	2,A2	100
1,1,1-Trichloroethane (Methyl chloroform)	20 - 400 (500 - 1000)	350/450	C-350	350/450	1000
Trichloroethylene	0.2 - 400 (160)	50/200	25	50/200	Ca
Trichlorofluoromethane	5 - 209	C-1000		C-1000	
Trichlorophenol	0.1 - 0.667				
1,2,3-Trichloropropane	100 (100)	10		10	1000
1,1,2-trichloro-1,2,2-trifluoroethane	0.5 - 200	1000/1250		1000/1250	4500
Triethanolamine dodecylbenzene sulfonate	0.3				
Triethylamine	0.009 - 2.8 (50)	10/15		10/15	1000
Triethylene glycol	"practically odorless"				
Trimethylamine	0.0001 - 1.7	10/15		10/15	
		WEEL - 1			
Trimethylbenzene (Mesitylene)	0.006 - 2.4	25		25	
Trimethyl phosphite	0.001	2		2	
Trinitrobutylxylene	6.5 x 10^{-6} - 0.0008				
Triphenyl phosphate	"odorless"			3 mg	N.A.
Turpentine	50 - 200 (100 - 200)	100		100	1900
n-Undecane	0.12				

CHEMICALS	WARNING CONCENTRATIONS[2]	Exposure Limits[1] PEL-TWA/STEL	REL	TLV®-TWA/STEL	IDLH LEVEL
n-Valeraldehyde	0.001 - 8.2	50		50	
Valeric acid	0.00060				
isoValeric acid	0.0018				
Vandium pentoxide - Dust	(0.5 - 2.2 mg/m^3)	0.05 mg/m^3	C-0.05 mg/m^3	0.05 mg/m^3	70 mg/m^3
Fume	0.05 mg/m^3	0.1 mg/m^3 (as Va)	0.05 mg/m^3		
Vanillin	3.2 x 10^{-8}				
Vinyl acetate	0.1 - 1	10/20	C-4	10/20	
Vinyl chloride	260 - 3000	1	LD	5,A1	Ca
Vinyl toluene	10 - 50 (50)	100		50/100	5000
Warfarin	"odorless"	0.1 mg/m^3		0.1 mg/m^3	200 mg/m^3
Xylene	0.05 - 200, fatigue (100 - 200)	100/150	100, C-200	100/150	1000
m-Xylene	0.08 - 40	100/150	100, C-200	100/150	1000
o-Xylene	0.08 - 40	100/150	100, C-200	100/150	1000
p-Xylene	0.08 - 40	100/150	100, C-200	100/150	1000
Xylidine	0.0048 - 0.06	2		2	150
Vinylidene chloride (1,1-Dichloroethylene)	190	1		5/20	
V M & P Naptha	10	300/400		300	

[1] The exposure limits are 8 hour Time Weighted Averages (TWA) unless otherwise noted.

[2] Fatigue = Indicates that the chemical can cause olfactory fatigue.

(a) = Simple asphyxiant. Check oxygen concentration.

A1 = Confirmed Human Carinogen (ACGIH)

A2 = Suspected Human Carcinogen (ACGIH) animal = irritation concentration based on animal studies

C = Ceiling Limit. Ceiling limits for REL may be limited to 10 minutes, 15 minutes or not to be exceeded for any time. Check individual value.

Ca = NIOSH has recommended that the substance be treated as a potential human carcinogen; IDLH's are not listed for those substances.

HWC = "To be handled in the workplace with caution" (NIOSH)

IDLH = Immediately Dangerous to Life or Health, NIOSH Pocket Guide to Chemical Hazards, Sept. 1985.

LD = "Reduce exposure to lowest reliably detectable level" (NIOSH)

LL = "Reduce exposure to lowest feasible level" (NIOSH)

ME = "Minimize occupational exposure" (NIOSH)

N.A. = NIOSH has not assigned an IDLH

NN = Not applicable because of NIOSH REL

NE = "No exposure limit recommended due to absence of a reliable monitoring method" (NIOSH)

P = "Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift." Each has a specific time limit.

PEL = Permissible Exposure Limits, "29 CFR 1910 Subpart Z," Occupational Safety and Health Administration (OSHA)

REL = Recommended Exposure Limits, NIOSH Recommendations for Occupational Safety and Health Standards, 1988, National Institute for Occupational Safety and Health (NIOSH)

TLV = Threshold Limit Value, Threshold Limit Values and Biological Exposure Indices for for 1988-1989, American Conference of Governmental Industrial Hygienists (ACGIH)

STEL = Short Term Exposure Limit

WEEL = American Industrial Hygiene Association Workplace Environmental Exposure Level Guides (1988). This is not a PEL but is placed in that column due to space limitations. The first number is an 8 hour TWA. The second number is a short term TWA. The time varies from 1 -15 minutes. Check individual values.

SECTION 5

PERSONAL PROTECTIVE EQUIPMENT

PART 3

SELF-CONTAINED BREATHING APPARATUS

I. INTRODUCTION

Respiratory apparatus must frequently be used during response to hazardous materials incidents. If the contaminant is unknown or the requirements for using air-purifying respirators cannot be met, then an atmosphere supplying respirator is required. Several types of atmosphere supplying devices are available:

-- Oxygen-generating

One of the oldest respirators is the oxygen-generating respirator, which utilizes a canister of potassium superoxide. The chemical reacts with water vapor to produce oxygen which replenishes the wearer's exhaled breath. Exhaled CO_2 is removed by a scrubber device containing LiOH. This reoxygenated air is then returned to the wearer. Oxygen-generating respirators have been used by the military and for escape purposes in mines. It generally is not used for hazardous material applications because of the chemical reaction taking place within the respirator itself.

-- Hose mask

This type of respirator consists of a facepiece attached to a large diameter hose which transports clean air from a remote area. In units where the wearer breathes the air in, the hose lines can go up to 75 feet. With powered units the hose length can vary from 50 to 250 feet.

-- Airline respirator

The airline respirator is similar to the hose mask, except that breathing grade air is delivered to the wearer under pressure; either from a compressor or a bank of compressed air cylinders. The air may flow continuously, or it may be the wearer breathes (demands it). The air source must not be depletable, and no more than 300 feet of airline is allowed. An escape device is required for entry into an IDLH atmosphere.

-- Self-contained breathing apparatus

The self-contained breathing apparatus (SCBA) consists of a facepiece and regulator mechanism connected to a cylinder of compressed air or oxygen carried by the wearer.

The self-contained breathing apparatus (SCBA) is generally used because it allows the wearer to work without being confined by a hose or airline. The wearer of the SCBA depends on it to supply clean breathing air.

If the wearer is not properly trained to wear the SCBA or it is not properly cared for, then it may fail to provide the protection expected.

The user should be completely familiar with the SCBA being worn. Checkout procedures have been developed for inspecting an SCBA prior to use, allowing the user to recognize potential problems. An individual who checks out the unit is more comfortable and confident wearing it.

There are two types of apparatus: closed-circuit, which use compressed oxygen, and open-circuit, which use compressed air. SCBA's may operate in one of two modes, demand or pressure-demand (positive-pressure). The length of time an SCBA operates is based on the air supply. The units available operate from 5 minutes to over 4 hours.

Pressure Demand (positive pressure) is the only approved type of open circuit SCBA for use in Hazardous Environments by the US EPA and NFPA.

Both open- and closed-circuit SCBA's will be discussed and the modes of operation explained. The bulk of the discussion deals with open circuit pressure-demand SCBA's which are most widely used because they offer more protection.

II. MODES OF OPERATION

A. Demand

In the demand mode, a negative pressure is created inside the facepiece and breathing tubes when the wearer inhales (**TABLE 6**). This negative pressure draws down a diaphragm in the regulator in an SCBA. The diaphragm depresses and opens the admission valve, allowing air to be inhaled. As long as the negative pressure remains, air flows to the facepiece.

The problem with demand operation is that the wearer can inhale contaminated air through any gaps in the facepiece-to-face sealing surface. Hence, a demand apparatus with a full facepiece is assigned a Protection Factor of only 100, the same as for a full face air-purifying respirator.

B. Pressure-Demand

An SCBA operating in the pressure-demand mode maintains a positive pressure inside the facepiece at all times. The system is designed so that the admission valve remains open until enough pressure is built up to close it. The pressure builds up because air is prevented from leaving the system until the wearer exhales. Less pressure is required to close the admission valve than is required to open the spring-loaded exhalation valve.

At all times, the pressure in the facepiece is greater than the ambient pressure outside the facepiece (**TABLE 6**). If any leakage occurs, it is outward from the facepiece. Because of this, the pressure-demand (positive pressure) SCBA has been assigned a Protection Factor of 10,000.

TABLE 6		
PRESSURE INSIDE FACEPIECE OF SCBA RELATIVE TO AMBIENT PRESSURE OUTSIDE		
	Demand	**Pressure Demand (positive pressure)**
Inhalation	-	+
Exhalation	+	+
Static (between breaths)	same	+

III. TYPES OF APPARATUS

A. Closed-Circuit

The closed-circuit SCBA (**FIGURE 4**), commonly called the rebreather, was developed especially for oxygen-deficient situations. Because it recycles exhaled breath and carries only a small oxygen supply, the service time can be considerably greater than an open-circuit device, which must carry all of the user's breathing air.

The air for breathing is mixed in a flexible breathing bag. This air is inhaled, deflating the breathing bag. The deflation depresses the admission valve, allowing the oxygen to enter the bag. There it mixes with exhaled breath, from which carbon dioxide has just been removed by passage through a CO_2 scrubber.

Most rebreathers operate in the demand mode. Several rebreathers are designed to provide a positive pressure in the facepiece. The approval schedule 13F under 30 CFR Part II for closed-circuit SCBA makes no provisions for testing "demand" or "pressure-demand" rebreathers. The approval schedule was set up to certify only rebreathers that happen to operate in the demand mode. Thus, rebreathers designed to operate in the positive pressure mode can be approved strictly as closed-circuit apparatus. Since regulations make no distinction, and selection is based on approval criteria, rebreathers designed to maintain a positive pressure can only be considered as a demand-type apparatus. Rebreathers use either compressed oxygen or liquid oxygen. To assure the quality of the air to be breathed, the oxygen must be at least medical grade breathing oxygen which meets the requirements set by the "U.S. Pharmacopeia".

B. Open-Circuit

The open-circuit SCBA requires a supply of compressed breathing air. The user simply inhales and exhales. The exhaled air is exhausted from the system. Because the air is not recycled, the wearer must carry the full air supply, which limits a unit to the amount of air that the wearer can easily carry. Available SCBA's can last from 5 to 60 minutes. Units which have 5-to-15 minute air supplies are only applicable to escape situations.

The air used in open-circuit apparatus must meet the requirements in the Compressed Gas Association's Pamphlet G-7.1, which calls for at least "Grade D". Grade D air must contain 19.5 to 23.5% oxygen with the balance being predominantly nitrogen. Condensed hydrocarbons are limited to 5 mg/m^3, carbon monoxide to 20 parts per million (ppm) and carbon dioxide to 1,000 ppm. An undesirable odor is also prohibited. Air quality can be checked using an oxygen meter, carbon monoxide meter and detector tubes.

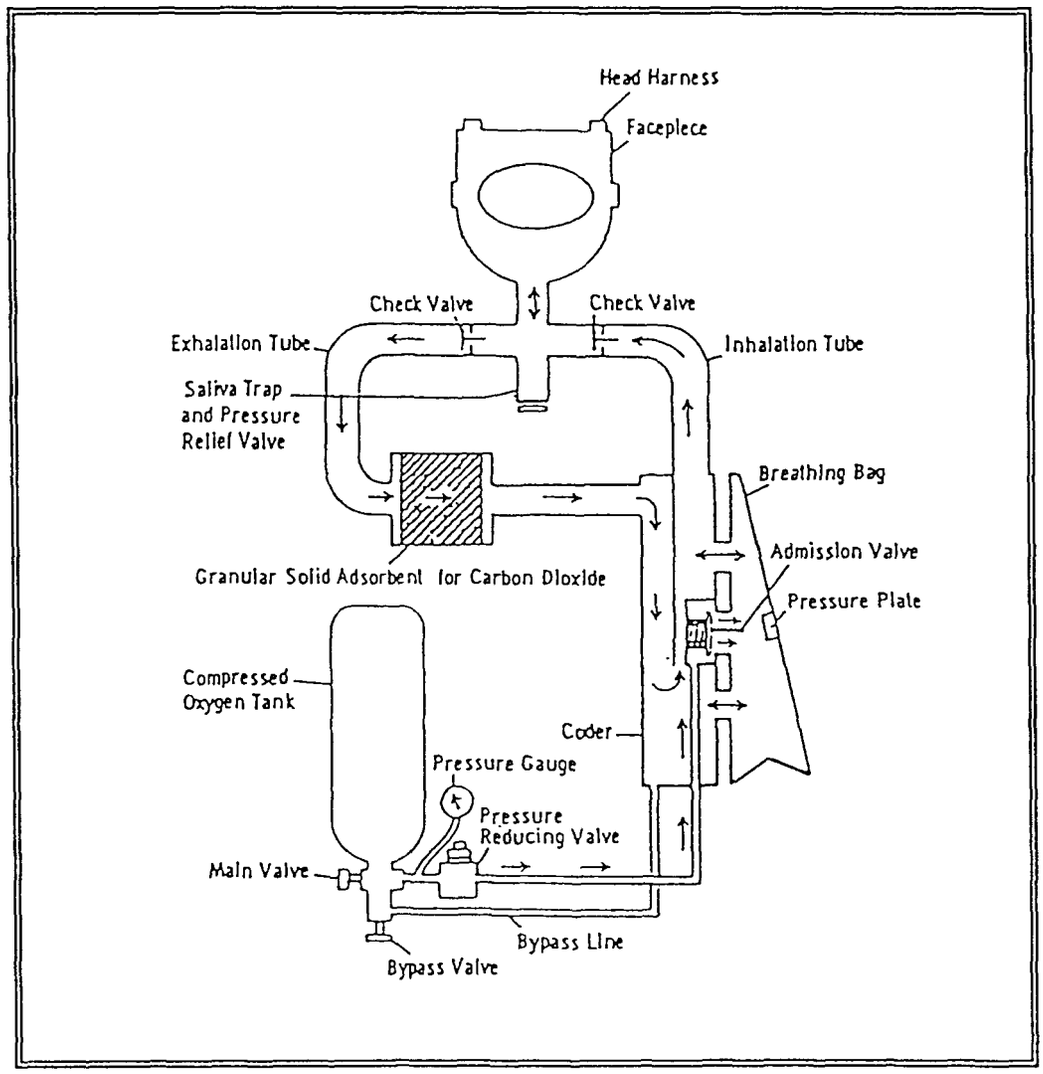


FIGURE 4

CLOSED-CIRCUIT SCBA

IV. COMPONENTS OF A TYPICAL OPEN-CIRCUIT PRESSURE DEMAND SCBA

A. Cylinder

Compressed air is considered a hazardous material. For this reason, any cylinder used with a SCBA must meet the Department of Transportation's (DOT) "General Requirements for Shipments and Packaging" (49 CFR Part 173) and "Shipping Container Specifications" (49 CFR Part 178).

A hydrostatic test must be performed on a cylinder at regular intervals: for steel & aluminum cylinders, every 5 years; for composite cylinders (glass fiber/aluminum), every 3 years. Composite cylinders are relatively new, designed with fiberglass. Composite cylinders have a DOT exemption because there are no set construction requirements at this time. Overall difference is in weight. The construction technology reduces the weight of the cylinder and thereby the overall weight of the SCBA.

Air volume of 45 cubic feet of Grade D air at a pressure of 2,216 pounds per square inch (psi) is needed for a 30-minute supply. Cylinders are filled using a compressor or a cascade system of several large cylinders of breathing air. If the cylinder is overfilled, a rupture disc releases the pressure. The rupture disc is located at the cylinder valve, along with a cylinder pressure gauge to be accurate within $\pm$ 5%. Because the gauge is exposed and subject to abuse, it should be used only for judging if the cylinder is full, and not for monitoring air supply to the wearer.

B. High-Pressure Hose

The high-pressure hose connects the cylinder and the regulator. The hose should be connected to the cylinder only by hand, never with a wrench. An O-ring inside the connector assures a good seal.

C. Alarm

A low-pressure warning alarm is located near the connection to the cylinder. This alarm sounds to alert the wearer that only 20-25% of the full cylinder air supply is available for retreat, usually 5 to 8 minutes.

D. Regulator Assembly

Air travels from the cylinder through the high-pressure hose to the regulator (**FIGURE 5**). There it can travel one of two paths. If the by-pass valve is opened, air travels directly through the breathing hose into the facepiece. If the mainline valve is opened, air passes through the regulator and is controlled by that mechanism. Also at the regulator (before air enters one of the valves) is another pressure gauge which also must be accurate to $\pm$ 5%. Because it is visible and well protected, this gauge should be used to monitor the air supply.

Under normal conditions, the bypass valve is closed and the mainline valve opened so air can center the regular. Once in the regulator, the air pressure is reduced from the actual cylinder pressure to approximately 50-100 psi by reducing mechanism. A pressure relief valve is located after the pressure reducer for safety should the pressure reducer malfunction. The airflow rate to meet NIOSH standards must meet or exceed 40 liters/minute. NFPA 1981 states the airflow rate must meet or exceed 100 liters/minute.

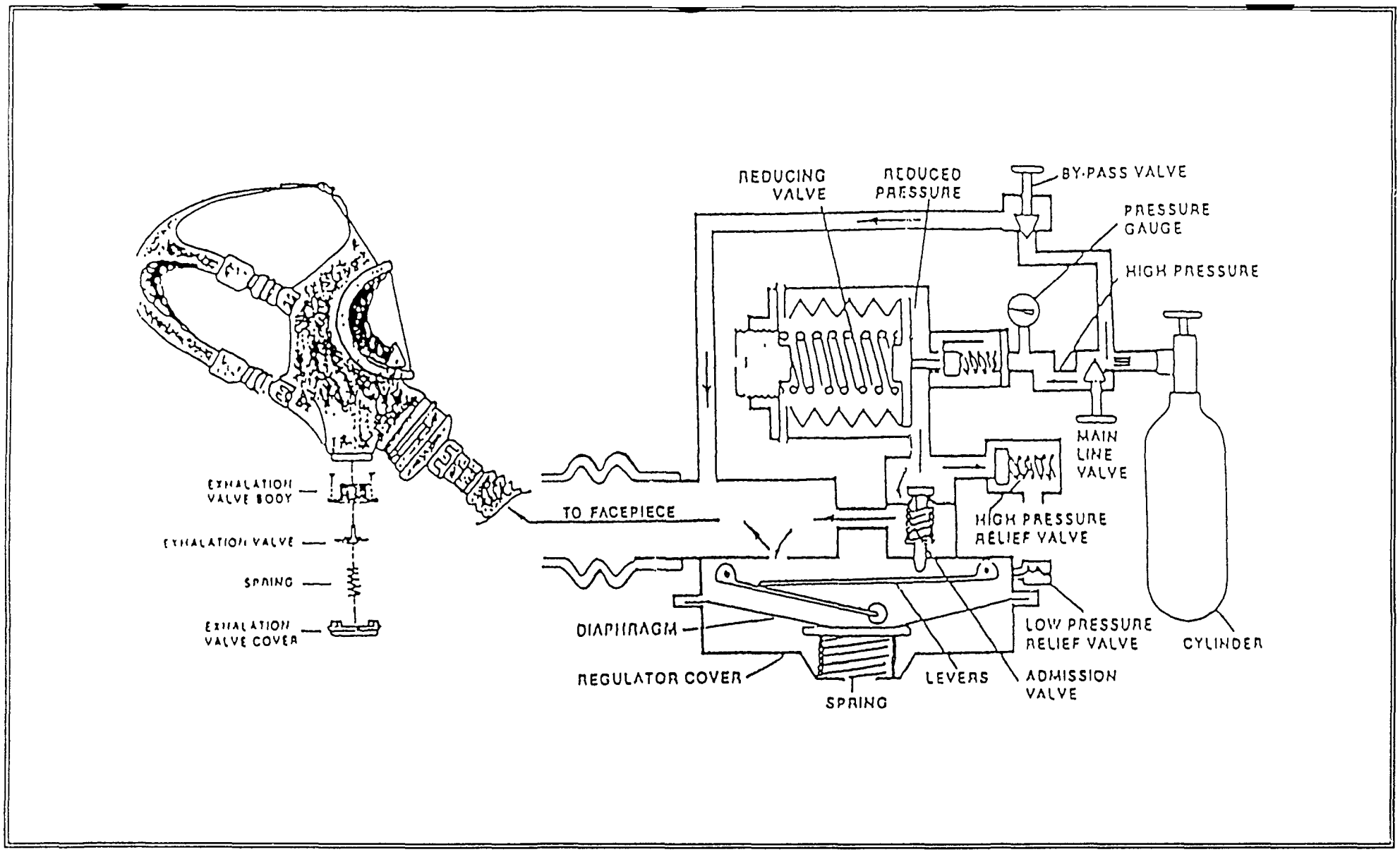


FIGURE 5

MSA PRESSURE DEMAND TYPE REGULATOR AIR FLOW

Selected from MSA Product Literature, by Mine Safety Appliances Co., Copyrighted by Mine Safety Appliances Co, reprinted with permission of Publisher.

E. Breathing Hose and Facepiece

The breathing hose connects the regulator to the facepiece. Rubber gaskets at both ends provide tight seals. The hose is usually constructed of neoprene and is corrugated to allow stretching.

Above the point in the mask where the hose is connected, is a one way check valve. This valve allows air to be drawn from the hose when the wearer inhales but prevents exhaled air from entering the breathing hose. If the check valve is not in place, the exhaled air may not be completely exhausted from the facepieces.

The facepiece is normally constructed of neoprene, but sometimes of silicone rubber. Five- or six-point suspension is used to hold the mask to the face. The visor lens is made of polycarbonate or other clear, shatter proof, and chemically resistant material. At the bottom of the facepiece is an exhalation value.

Some masks include an air-tight speaking diaphragm, which facilitates communications while preventing contaminated air from entering.

F. Back Pack and Harness

A back pack and harness support the cylinder and regulator, allowing the user to move freely. Weight should be supported on the hips not the shoulders.

V. INSPECTION AND CHECKOUT

The SCBA must be inspected according to manufacturers as well as 29 CFR recommendations. In addition, the SCBA should be checked out immediately prior to use. Checkout and inspection procedures should be followed closely to assure safe operation of the unit.

VI. IMPORTANT INFORMATION ON CYLINDER

A cylinder on a SCBA typically carries the following information (**FIGURE 6**).

1. DOT exemption for composite cylinder
2. DOT rated pressure and air volume
3. Cylinder number
4. Manufacturer's name, symbol and part number
5. Original hydrostatic test date, month/year

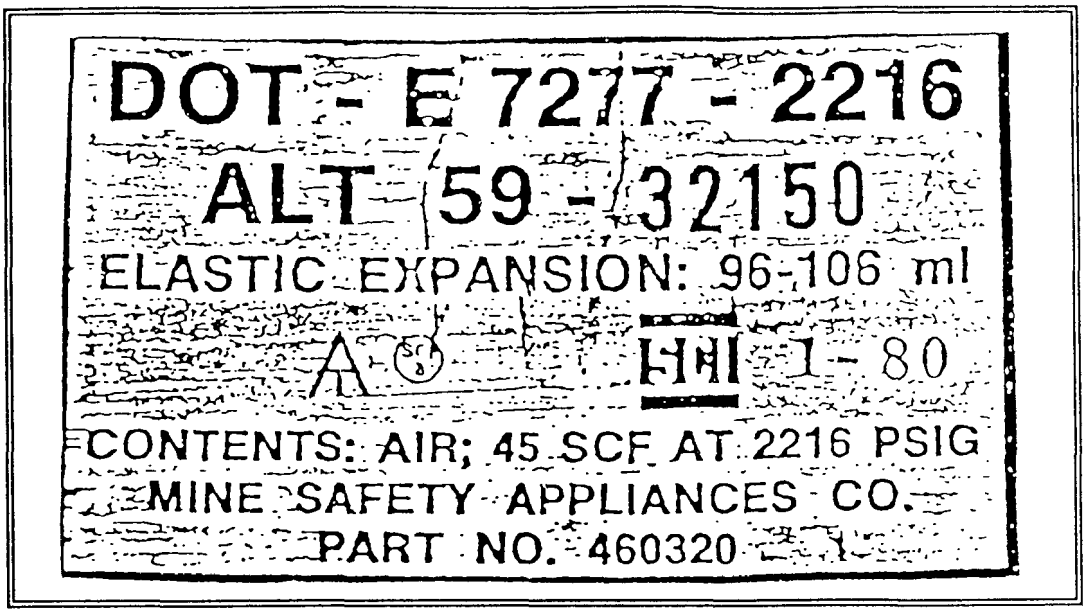


FIGURE 6

INFORMATION ON TYPICAL SCBA CYLINDER

VII. NFPA 1981 "OPEN CIRCUIT SELF-CONTAINED BREATHING APPARATUS FOR FIRE FIGHTERS" 1987 Edition

The National Fire Protection (NFPA) has developed a standard for performance requirements and appropriate testing procedures designed to simulate various environmental conditions that fire fighter's SCBA can be exposed to during use and storage. These requirements are in addition to the basic NIOSH/MSHA certification requirements. This Standard, NFPA 1981, now applies only to open circuit SCBA.

A. Basic Design Requirements

The basic design requirements for SCBA units under 1981 are:

1. That the units be NIOSH/MSMA certified positive-pressure.

2. The maximum weight shall not exceed 35 pounds, in accordance with NIOSH/MSMA certification.

3. The rated service time shall be 30 minutes or more.

4. No positive-pressure unit that can be switched to demand mode.

5. The unit shall not be approved under the Bureau of Mines Schedule

6. The manufacturer shall provide with each SCBA instructions on maintenance, storage, disinfecting, inspection, use, operations,limitations and training materials.

B. General Requirements

Additionally, SCBA units must meet certain general requirements which include:

1. Labeling showing that the unit meets the requirements.

2. Initial, annual and fifth year testing of the SCBA.

3. Retesting of unit after any modifications.

4. Test series to include three categories, with on SCBA used per category.

C. Performance Tests

1. Airflow

This test increases the current NIOSH breathing machine requirements of 40 liters per minute to 100 liters per minute. The 100 liters per minute volume was derived from a review of several studies indicating that a ventilation rate of 100 standard liters per minute encompasses the 98th percentile of all fire fighters studies.

NOTE: An airflow test is then performed after each of the following tests, with the exception of the fabric component test, to ensure breathing apparatus performance.

2. Thermal Resistance Test

This series of test expose the breathing apparatus to various temperature extremes and temperature cycles that breathing apparatus might be exposed to during actual firefighting operations.

3. Vibration and Shock

This test is designed to provide a reasonable level of assurance that when the breathing apparatus is exposed to vibration, such as being carried on a rig that often travels over rough road surfaces, the apparatus will perform and function properly.

4. Fabric Components Test

Flame, heat and thread tests are added to provide a reasonable level of assurance that the fabric components of a harness assembly used to hold the backplate to the wearer's body will remain intact during firefighting operations.

5. Accelerated Corrosion Resistance Test

This test is to provide a reasonable level of assurance that the breathing apparatus is designed to resist corrosion that may form and interfere with the apparatus performance and function.

6. Particulate Resistance Test

This test exposes the breathing apparatus to a specified concentration of particulates to provide a reasonable level of assurance that the apparatus is designed to properly function when exposed to dust conditions commonly present during firefighting operations.

7. Facepiece Lens Abrasion Resistance Test

This test is designed to provide a reasonable level of assurance that the facepiece lens of the breathing apparatus is not easily scratched during firefighting operations that could result in reduced visibility for the fire fighter.

8. Communications Test

This test is designed to assure that the facepiece of the breathing apparatus does not significantly reduce a fire fighter's normal voice communications.

SECTION 5

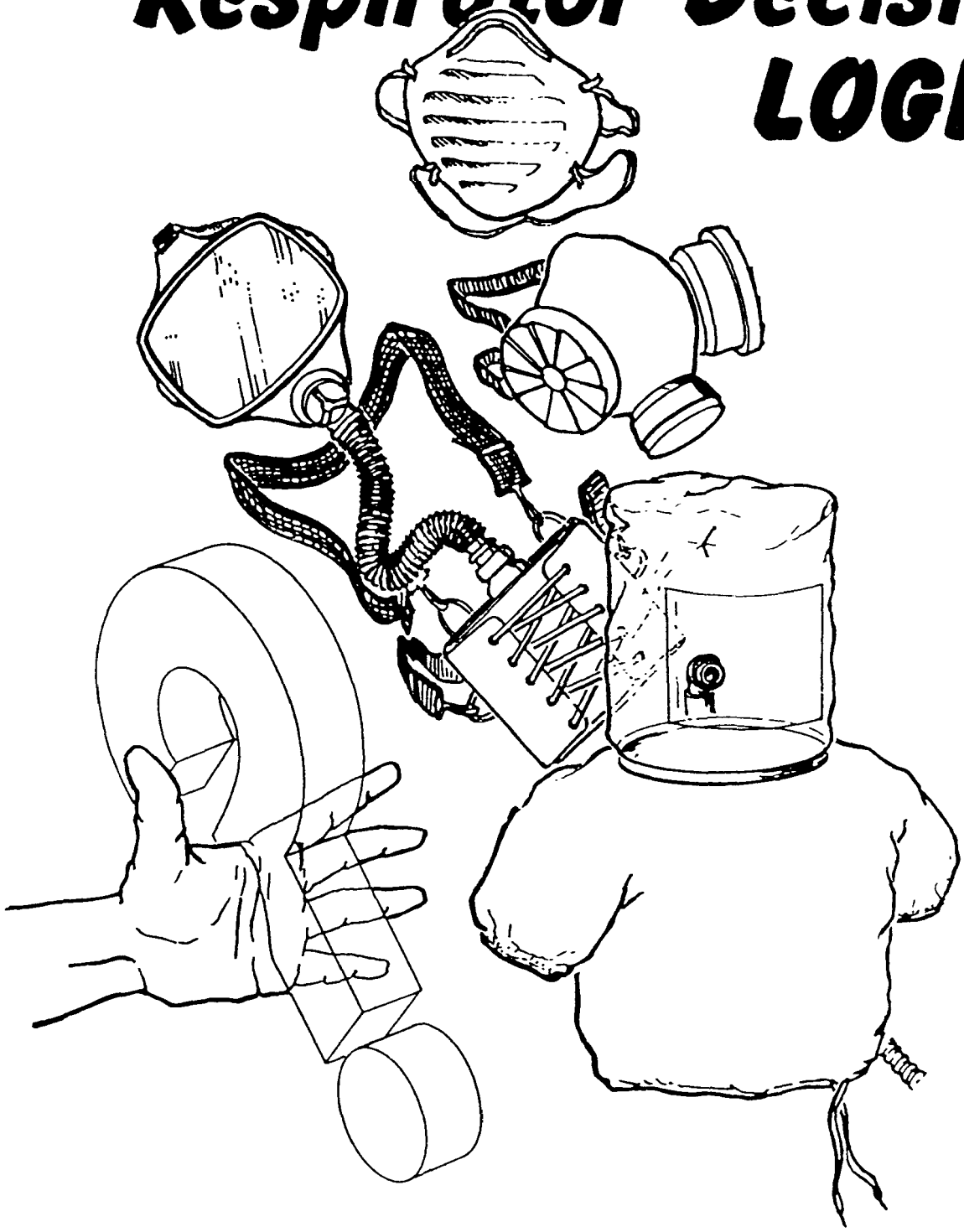
PERSONAL PROTECTIVE EQUIPMENT

PART 4

NIOSH RESPIRATOR DECISION LOGIC

NIOSH

Respirator Decision LOGIC



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

NIOSH RESPIRATOR DECISION LOGIC

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
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National Institute for Occupational Safety and Health
Division of Standards Development and Technology Transfer

May 1987

DISCLAIMER

Mention of the name of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health.

DHHS (NIOSH) Publication No. 87-108

FOREWORD

The initial Respirator Decision Logic was developed in 1975 as part of the National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA) Standards Completion Program and was updated in 1978. Due to technical advances in respirator design and research, NIOSH has again revised the Respirator Decision Logic.

This revision retains many aspects of the original Respirator Decision Logic, but it differs in five areas: odor warning properties with respect to air-purifying cartridge/canister respirators, recognition of the problems in assigning protection factors, changes in protection factors for certain respirator classes, respirator recommendations for carcinogens, and medical recommendations.

The recognition of wide variation among workers in their sensitivities for detection of odors has led to the recommendation that employers not rely solely on currently published data on odor thresholds to ensure that workers who wear air-purifying cartridge or canister respirators are capable of smelling the contaminant at the applicable exposure limit. Recent research on in-plant respirator testing suggests that some previously assigned protection factors based on data from laboratory fit testing may not be valid. This revised Respirator Decision Logic has incorporated assigned protection factors based on data from recent in-plant research for some powered air-purifying respirators (PAPR) and some similar respirators, such as loose-fitting and tight-fitting continuous flow air-line respirators. Since NIOSH maintains that there is no safe exposure to carcinogens, only the most protective respirators should be used to protect workers from exposure to carcinogens in the workplace. Finally, specific medical recommendations are included to assist physicians in determining an individual's fitness to wear a respirator.

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I. INTRODUCTION

A. Background and Scope

The National Institute for Occupational Safety and Health (NIOSH) routinely makes recommendations regarding the use of respirators for workers exposed to workplace environments that contain hazardous concentrations of airborne contaminants and/or oxygen-deficient atmospheres. Such recommendations are made only when engineering controls are not technically feasible, while controls are being installed or repaired, or when emergency and other temporary situations arise. Respirators are the least preferred method of worker protection from respiratory hazards because they can be unreliable if an adequate respiratory protection program is not established by the employer and because they require worker cooperation. The intent of this decision logic is to provide industrial hygienists and other professionals knowledgeable in respirator selection with a procedure for selecting suitable classes of respirators for particular concentrations of specific contaminants. In this decision logic, concerns are raised about limitations of the data used to set protection factors for several classes of respirators.

To ensure uniformity and adherence to proper respirator usage, NIOSH recommendations have been based on the Respirator Decision Logic developed jointly in 1975 by NIOSH and the Occupational Safety and Health Administration (OSHA) as part of the Standards Completion Program and updated in June 1978. That decision logic incorporated requirements contained in 30 CFR 11 and fit factor data developed by the Los Alamos National Laboratory (LANL). NIOSH has now modified that decision logic to reflect new developments that include increased use of respirators to control exposure to carcinogens in the workplace, introduction of new respiratory equipment, and reporting of field research data on workplace protection factors (WPF's).

This modified decision logic identifies the criteria necessary to determine the classes of respirators that will provide a known degree of respiratory protection for a given work environment, assuming that the respirators are used correctly. The degree of protection is related in part to protection factors. Many of the assigned protection factors (APF's) that appear in this decision logic are based on laboratory studies and should be regarded as approximate.

The selection of a specific respirator must be made by individuals knowledgeable about the limitations associated with each class of respirators and familiar with the actual workplace environment, including the job task(s) to be performed. The correct use of a respirator is just as important as the selection process if adequate worker protection is to be achieved. Without a complete respiratory protection program, workers will not receive the degree of protection anticipated from a respirator, even if it is a correct choice for the situation. Training, motivation, medical

evaluation, fit testing, and a respirator maintenance program are critical elements for the successful use of a respirator. As a minimum, compliance with 29 CFR 1910.134 is mandatory whenever respirators are used by workers, whether on a required or voluntary basis.

B. Cautionary Statements

NIOSH concerns about the use of respirators are discussed further in various parts of the document and are summarized in the following six cautionary statements:

- **Assigned Protection Factors**

  In general, the assigned protection factors (APF's) that appear in this decision logic are not based on measurements of actual field (workplace) performance. As noted in the footnotes accompanying Tables 1, 2, and 3, in only a few instances are the APF's based on any workplace performance testing; the majority of the APF's have no workplace performance basis at all. APF's based solely on laboratory fit testing should be viewed and applied with particular caution, even when the laboratory testing involves a simulated work regimen. To date, no relation has been demonstrated between laboratory fit factors and measured workplace performance. As more performance testing of respirators is undertaken in the workplace by NIOSH and others, NIOSH may find it necessary to revise the APF's upward or downward. For the present, APF's should not be considered reliable predictors of performance levels that will be achieved during actual use, since APF's are not based on a sufficient amount of workplace testing.

- **Fit Testing**

  No qualitative or quantitative fit tests have been demonstrated to be capable of effectively identifying inadequately fitting respirators (i.e., respirator-wearer combinations that provide less protection than the APF). The presently used fit tests (e.g., ANSI-recommended, OSHA-approved) may fail to identify individual wearers with inadequate respiratory protection. Thus fit tests should be used with caution and with recognition of their possible deficiencies. As appropriate, periodic evaluations of the effectiveness of each respirator during use in the workplace should be conducted to ensure that each wearer is being provided with adequate respiratory protection.

- **QNFT Fit Factor Screening Levels**

  Regarding quantitative fit testing (QNFT), no studies are available to indicate what fit factor value (i.e., screening level) will ensure a high probability of identifying inadequately fitting respirators. That is, there are no studies demonstrating what fit factor values are adequate

accept/reject criteria for QNFT fit screening. When QNFT is used for fit screening, the fit factor screening level should be chosen with caution and with recognition of the uncertainty of its effectiveness. As appropriate, periodic evaluation of the effectiveness of each respirator during use in the workplace should be conducted to ensure that each wearer is being provided with adequate respiratory protection.

- **Adequate Warning Properties**

No physiological effects in humans (e.g., odor, taste, eye irritation, respiratory irritation) have been demonstrated as being capable of consistently providing respirator wearers with timely, consistent, persistent, and reliable warning of hazardous airborne concentrations *inside a respirator. Individual wearers may be unable to detect the* warning effect when necessary and may fail to take action necessary to protect themselves (e.g., leaving the area where respirators are necessary or changing the sorbent cartridge or canister). When warning properties must be relied on as part of a respiratory protection program, the employer should accurately, validly, and reliably screen each prospective wearer for the ability to detect the warning properties of the hazardous substance(s) at exposure levels that are less than the exposure limits for the substance(s). Warning properties should be regarded with caution and with recognition of their unreliability.

- **Service Life Information**

For essentially all gases and vapors, no adequate service life information is available to respirator wearers or to those responsible for respiratory protection programs. When this information is not available, respirators with air-purifying sorbent elements should be used with caution and with recognition of the wide variability of service lives under differing use conditions. Employers should possess valid and reliable estimates of service lives for all sorbent elements used in the respiratory protection program. Service life test data should be representative of all conditions of intended use that can be reasonably anticipated. Factors known to affect the service lives of sorbent elements include, but are not limited to, the make and model of sorbent element, airborne concentrations of contaminant(s), and relative humidity through each sorbent element. When appropriate service life data is available, any reliance on the data should be undertaken with caution and with recognition of the limitations and uncertainties of the information.

- **Determination of Protection Factor Levels Required for Adequate Protection**

Workers are never exposed to a single unvarying concentration of a contaminant. In a given work area, individual exposures may vary widely between workers, during a workshift, and between days. The range of potential exposures should be appropriately determined for all workers and for all circumstances that can be reasonably anticipated. The

highest anticipated exposure for each respirator wearer should be used to compute the protection factor required for each wearer. Required protection factors should be used with caution and with recognition of their uncertainties.

II. RESPIRATOR DECISION LOGIC

This decision logic contains a series of questions regarding situations which may require the use of respirators. (See Respirator Decision Logic Sequence, page 8.) In answering these questions, the user of this decision logic is assisted in identifying specific classes of respirators, applicable restrictions, and the appropriate respirator selection table to use. When using one of the tables to identify a suitable class of respirators, the user must keep in mind the restrictions identified in the question section of this decision logic.

This decision logic identifies the criteria necessary to determine the classes of respirators that will provide the minimum acceptable degree of protection for a chemical at a given concentration. Classes of respirators offering greater protection can usually be used in place of the minimum acceptable class of respirators. Respirator classes are consistent with respirator certification groupings as specified in 30 CFR 11.

The recommendations in this decision logic are based primarily on the physical, chemical, and toxicologic properties of the contaminant and on the limitations of each class of respirators, including filtration efficiency, air supply capability, and face seal characteristics and leakage. Thus this decision logic is limited to identifying classes of acceptable respirators, rather than individual respirators.

After various classes of respirators are identified as being suitable for a given situation, an evaluation is made of other factors of the particular work environment so that the best respirator within the recommended classes can be chosen. In some situations, the selection of a respirator classified as providing a higher level of protection may be advisable.

To assist the user, this decision logic contains ten subparagraphs following the Respirator Decision Logic Sequence that describe respirator limitations, use of applicable exposure limits, warning properties, protection factors, oxygen limitations, and medical evaluation of suitability to wear respirators. Additional supporting information is contained in Appendices A through E. To properly use this decision logic, the user should carefully read the subparagraphs.

The assigned protection factors (APF's) used in this decision logic were based on quantitative fit factor data developed by Los Alamos National Laboratories (LANL) under contract to NIOSH and on field evaluation data gathered by NIOSH and others. Specific references and summaries of the data used to generate certain protection factors can be found in Subparagraph 8, page 28. Fit factors determined for the individual wearer of a respirator by quantitative fit testing or by any other method used to determine fit should not be substituted for the APF given for each class of respirators. However, the fit factor determined through quantitative fit testing must be greater than the APF; otherwise, the respirator cannot be used by the worker.

A. Criteria for Selecting Respirators

To use this decision logic, the user must first assemble the necessary toxicologic, safety, and other relevant information for each contaminant, including the following:

- General use conditions, including determination of contaminant(s);
- Physical, chemical, and toxicologic properties of the contaminant(s);
- Odor threshold data;
- NIOSH recommended exposure limit (REL) or when no REL exists, OSHA permissible exposure limit (PEL) or other applicable exposure limit;
- Immediately dangerous to life or health (IDLH) concentration;
- Eye irritation potential; and
- Any service life information available (for cartridges and canisters).

Obtaining complete information on all criteria needed to use this decision logic may be difficult. When conflicting or inadequate data are found, experts should be consulted before decisions are made that could affect the proper use of this decision logic. In addition, the adequacy of the respirator selected is dependent on the validity of the exposure limit used. While the decision logic can be used with any exposure limit, NIOSH recommends that an REL be used when one exists for a given contaminant. For a more detailed discussion on the use of exposure limits, especially when selecting respirators for protection against carcinogens, see Subparagraph 2, page 21.

The information obtained on general use conditions for respirators should include a description of the actual job task, including the duration and frequency, location, physical demands, and industrial processes, as well as the comfort of the respirators. Some general use conditions may preclude the use of specific types of respirators in certain circumstances because the individual must be medically and psychologically suitable to wear a given respirator for a given task, particularly if the respirator is a self-contained breathing apparatus (SCBA).

Information obtained on the service life of the cartridge/canister under conditions of intended use should be evaluated regardless of the odor warning properties of the chemicals. These evaluations should be based on all gas(es) and vapor(s) present at the temperature and relative humidity extremes (high and low) in the workplace. NIOSH recommends that when the employer or a representative of the employer conducts the tests, the challenge concentrations of the gases and vapors should be at least 10 times the maximum use concentration of the respirator. The service life value

obtained from these tests should be used to determine how long a cartridge/canister could provide protection under actual use conditions. This information can be used to set up cartridge replacement schedules and should be used in conjunction with sensory warning properties. Workers should be trained to exit the contaminated area whenever they detect the odor of the contaminant. (See Subparagraph 6, page 26, for a discussion on service life testing for chemicals with poor warning properties.)

B. Restrictions and Requirements for All Respirator Usage

The following requirements and restrictions must be considered to ensure that the respirator selected will provide adequate protection under the conditions of intended use:

1. A complete respiratory protection program should be instituted which includes regular worker training; maintenance, inspection, cleaning, and evaluation of the respirator; use of the respirator in accordance with the manufacturer's instructions; fit testing; and environmental monitoring. Whenever possible, quantitative evaluation of the protection factor in the workplace should be performed to confirm the actual degree of protection provided by the respirator to each worker. Minimum respiratory protection requirements for all contaminants can be found in the OSHA Safety and Health Standards, 29 CFR 1910.134, and in separate sections for specific contaminants (e.g., 1910.1001 for asbestos, 1910.1025 for lead, etc.).

2. Qualitative or quantitative fit tests should be provided as appropriate to ensure that the respirator fits the individual. Periodic evaluation of the effectiveness of each respirator during use in the workplace should be conducted to ensure that each wearer is being provided with adequate respiratory protection. When quantitative fit testing (QNFT) is used, the fit factor screening level should be chosen with caution and with the recognition of the uncertainty of its effectiveness since no studies have demonstrated what fit factor values provide adequate accept/reject criteria for quantitative fit screening.

3. Negative pressure respirators should not be used when facial scars or deformities interfere with the face seal.

4. No respirator (including positive pressure respirators) should be used when facial hair interferes with the face seal.

5. The respirators should be properly maintained, correctly used, and conscientiously worn.

6. The usage limitations of air-purifying elements, particularly gas and vapor cartridges, should not be exceeded.

7. The respirators must be approved by the Mine Safety and Health Administration and the National Institute for Occupational Safety and Health (MSHA/NIOSH).

8. Workers should be instructed to leave the contaminated area immediately upon suspicion of respirator failure and then to determine the problem.

9. Workers are not exposed to a single unvarying concentration of a hazardous substance, rather individual exposures may vary throughout a workshift and between days. The highest anticipated concentration should therefore be used to compute the required protection factor for each respirator wearer.

10. Respirator wearers should be aware of the variability in human responses to the warning properties of hazardous substances. When warning properties must be relied on as part of a respiratory protection program, the employer should screen each prospective wearer for the ability to detect the warning properties of the hazardous substance(s) at exposure concentrations that are less than the REL for each given substance. (See Subparagraph 6, page 26, and Appendix C, page 48, for additional information.)

11. The assigned protection factors (APF's) that appear in this decision logic are based for the most part on laboratory studies. However, a few APF's have been validated and revised as necessary after consideration of data obtained from studies of workplace protection factors (WPF's). As more WPF testing of respirators is undertaken by NIOSH and others, the APF values may be further revised. For the present, the APF's should be regarded as approximate if they are not based on WPF's.

C. Respirator Decision Logic Sequence

After all criteria have been identified and evaluated and after the requirements and restrictions of the respiratory protection program have been met, the following sequence of questions can be used to identify the class of respirators that should provide adequate respiratory protection:

1. Is the respirator intended for use during fire fighting?

   a. If yes, only a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure demand or other positive pressure mode is recommended.

   b. If no, proceed to Step 2.

2. Is the respirator intended for use in an oxygen-deficient atmosphere, i.e., less than 19.5% oxygen at sea level? (Refer to Subparagraph 1, page 21, for a discussion of oxygen deficiency.)

   a. If yes, any type of SCBA or supplied-air respirator (SAR) with an auxiliary SCBA is recommended. Auxiliary SCBA must be of sufficient duration to permit escape to safety if the air supply is interrupted. If additional contaminants are present, proceed to Step 3.

b. If no, proceed to Step 3.

3. Is the respirator intended for use during emergency situations?

a. If yes, two types of respirators are recommended: a SCBA with a full facepiece operated in pressure demand or other positive pressure mode or an SAR with a full facepiece operated in pressure demand or other positive pressure mode in combination with an auxiliary SCBA operated in pressure demand or other positive pressure mode. Auxiliary SCBA must be of sufficient duration to permit escape to safety if the air supply is interrupted.

b. If no, proceed to Step 4.

4. Is the contaminant regulated by the Department of Labor as a potential occupational carcinogen or identified by NIOSH as a potential human carcinogen in the workplace, and is the contaminant detectable in the atmosphere?

a. If yes, two types of respirators are recommended: a SCBA with a full facepiece operated in pressure demand or other positive pressure mode or an SAR with a full facepiece operated in pressure demand or other positive pressure mode in combination with an auxiliary SCBA operated in pressure demand or other positive pressure mode. Auxiliary SCBA must be of sufficient duration to permit escape to safety if the air supply is interrupted.

b. If no, proceed to Step 5.

5. Is the exposure concentration of the contaminant, as determined by acceptable industrial hygiene methods, less than the NIOSH REL or other applicable exposure limit? (Whenever a worker is given a respirator to use on a voluntary basis when ambient levels are below applicable limits, OSHA requires the implementation of a complete respiratory protection program, which includes medical evaluation, training, fit testing, periodic environmental monitoring, and all other requirements in 29 CFR 1910.134.)

a. If yes, a respirator would not be required except for an escape situation. Proceed to Step 7.

b. If no, proceed to Step 6.

6. Are conditions such that a worker who is required to wear a respirator can escape from the work area and not suffer loss of life or immediate or delayed irreversible health effects if the respirator fails, i.e., are the conditions <u>not</u> immediately dangerous to life or health (IDLH)? (Refer to Subparagraph 3, page 22, for additional information on IDLH's.)

a. If yes, conditions are not considered to be IDLH. Proceed to Step 7.

b. If no, conditions are considered to be IDLH. Two types of respirators are recommended: a SCBA with a full facepiece operated in pressure demand or other positive pressure mode or an SAR with a full facepiece operated in pressure demand or other positive pressure mode in combination with an auxiliary SCBA operated in pressure demand or other positive pressure mode. The auxiliary SCBA must be of sufficient duration to permit escape to safety if the air supply is interrupted.

7. Is the contaminant an eye irritant, or can the contaminant cause eye damage at the exposure concentration? (Refer to Subparagraph 4, page 23, for a discussion of eye irritation and damage.)

a. If yes, a respirator equipped with a full facepiece, helmet, or hood is recommended. Proceed to Step 8.

b. If no, an orinasal respirator may still be an option, depending on the exposure concentration. Proceed to Step 8.

8. Divide the 8-hour time-weighted average (TWA) exposure concentration for the contaminant (or maximum exposure concentration for a contaminant with a ceiling limit) determined in Step 5 by the NIOSH REL or other applicable exposure limit to determine the minimum protection factor required. For escape respirators, determine the potential for generation of a hazardous condition caused by an accident or equipment failure. If a potentially hazardous condition could occur or a minimum protection factor has been calculated, proceed to Step 9.

9. If the physical state of the contaminant is a particulate (solid or liquid) during periods of respirator use, proceed to Step 10; if it is a gas or vapor, proceed to Step 11; if it is a combination of gas or vapor and particulate, proceed to Step 12.

10. Particulate Respirators

10.1. Is the particulate respirator intended only for escape purposes?

a. If yes, refer to Subparagraph 5, page 24, for a discussion and selection of "escape only" respirators.

b. If no, the particulate respirator is intended for use during normal work activities. Proceed to Step 10.2.

10.2. A filter medium that will provide protection against exposure to the particulate in question is recommended. (Refer to Subparagraph 9, page 29, for a discussion on limitations of approvals for filter media.) Proceed to Step 10.3.

10.3. Respirators that have not been previously eliminated from Table 1 and that have APF's equal to or greater than the minimum protection factor determined in Step 8 are recommended. (Refer to Subparagraph 8, page 28, and Appendix D, page 50, for a discussion of protection factors, and to Subparagraph 9, page 29, for a discussion on limitations of filter approvals.) Maximum airborne concentrations for each level of respiratory protection can be calculated by multiplying the NIOSH REL or other applicable exposure limit by the APF for that class of respirators. Workers wearing respirators should meet the medical guidelines discussed in Subparagraph 10, page 30.

11. Gas/Vapor Respirators

11.1. Is the gas/vapor respirator intended for "escape only" purposes?

a. If yes, refer to Subparagraph 5, page 24, for a discussion on selection of "escape only" respirators.

b. If no, the gas/vapor respirator is intended for use during normal work activities. Proceed to Step 11.2.

11.2. Are the warning properties for the gas/vapor contaminant adequate at or below the NIOSH REL or other applicable exposure limit? (Refer to Subparagraph 6, page 26, and Appendix C, page 48, for additional information on requirements for adequate warning properties.)

a. If yes, proceed to Step 11.3.

b. If no, an air-purifying respirator equipped with an effective end-of-service-life indicator (ESLI), a supplied-air respirator, or a self-contained breathing apparatus is recommended. (Refer to Appendix A, page 43, for additional information on approval of air-purifying respirators with ESLI's.) Proceed to Step 11.4.

11.3. An air-purifying chemical cartridge/canister respirator is recommended that has a sorbent suitable for the chemical properties of the anticipated gas/vapor contaminant(s) and for the anticipated exposure levels. (Refer to Subparagraph 7, page 27, for the recommended maximum use concentrations of air-purifying chemical cartridge/canister respirators.) Proceed to Step 11.4.

11.4. Respirators that have not been previously eliminated from Table 2 and that have APF's equal to or greater than the minimum protection factor determined in Step 8 are recommended. (Refer to Subparagraph 8, page 28, and Appendix D, page 50, for a discussion of protection factors.) Maximum airborne concentrations for each class of respiratory protection can be calculated by multiplying the NIOSH REL or other applicable exposure limit by the APF for that class of respirators. The calculated maximum use concentration limits should not exceed the limitations noted in Subparagraph 7, page 27. Workers wearing respirators should meet the medical guidelines discussed in Subparagraph 10, page 30.

12. Combination Particulate and Gas/Vapor Respirators

12.1. Is the combination respirator intended for "escape only" purposes?

a. If yes, refer to Subparagraph 5, page 24, for a discussion and selection of "escape only" respirators.

b. If no, the combination respirator is intended for use during normal work activities. Proceed to Step 12.2.

12.2. Does the gas/vapor contaminant have adequate warning properties at or below the NIOSH REL or other applicable exposure limit? (Refer to Subparagraph 6, page 26, and Appendix C, page 48, for additional information on requirements for adequate warning properties.)

a. If yes, proceed to Step 12.3.

b. If no, either an air-purifying respirator equipped with an effective ESLI (Appendix A, page 43), a supplied-air respirator, or a self-contained respirator is recommended. Proceed to Step 12.4.

12.3. An air-purifying chemical cartridge/canister is recommended that has a particulate prefilter suitable for the specific type(s) of gas/vapor and particulate contaminant(s) and for the exposure concentrations. (Refer to Subparagraphs 7, page 27, and Subparagraph 9, page 29, for recommended maximum use concentrations and filter limitations.) Proceed to Step 12.4.

12.4. Respirators that have not been previously eliminated from Table 3 and that have APF's equal to or greater than the minimum protection factor determined in Step 8 are recommended. (Refer to Subparagraph 8, page 28, and Appendix D, page 50, for a discussion of protection factors and Subparagraph 9, page 29, for a discussion on limitations of filter approvals.) Maximum airborne concentrations for each level of respiratory protection can be calculated by multiplying the NIOSH REL or other applicable exposure limit by the APF for that class of respirators. The calculated maximum use concentration limits should not exceed the limitations noted in Subparagraph 7, page 27. Workers wearing respirators should meet the medical guidelines discussed in Subparagraph 10, page 30.

Table 1.--Assigned protection factor classifications of respirators for protection against particulate exposures[1]

Assigned protection factor	Type of respirator
5	Single-use (see definition in Glossary) or quarter mask[2] respirator
10	Any air-purifying half-mask respirator including disposable[3] (see definition in Glossary) equipped with any type of particulate filter except single use[2,4]
	Any air-purifying full facepiece respirator equipped with any type of particulate filter[5]
	Any supplied-air respirator equipped with a half-mask and operated in a demand (negative pressure) mode[2]
25	Any powered air-purifying respirator equipped with a hood or helmet and any type of particulate filter[4]
	Any supplied-air respirator equipped with a hood or helmet and operated in a continuous flow mode[4]
50	Any air-purifying full facepiece respirator equipped with a high efficiency filter[2]
	Any powered air-purifying respirator equipped with a tight-fitting facepiece and a high efficiency filter[4]
	Any supplied-air respirator equipped with a full facepiece and operated in a demand (negative pressure) mode[2]
	Any supplied-air respirator equipped with a tight-fitting facepiece and operated in a continuous flow mode[4]

1 Only high efficiency filters are permitted for protection against particulates having exposure limits less than 0.05 mg/m^3.

2 The assigned protection factors (APF's) were determined by Los Alamos National Laboratories (LANL) by conducting quantitative fit testing on a panel of human volunteers [6].

3 An APF factor of 10 can be assigned to disposable particulate respirators if they have been properly fitted using a quantitative fit test.

4 APF's were based on workplace protection factor (WPF) data or laboratory data more recently reported than the LANL data [7-11, 14-17].

5 The APF was based on consideration of efficiency of dust, fume, and/or mist filters.

Table 1.--Assigned protection factor classifications of respirators for protection against particulate exposures[1]--Continued

Assigned protection factor	Type of respirator
50 cont.	Any self-contained respirator equipped with a full facepiece and operated in a demand (negative pressure) mode[2]
1,000	Any supplied-air respirator equipped with a half-mask and operated in a pressure demand or other positive pressure mode[2]
2,000	Any supplied-air respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode[2]
10,000	Any self-contained respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode[2]
	Any supplied-air respirator equipped with a full facepiece operated in a pressure demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure demand or other positive pressure mode[2]

1 Only high efficiency filters are permitted for protection against particulates having exposure limits less than 0.05 mg/m^3.

2 The assigned protection factors (APF's) were determined by Los Alamos National Laboratories (LANL) by conducting quantitative fit testing on a panel of human volunteers [6].

3 An APF of 10 can be assigned to disposable particulate respirators if they have been properly fitted using a quantitative fit test.

4 The APF's were based on workplace protection factor (WPF) data or laboratory data more recently reported than the LANL data [7-11, 14-17].

5 The APF was based on consideration of efficiency of dust, fume, and/or mist filters.

Table 2.--Assigned protection factor classifications of respirators for protection against gas/vapor exposures

Assigned protection factor[1]	Type of respirator
10	Any air-purifying half mask respirator (including disposable) equipped with appropriate gas/vapor cartridges[2]
	Any supplied-air respirator equipped with a half mask and operated in a demand (negative pressure) mode[2]
25	Any powered air-purifying respirator with a loose-fitting hood or helmet[3]
	Any supplied-air respirator equipped with a hood or helmet and operated in a continuous flow mode[3]
50	Any air-purifying full facepiece respirator equipped with appropriate gas/vapor cartridges or gas mask (canister respirator)[2]
	Any powered air-purifying respirator equipped with a tight-fitting facepiece and appropriate gas/vapor cartridges or canisters[3]
	Any supplied-air respirator equipped with a full facepiece and operated in a demand (negative pressure) mode[2]
	Any supplied-air respirator equipped with a tight-fitting facepiece operated in a continuous flow mode[3]
	Any self-contained respirator equipped with a full facepiece and operated in a demand (negative pressure) mode[2]
1,000	Any supplied-air respirator equipped with a half-mask and operated in a pressure demand or other positive pressure mode[2]

1 The assigned protection factor (APF) for a given class of air-purifying respirators may be further reduced by considering the maximum use concentrations for each type of gas and vapor air-purifying element.

2 The APF's were determined by Los Alamos National Laboratories (LANL) by conducting quantitative fit testing on a panel of human volunteers [6].

3 The APF's were based on workplace protection factor (WPF) data or laboratory data more recently reported than the LANL data [7-11, 14-17].

Table 2.--Assigned protection factor classifications of respirators for protection against gas/vapor exposures--Continued

Assigned protection factor[1]	Type of respirator
2,000	Any supplied-air respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode[2]
10,000	Any self-contained respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode[2]
	Any supplied-air respirator equipped with a full facepiece operated in a pressure demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure demand or other positive pressure mode[2]

1 The assigned protection factor (APF) for a given class of air-purifying respirators may be further reduced by considering the maximum use concentrations for each type of gas and vapor air-purifying element.

2 The APF's were determined by Los Alamos National Laboratories (LANL) by conducting quantitative fit testing on a panel of human volunteers [6].

3 The APF's were based on workplace protection factor (WPF) data or laboratory data more recently reported than the LANL data [7-11, 14-17].

Table 3.--Assigned protection factor classifications of respirators for protection against combination gas/vapor and particulate exposures[1]

Assigned protection factor[2]	Type of respirator
10	Any air-purifying half-mask respirator equipped with appropriate gas/vapor cartridges in combination with any type of particulate filter[3]
	Any full facepiece respirator with appropriate gas/vapor cartridges in combination with a dust or mist or fume; dust and mist; or dust, mist, and fume filter[4]
	Any supplied-air respirator equipped with a half-mask and operated in a demand (negative pressure) mode[3]
25	Any powered air-purifying respirator equipped with a loose-fitting hood or helmet[5]
	Any supplied-air respirator equipped with a hood or helmet and operated in a continuous flow mode[5]
50	Any air-purifying full facepiece respirator equipped with appropriate gas/vapor cartridges in combination with a high efficiency filter or an appropriate canister incorporating a high efficiency filter[3]
	Any powered air-purifying respirator with a tight-fitting facepiece equipped with appropriate gas/vapor cartridges in combination with a high efficiency filter or an appropriate canister incorporating a high efficiency filter[5]
	Any supplied-air respirator equipped with a full facepiece and operated in a demand (negative pressure) mode[3]

1 Only high efficiency filters are permitted for protection against particulates having exposure limits less than 0.05 mg/m^3.

2 *The assigned protection factor (APF) for a given class of air-purifying* respirators may be further reduced by considering the maximum use concentrations for each type of gas and vapor air-purifying element.

3 The APF's were determined by Los Alamos National Laboratories (LANL) by conducting quantitative fit testing on a panel of human volunteers [6].

4 The APF was based on consideration of efficiency of dust, fume, and/or mist filters.

5 The APF's were based on workplace protection factor (WPF) data or laboratory data more recently reported than the LANL data [7-11, 14-17].

Table 3.--Assigned protection factor classifications of respirators for protection against combination gas/vapor and particulate exposures[1]--Continued

Assigned protection factor[2]	Type of respirator
50 cont.	Any supplied-air respirator equipped with a tight-fitting facepiece and operated in a continuous flow mode[5]
	Any self-contained respirator equipped with a full facepiece and operated in a demand (negative pressure) mode[3]
1,000	Any supplied-air respirator equipped with a half-mask and operated in a pressure demand or other positive pressure mode[3]
2,000	Any supplied-air respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode[3]
10,000	Any self-contained respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode[3]
	Any supplied-air respirator equipped with a full facepiece operated in a pressure demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure demand or other positive pressure mode[3]

1 Only high efficiency filters are permitted for protection against particulates having exposure limits less than 0.05 mg/m^3.
2 The assigned protection factor (APF) for a given class of air-purifying respirators may be further reduced by considering the maximum use concentrations for each type of gas and vapor air-purifying element.
3 The APF's were determined by Los Alamos National Laboratories (LANL) by conducting quantitative fit testing on a panel of human volunteers [6].
4 The APF was based on consideration of efficiency of dust, fume, and/or mist filters.
5 The APF's were based on workplace protection factor (WPF) data or laboratory data more recently reported than the LANL data [7-11, 14-17].

The Respirator Decision Logic Sequence is presented in Figure 1 in the form of a flow chart. This flow chart can be used to identify suitable classes of respirators for adequate protection against specific environmental conditions. Refer to the corresponding narrative section for additional information pertaining to a specific part of the flow chart.

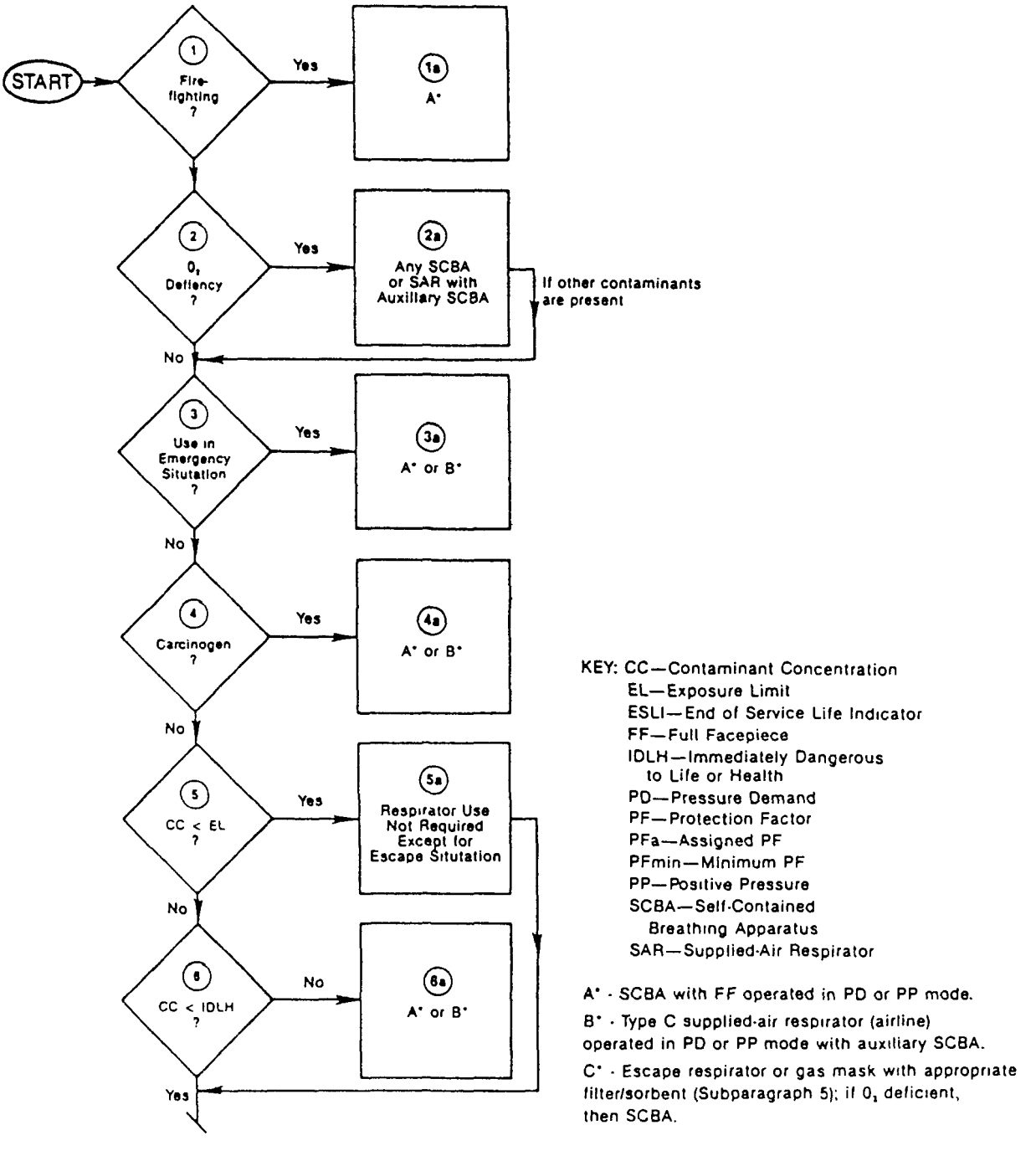

Figure 1. — Flow Chart of Respirator Decision Logic Sequence

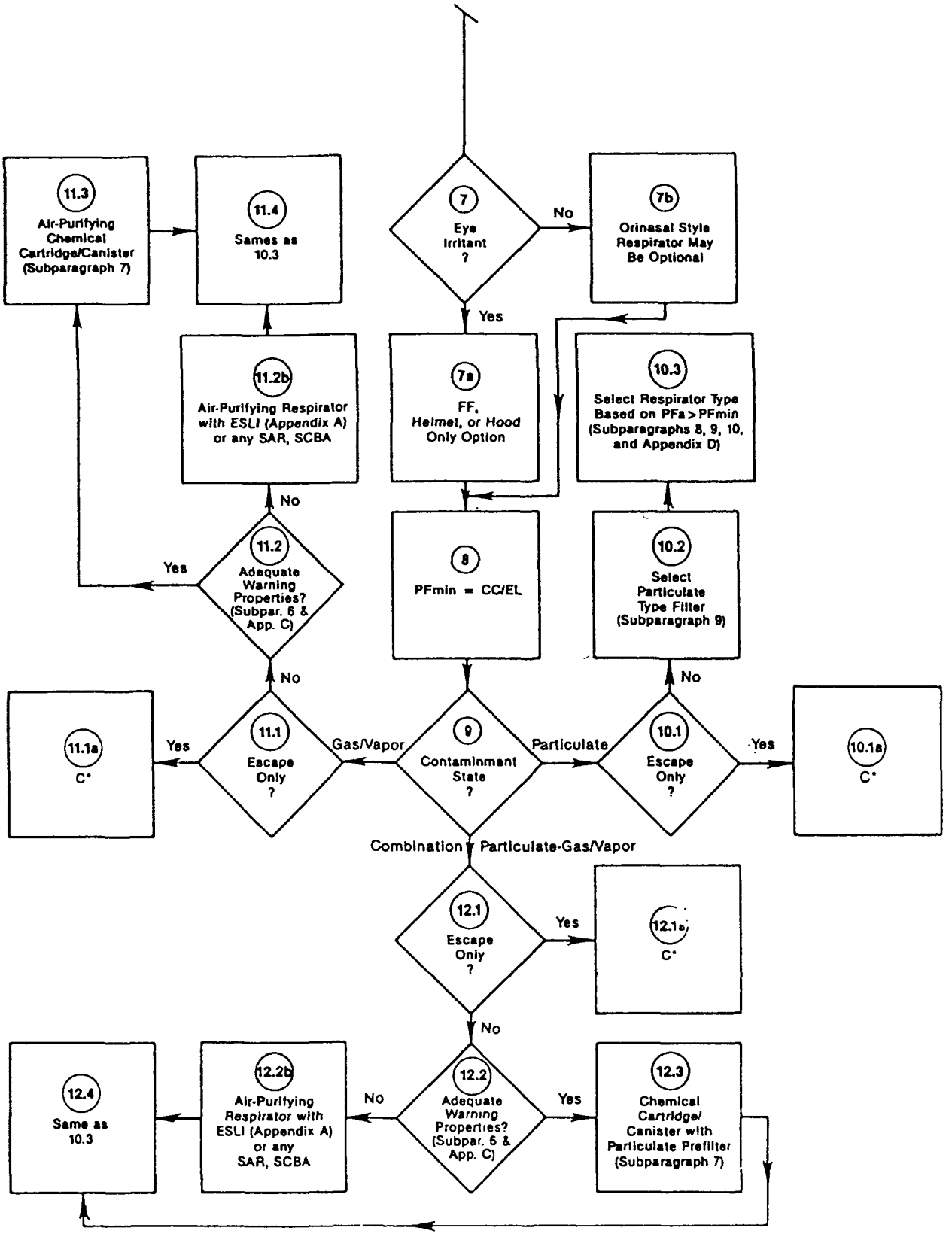

Figure 1. — Flow Chart of Respirator Decision Logic Sequence — Continued

D. Subparagraphs

The following subparagraphs provide additional information to assist the reader in using the Respirator Decision Logic Sequence:

Subparagraph 1: Oxygen-Deficient Atmosphere

The National Institute for Occupational Safety and Health (NIOSH) defines an oxygen-deficient atmosphere as any atmosphere containing oxygen at a concentration below 19.5% at sea level [1]. NIOSH certification of air-line or air-purifying respirators is limited to those respirators used in atmospheres containing at least 19.5% oxygen, except for those air-line respirators equipped with auxiliary self-contained breathing apparatus (SCBA).

The minimum requirement of 19.5% oxygen at sea level provides an adequate amount of oxygen for most work assignments and includes a safety factor. The safety factor is needed because oxygen-deficient atmospheres offer little warning of the danger, and the continuous measurement of an oxygen-deficient atmosphere is difficult.

At oxygen concentrations below 16% at sea level, decreased mental effectiveness, visual acuity, and muscular coordination occur. At oxygen concentrations below 10%, loss of consciousness may occur, and below 6% oxygen, death will result. Often only mild subjective changes are noted by individuals exposed to low concentrations of oxygen, and collapse can occur without warning [2,3,4].

Since oxygen-deficient atmospheres are life-threatening, only the most reliable respirators are recommended; the most reliable respirators are the self-contained breathing apparatus or the supplied-air respirators with auxiliary self-contained units. Because a high protection factor is not necessary to ensure an adequate supply of oxygen even in an atmosphere containing no oxygen, any certified self-contained unit is adequate. All aspects of a respiratory protection program must be instituted for these recommendations to be valid.

Subparagraph 2: Exposure Limits

The majority of the OSHA PEL's were adopted from the American Conference of Governmental Industrial Hygienists (ACGIH) TLVs® published in 1968. The difficulty in changing PEL's through promulgation of standards when new toxicologic information is identified has caused many standards to become outdated. The effectiveness of this decision logic is limited to the adequacy of the selected exposure limits in protecting the health of workers. Exposure limits based on a thorough evaluation of more recent or extensive data should be given priority.

For all chemicals that cause irritation or systemic effects but do not cause carcinogenic effects, it is currently believed that a threshold exposure

concentration exists such that virtually all persons in the working population (with the possible exception of hypersensitive individuals) would experience no adverse health effects.

For many carcinogenic substances, most available data provide no evidence for the existence of a threshold exposure concentration below which the substance would be safe. As with noncarcinogenic substances, there appears to be a dose-response relationship for carcinogenic substances. If no threshold exists for a carcinogen, then there is no safe exposure concentration; however, lower exposures would be associated with lower risks.

For some carcinogens, NIOSH attempts to identify the lowest REL on the basis of the quantitative detection limit for the method used to monitor exposures. For other carcinogens, NIOSH does not identify a precise exposure limit but recommends instead that the employer control worker exposures to the lowest feasible limit.

Regardless of the selected exposure limit for a carcinogen, the best engineering controls and work practices should be instituted. Respirators should not be used as a substitute for proper control measures. When respiratory protection is required to achieve the lowest exposure concentration, then only the most effective respirators should be used. Two types of respirators are recommended: a full facepiece SCBA operated in a pressure-demand or other positive pressure mode or a full facepiece supplied-air respirator (SAR) operated in a pressure-demand or other positive pressure mode in combination with a SCBA operated in a pressure demand or other positive pressure mode. The practicality of each situation must be assessed to determine the most technically feasible protection for the worker.

Other variables such as the specific situation, worker, or job may influence the selection of the appropriate exposure limit for a given contaminant. For example, the effects of some hazardous substances may be increased due to exposure to other contaminants present in the workplace or the general environment or to medications or personal habits of the worker. Such factors, which would affect the toxicity of a contaminant, would not have been considered in the determination of the specific exposure limit. Also, some substances are absorbed by direct contact with the skin and mucous membranes, thus potentially increasing the total exposure.

Subparagraph 3: Immediately Dangerous to Life or Health (IDLH)

An IDLH exposure condition is defined in this decision logic as one that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment. The purpose of establishing an IDLH exposure level is to ensure that the worker can escape from a given contaminated environment in the event of failure of the respiratory protection equipment. The IDLH is considered a maximum level

above which only a highly reliable breathing apparatus providing maximum worker protection is permitted. Any appropriate approved respirator may be used to its maximum use concentration up to the IDLH concentration.

In establishing the IDLH concentration, the following conditions must be assured:

a. The ability to escape without loss of life or immediate or delayed irreversible health effects. (Thirty minutes is considered the maximum time for escape so as to provide some margin of safety in calculating the IDLH.)

b. The prevention of severe eye or respiratory irritation or other reactions that would hinder escape.

Sources of information for determining whether the exposure limit for a contaminant represents an IDLH condition are as follows:

a. Specific IDLH guidelines provided in the literature such as the American Industrial Hygiene Association (AIHA) Hygienic Guides and the NIOSH Pocket Guide for Hazardous Chemical Substances (previous editions were published jointly by NIOSH and OSHA), and/or

b. Human exposure and effects data, and/or

c. Animal exposure and effects data, and/or

d. Where such data specific to the contaminant are lacking, toxicologic data from analogous substances and chronic animal exposure data may be considered.

Subparagraph 4: Eye Irritation

Eye protection in the form of respirators with full facepieces, helmets, or hoods is required for routine exposures to airborne contaminants that cause any irritation to the mucous membranes of the conjunctivae or the cornea or cause any reflex tearing. Eye protection is required for contaminants that cause minor subjective effects as well as for those that cause any damage, including disintegration and sloughing of conjunctival or corneal epithelium, edema, or ulceration. NIOSH is not aware of any standards for gas-tight goggles that would permit NIOSH to recommend such goggles as providing adequate eye protection.

For escape, some eye irritation is permissible if the severity of irritation does not inhibit the escape and if no irreversible scarring or ulceration of the eyes or conjunctivae is likely.

When data on threshold levels for eye irritation are insufficient, quarter- or half-mask respirators can be used, provided that the worker experiences

no eye discomfort and no pathologic eye effects develop. Workers should be told that if any eye discomfort is experienced, they will be provided with respirators that have full facepieces, helmets, or hoods and that provide protection equivalent to the quarter- or half-mask respirators.

Subparagraph 5: Escape Apparatus

Escape devices have a single function: to allow a person working in a normally safe environment sufficient time to escape from suddenly occurring respiratory hazards.

Escape devices can be separated into two categories: air-purifying respirators and self-contained breathing apparatus. Air-purifying respirators remove contaminants from the air by sorbent and/or filter media, but because they do not provide air, these respirators cannot be used in an oxygen-deficient atmosphere. Air-purifying escape respirators include the escape gas mask (canister) respirator, the gas mask (canister) respirator, and the filter self-rescuer. The escape gas mask consists of a half-mask or a mouthpiece respirator. The mouthpiece respirator can be used for short periods of time to escape from low concentrations of organic vapor or acid gas. The escape gas mask, which utilizes a half-mask, filters contaminants from the air. These respirators may also be used to escape from low concentrations of organic vapor or acid gas. Escape gas mask respirators equipped with full facepieces can also be used for escape from IDLH conditions but not from oxygen-deficient atmospheres. No air-purifying device is suitable for escape from a potentially oxygen-deficient atmosphere. The filter self-rescue unit is the mouthpiece device, which is designed to protect specifically against less than 1% carbon monoxide.

A self-contained breathing apparatus (SCBA) provides air to the user for escape from oxygen-deficient environments. Escape SCBA devices are commonly used with full facepieces or hoods and, depending on the supply of air, are usually rated as 3- to 60-minute units. Self-contained self-rescuer (SCSR) devices have been approved by MSHA/NIOSH for escape from mines, but these devices may also have application in other similar environments. SCSR's are mouthpiece respirators that provide a source of oxygen-enriched air for up to 60 minutes. All SCBA devices can be used in oxygen-deficient atmospheres.

When selecting escape apparatus, careful consideration must be given to potential eye irritation. This consideration is important for determining whether a gas mask or SCBA equipped with a full facepiece should be selected rather than a device equipped with a half-mask or mouthpiece.

The majority of gas masks or escape gas masks can be used in situations involving gas(es), vapor(s), or particulates. For escape from particulate-contaminated environments, an air-purifying element must be selected that will provide protection against the given type of particulate. The information in Table 4 should be used to select the appropriate escape apparatus.

Table 4.--Selection options for escape respirators

Escape conditions	Type of respirator
Short distance to exit, no obstacles (no oxygen deficiency)	Any escape gas mask[1] (canister respirator) or gas mask[2] (canister respirator)
	Any escape self-contained breathing apparatus having a suitable service life[3]
	Any acceptable device for entry into emergency situations
Long distance to exit or obstacles along the way (no oxygen deficiency)	Any gas mask[2]
	Any escape self-contained breathing apparatus having a suitable service life[3]
	Any self-contained self-rescuer having a suitable service life
Potential oxygen deficiency	Any escape self-contained breathing apparatus having a suitable service life[3]
	Any self-contained self-rescuer having a suitable service life

1 An escape gas mask is a respirator designed for use during escape only from immediately dangerous to life or health (IDLH) or non-IDLH atmospheres. It may consist of a half mask facepiece or mouthpiece, appropriate air-purifying element for the contaminant, and associated connections. Maximum use concentrations for these types of respirators are designated by the manufacturer.

2 A gas mask consists of a full facepiece and either chin-style or front- or back-mounted canisters with associated connections. Maximum use concentrations for canister air-purifying elements are listed in Table 5.

3 Escape self-contained breathing apparatus can have rated service lives of 3 to 60 minutes. All acceptable devices for entry into emergency situations can also be used.

Subparagraph 6: Potential Warning Properties for Use With Cartridge/Canister Air-Purifying Respirators

For the purpose of this decision logic, warning properties are defined according to odor, taste, eye irritation, or respiratory irritation. Adequate warning properties imply that the gas or vapor of interest has a persistent odor or irritant effect at concentrations at or below the OSHA PEL or NIOSH REL. Recognition of an odor depends on a person's sensory ability to detect it. Since the range of odor recognition thresholds within a population is very large, odor recognition should not be relied on as the only means for determining that a cartridge or canister is no longer effectively removing a contaminant from the air. A more detailed discussion of variability of odor detection within a population is provided in Appendix C.

NIOSH recommends that the employer ensure that each worker who is required to wear an air-purifying cartridge or canister respirator is capable of recognizing the odor of the substance of concern at a concentration at or below the applicable exposure limit. Such a determination will necessitate that an odor screening test be conducted on each individual for each substance of concern in the particular workplace.

It is recognized that existing screening tests are subjective in nature and not sufficiently sensitive and that conducting screening tests for a group of workers exposed to several substances may be impractical. Therefore, NIOSH knows of no compelling reason not to develop quantitative service life test data to supplement or replace odor screening test results if it can be demonstrated that such a procedure will afford the wearer a level of protection at least equivalent to that indicated by odor screening. Even when service life test data are used, the employer and the respirator wearer should not ignore the usefulness of sensory detection properties (for those who can detect the contaminant's presence) to serve as a warning that the cartridge/canister has failed or that the integrity of the respirator face seal has been compromised.

It is important to realize that 30 CFR 11 [specifically, 30 CFR 11.90(b) (note 4) for gas masks (canister respirators) and 30 CFR 11.150 (note 7) for chemical cartridge respirators], which provides for approval of air-purifying (organic vapor) devices, prohibits their approval for use against organic vapors with poor warning properties unless there is an OSHA standard which permits their use. A more detailed discussion appears in Appendix C.

A recent policy decision by NIOSH allows the use of respirators with effective end-of-service-life indicators for protection against contaminants with poor warning properties, provided that certain conditions are met. These conditions are described in that policy statement, which is reproduced in Appendix A.

Subparagraph 7: Limitations of Respirators for Gases and Vapors

Air-purifying respirators cannot be used in IDLH atmospheres or in atmospheres containing less then 19.5% oxygen by volume. Gas masks (canister respirators) may be used for escape if the atmosphere is not oxygen-deficient.

If, after the APF is multiplied by the REL or other applicable exposure limit (APF X REL), the product exceeds the IDLH value, then the IDLH value shall be the maximum use concentration. (See Tables 1, 2, and 3.) In addition, there are maximum use concentrations associated with all gas and vapor air-purifying elements. (See Table 5.)

Air-purifying devices should not be allowed for either entry into or escape from hazardous environments when supporting evidence exists to demonstrate that unreasonably short service life would occur at the maximum use concentration.

Where there is reason to suspect that a sorbent has a high heat of reaction with a substance, use of that sorbent is not recommended. For such a substance, only non-oxidizable sorbents should be allowed.

Air-purifying respirators cannot be used for protection against gases and vapors with poor warning properties unless the respirator is approved with an effective ESLI. (See Appendix A.)

Although limited in number, there are specific air-purifying respirators that are approved by MSHA/NIOSH for protection against gases and vapors when respirators approved for a given class of contaminants (e.g., organic vapors) cannot be used due to sorbent deficiencies.

Subparagraph 8: Assigned Protection Factors (APF's)

APF's (sometimes referred to in the literature as respirator protection factors), which appear in the 1975 and 1978 versions of the OSHA/NIOSH Respirator Decision Logic, in the 1980 American National Standards Institute (ANSI) standards for respiratory protection, and in all OSHA health standards, are based on quantitative fit testing (QNFT) of respirators [6]. (See definition of fit factors in Appendix D.) No data have been reported in the literature to demonstrate that the results of QNFT are sufficiently indicative of the protection that a given respirator provides in the workplace. Recent studies by NIOSH [7-9] and others [10-12] have suggested that fit factors do not correlate with the workplace protection factors provided by powered air-purifying respirators (PAPR's) and negative pressure half-mask respirators. (See definition of workplace protection factors in Appendix D.)

Table 5.--NIOSH recommended maximum use concentrations (expressed in ppm) for gas and vapor air-purifying elements

	Classification of gas and vapor air-purifying elements		
Type of gas or vapor	Cartridge(s)	Chin-style canister	Front- or back-mounted canister
Organic vapors	1,000*	5,000†	20,000†
Acid gases			
Sulfur dioxide (SO_2)	50	100	100
Chlorine (Cl_2)	10	25	25
Hydrochloric (HCl)	50	100	100
Ammonia (NH_3)	300	500	500
Methyl amine (CH_3NH_2)	100	--	--
Carbon monoxide (CO)	NA	NA	1,500

* Maximum use concentration will be 1,000 ppm or the immediately dangerous to life or health (IDLH) value for the specific organic vapor, whichever is lower.

† Maximum use concentration for "entry into" will be limited to the value listed or to the IDLH value for the specific organic vapor, whichever is lower.

APF's that are still based on the fit factors determined by Los Alamos National Laboratories (LANL) can be used for those classes of respirators for which no WPF data or simulated workplace protection factor (SWPF) data are available. However, as WPF data are developed, these APF's will be revised, as have the current APF's for powered air-purifying respirators (PAPR's) [7-9,11,14-16]. It should be noted that a number of studies [17-20] on the workplace performance of respirators have appeared in the literature. However, the results of these studies are of little value for establishing APF's because their protocols did not require proper fit or correct use and conscientious wearing of the respirator while in-facepiece sampling was done. A notable exception is the study by Revoir (1974) [21].

When WPF data existed, NIOSH utilized the point estimate equation proposed by Myers et al. [13] to help establish the APF's recommended in this *decision logic. The point estimate equation is as follows:*

$$\text{protection factor (PF)} = \mu g / Sg^{Zp}$$

where μg = the geometric mean of the measured WPF

Sg = the geometric standard deviation of the measured WPF

Zp = the value corresponding to the selected proportion (p) on the log-normal probability distribution

When WPF data existed, NIOSH selected a confidence limit of p=0.95. Thus for a given set of data and given class of respirators, NIOSH would expect that 95% of the WPF's would exceed the calculated point estimate value.

Despite the fact that some of the PF's have a statistical basis, they are still only estimates of an approximate level of protection. It must not be assumed that the numerical values of the APF's presented in this decision logic represent the absolute minimum level of protection that would be achieved for all workers in all jobs against all respiratory hazards. The industrial hygienist or other professional responsible for providing respiratory protection or evaluating respiratory protection programs is therefore encouraged to evaluate as accurately as possible the actual protection being provided by the respirator.

Subparagraph 9: Particulate Filter Respirators

MSHA/NIOSH particulate respirators are certified according to seven basic categories. These categories consist of the following types of exposures:

- Dusts: Airborne exposure limit not less than 0.05 mg/m^3 or 2 mppcf (see Appendix B);

- Fumes: Airborne exposure limit not less than 0.05 mg/m^3 or 2 mppcf;

- Mists: Airborne exposure limit not less than 0.05 mg/m^3 or 2 mppcf (see Appendix B);

- Dusts, Fumes, and Mists: Airborne exposure limit less than 0.05 mg/m^3 or 2 mppcf and radionuclides;

- Radon Daughters;

- Asbestos-Containing Dusts and Mists (see Appendix B); and

- Single-Use Dust and Mist Respirators (see Appendix B).

Subparagraph 10: Suggested Medical Evaluation and Criteria for Respirator Use

The following NIOSH recommendations allow latitude for the physician in determining a medical evaluation for a specific situation. More specific guidelines may become available as knowledge increases regarding human stresses from the complex interactions of worker health status, respirator usage, and job tasks. While some of the following recommendations should be part of any medical evaluation of workers who wear respirators, others are identified as being applicable for specific situations.

a. A Physician Should Make the Determination of Fitness to Wear a Respirator by Considering the Worker's Health, the Type of Respirator, and the Conditions of Respirator Use.

The recommendation above satisfies OSHA regulations and leaves the final decision of an individual's fitness to wear a respirator to the person who is best qualified to evaluate the multiple clinical and other variables. Much of the clinical and other data could be gathered by other personnel. It should be emphasized that the clinical examination alone is only one part of the fitness determination and that collaboration with foremen, industrial hygienists, and others may often be needed to better assess the work conditions and other factors that affect an individual's fitness to wear a respirator.

b. A Medical History and At Least a Limited Physical Examination are Recommended.

The medical history and physical examination should emphasize the evaluation of the cardiopulmonary system and should elicit any history of respirator use. The history is an important tool in medical diagnosis and can be used to detect most problems that might require further

evaluation. Objectives of the physical examination should be to confirm the clinical impression based on the history and to detect important medical conditions (such as hypertension) that may be essentially asymptomatic.

c. While Chest X-Ray and/or Spirometry May Be Medically Indicated in Some Fitness Determinations, These Should Not Be Routinely Performed.

In most cases, the hazardous situations requiring the wearing of respirators will also mandate periodic chest X-ray and/or spirometry for exposed workers. When such information is available, it should be used in the determination of fitness to wear respirators. (See Recommendation h, page 33.)

Routine chest X-rays and spirometry are not recommended solely as data for determining if a respirator should be worn. In most cases, with an essentially normal clinical examination (history and physical) these data are unlikely to influence the respirator fitness determination; additionally, the X-ray would be an unnecessary source of radiation exposure to the worker. Chest X-rays in general do not accurately reflect a person's cardiopulmonary physiologic status, and limited studies suggest that mild to moderate impairment detected by spirometry would not preclude the wearing of respirators in most cases. Thus it is recommended that chest X-ray and/or spirometry be done only when clinically indicated. (See Appendix E, page 52, for further discussion on the pulmonary effects of wearing respirators.)

d. The Recommended Periodicity of Medical Fitness Determinations Varies According to Several Factors but Could Be as Infrequent as Every 5 Years.

Federal or other applicable regulations shall be followed regarding the frequency of respirator fitness determinations. The guidelines for most work conditions for which respirators are required are shown in Table 6. These guidelines are similar to those recommended by ANSI, which recommends annual determinations after age 45 [22]. The more frequent examinations with advancing age relate to the increased prevalence of most diseases in older people. More frequent examinations are recommended for individuals performing strenuous work involving the use of SCBA. These guidelines are based on clinical judgment and, like the other recommendations in this section, should be adjusted as clinically indicated.

e. The Respirator Wearer Should Be Observed During a Trial Period to Evaluate Potential Physiological Problems

In addition to considering the physical effects of wearing respirators, the physician should determine if wearing a given respirator would cause extreme anxiety or claustrophobic reaction in the individual. This could be done during training, while the worker is wearing the respirator and

is engaged in some exercise that approximates the actual work situation.

Present regulations state that a worker should be provided the opportunity to wear the respirator "in normal air for a long familiarity period..." [23]. This trial period should also be used to evaluate the ability and tolerance of the worker to wear the respirator [24]. This trial period need not be associated with respirator fit testing and should not compromise the effectiveness of the vital fit testing procedure.

Table 6.--Suggested frequency of medical fitness determinations*

	Worker age (years)		
	<35	35 - 45	>45
Most work conditions requiring respirators	Every 5 yrs	Every 2 yrs	1-2 yrs
Strenuous work conditions with SCBA†	Every 3 yrs	Every 18 mos	Annually

* Interim testing would be needed if changes in health status occur.
† SCBA = self-contained breathing apparatus

f. Examining Physicians Should Realize that the Main Stress of Heavy Exercise While Using a Respirator Is Usually on the Cardiovascular System and that Heavy Respirators (e.g., Self-Contained Atmosphere Supplying) Can Substantially Increase this Stress. Accordingly, Physicians May Want To Consider Exercise Stress Tests with Electrocardiographic Monitoring When Heavy Respirators Are Used, When Cardiovascular Risk Factors Are Present, or When Extremely Stressful Conditions Are Expected.

Some respirators may weigh up to 35 pounds and may increase workloads by 20 percent. Although a lower activity level could compensate for this added stress [25], a lower activity level might not always be possible. Physicians should also be aware of other added stresses, such as heavy protective clothing and intense ambient heat, which would increase the worker's cardiac demand. As an extreme example, firefighters who use SCBA inside burning buildings may work at maximal exercise levels under life-threatening conditions. In such cases, the detection of occult cardiac disease, which might manifest itself during heavy stress, may be important. Some authors have either recommended stress testing [26] or

at least its consideration in the fitness determination [22]. Kilbom [26] has recommended stress testing at 5-year intervals for firefighters below age 40 who use SCBA and at 2-year intervals for those aged 40-50. He further suggested that firemen over age 50 not be allowed to wear SCBA.

Exercise stress testing has not been recommended for medical screening for coronary artery disease in the general population [27,28]. It has an estimated sensitivity and specificity of 78% and 69%, respectively, when the disease is defined by coronary angiography [27,29]. In a recent 6-year prospective study, stress testing to determine the potential for heart attack indicated a positive predictive value of 27% when the prevalence of disease was 3 1/2% [30,31]. While stress testing has limited effectiveness in medical screening, it could serve to detect those individuals who may not be able to complete the heavy exercise required in some jobs.

A definitive recommendation regarding exercise stress testing cannot be made at this time. Further research may determine whether this is a useful tool in selected circumstances.

g. An Important Concept Is that "General Work Limitations and Restrictions Identified for Other Work Activities Also Shall Apply for Respirator Use" [22].

In many cases, if a worker is able to do an assigned job without an increased risk to health while not wearing a respirator, the worker will in most situations not be at increased risk when performing the same job while wearing a respirator.

h. Because of the Variability in the Types of Respirators, Work Conditions, and Workers' Health Status, Many Employers May Wish to Designate Categories of Fitness To Wear Respirators, Thereby Excluding Some Workers from Strenuous Work Situations Involving the Wearing of Respirators.

Depending on the various circumstances, there could be several permissible categories of respirator usage. One possible scheme would consist of three overall categories: full respirator use, no respirator use, and limited respirator use including "escape only" respirators. The latter category excludes heavy respirators and strenuous work conditions. Before identifying the conditions that would be used to classify workers into various categories, it is critical that the physician be aware that these conditions have not been validated and are presented only for consideration. The physician should modify the use of these conditions based on actual experience, further research, and individual worker sensitivities. The physician may wish to consider the following conditions in selecting or permitting the use of respirators:

- History of spontaneous pneumothorax;
- Claustrophobia/anxiety reaction;
- Use of contact lens (for some respirators);
- Moderate or severe pulmonary disease;
- Angina pectoris, significant arrhythmias, recent myocardial infarction;
- Symptomatic or uncontrolled hypertension; and
- Age.

It seems unlikely that wearing a respirator would play any significant role in causing lung damage such as pneumothorax. However, without good evidence that wearing a respirator would not cause such lung damage, it may be prudent to prohibit the individual with a history of spontaneous pneumothorax from wearing a respirator.

Moderate lung disease is defined by the Intermountain Thoracic Society [32] as being a forced expiratory volume in one second (FEV_1) divided by the forced vital capacity (FVC) (i.e., FEV_1/FVC) of 0.45 to 0.60 or an FVC of 51 to 65% of the predicted FVC value. Similar arbitrary limits could be set for age and hypertension. It would seem more reasonable, however, to combine several risk factors into an overall estimate of fitness to wear respirators under certain conditions. Here the judgment and clinical experience of the physician are needed. Even many impaired workers would be able to work safely while wearing respirators if they could control their own work pace, including having sufficient time to rest.

Conclusion

Individual judgment is needed in determining the factors affecting an individual's fitness to wear a respirator. While many of the preceding guidelines are based on limited evidence, they should provide a useful starting point for a respirator fitness screening program. Further research is needed to validate these recommendations and others currently in use. Of particular interest would be laboratory studies involving physiologically impaired individuals and field studies conducted under actual day-to-day work conditions.

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IV. GLOSSARY

The following definitions of terms are provided to assist in the understanding and application of this decision logic.

ASSIGNED PROTECTION FACTOR (APF): See **PROTECTION FACTOR.**

BREAKTHROUGH: The penetration of challenge material(s) through a gas or a vapor air-purifying element. The quantity or extent of breakthrough during service life testing is often referred to as the percentage of the input concentration.

DISPOSABLE RESPIRATORS: A respirator that is discarded after the end of its recommended period of use, after excessive resistance or physical damage, or when odor breakthrough or other warning indicators render the respirator unsuitable for further use.

DUST: A solid, mechanically produced particle with a size ranging from submicroscopic to macroscopic.

EMERGENCY RESPIRATOR USE SITUATION: A situation that requires the use of respirators due to the unplanned generation of a hazardous atmosphere (often of unknown composition) caused by an accident, mechanical failure, or other means and that requires evacuation of personnel or immediate entry for rescue or corrective action.

ESCAPE GAS MASK: A gas mask that consists of a half-mask facepiece or mouthpiece, a canister, and associated connections and that is designed for use during escape only from hazardous atmospheres (see Subparagraph 5).

ESCAPE ONLY RESPIRATOR: Respiratory devices that are designed for use only during escape from hazardous atmospheres.

FILTERING FACEPIECE: A particulate respirator with a filter as an integral part of the facepiece or with the entire facepiece composed of the filtering medium. (See **SINGLE-USE DUST** or **DUST and MIST RESPIRATORS** and **DISPOSABLE RESPIRATORS.**)

FIT FACTOR: A quantitative measure of the fit of a specific respirator facepiece to a particular individual. (For further discussion of fit factors, refer to Appendix D.)

FUME: A solid condensation particulate, usually of a vaporized metal.

GAS: An aeriform fluid that is in a gaseous state at standard temperature and pressure.

IMMEDIATELY DANGEROUS TO LIFE OR HEALTH (IDLH): Acute respiratory exposure that poses an immediate threat of loss of life, immediate or

delayed irreversible adverse effects on health, or acute eye exposure that would prevent escape from a hazardous atmosphere.

MIST: A liquid condensation particle.

ORINASAL RESPIRATOR: A respirator that covers the nose and mouth and that generally consists of a quarter- or half-facepiece.

PLANNED or UNPLANNED ENTRY into an IDLH ENVIRONMENT, AN ENVIRONMENT OF UNKNOWN CONCENTRATION of HAZARDOUS CONTAMINANT, or an ENVIRONMENT of UNKNOWN COMPOSITION: A situation in which respiratory devices are recommended to provide adequate protection to workers entering an area where the contaminant concentration is above the IDLH or is unknown.

POTENTIAL OCCUPATIONAL CARCINOGEN: Any substance, or combination or mixture of substances, which causes an increased incidence of benign and/or malignant neoplasms, or a substantial decrease in the latency period between exposure and onset of neoplasms in humans or in one or more experimental mammalian species as the result of any oral, respiratory, or dermal exposure, or any other exposure which results in the induction of tumors at a site other than the site of administration. This definition also includes any substance that is metabolized into one or more potential occupational carcinogens by mammals (29 CFR 1990.103, OSHA Cancer Policy).

PROTECTION FACTORS (See Appendix D):

> **ASSIGNED PROTECTION FACTOR (APF):** The minimum anticipated protection provided by a properly functioning respirator or class of respirators to a given percentage of properly fitted and trained users.
>
> **SIMULATED WORKPLACE PROTECTION FACTOR (SWPF):** A surrogate measure of the workplace protection provided by a respirator.
>
> **WORKPLACE PROTECTION FACTOR (WPF):** A measure of the protection provided in the workplace by a properly functioning respirator when correctly worn and used.

RECOMMENDED EXPOSURE LIMIT (REL): An 8- or 10-hour time-weighted average (TWA) or ceiling (C) exposure concentration recommended by NIOSH that is based on an evaluation of the health effects data.

SERVICE LIFE: The length of time required for an air-purifying element to reach a specific effluent concentration. Service life is determined by the type of substance being removed, the concentration of the substance, the ambient temperature, the specific element being tested (cartridge or canister), the flow rate resistance, and the selected breakthrough value. The service life for a self-contained breathing apparatus (SCBA) is the period of time, as determined by the NIOSH certification tests, in which adequate breathing gas is supplied.

SINGLE-USE DUST or DUST AND MIST RESPIRATORS: Respirators approved for use against dusts or mists that may cause pneumoconiosis and fibrosis.

VAPOR: The gaseous state of a substance that is solid or liquid at temperatures and pressures normally encountered.

V. APPENDICES

APPENDIX A. NIOSH POLICY STATEMENT ON APPROVAL OF AIR-PURIFYING RESPIRATORS WITH END-OF-SERVICE-LIFE INDICATORS

Department of Health and Human Services
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

NIOSH/MSHA TESTING AND CERTIFICATION OF AIR-PURIFYING RESPIRATORS WITH END-OF-SERVICE-LIFE INDICATORS

Agency: National Institute for Occupational Safety and Health (NIOSH)

Action: Notice of Acceptance of Applications for Approval of Air-Purifying Respirators with End-of-Service-Life Indicators

Summary: 30 CFR 11; Sec. 11.150 states that NIOSH and MSHA may, after a review of the effects on wearers' health and safety, approve respirators for gases and vapors not specifically listed in that section. The current regulations also permit the use of "window indicators" for gas masks to warn the wearer when the canister will no longer remove a contaminant [11.102-5(c)(2)]. Although indicators are not mentioned in Subpart L, Chemical Cartridge Respirators, there is nothing in the regulations which explicitly prohibits their use. A NIOSH policy to allow end-of-service-life indicators (ESLI's) on air-purifying respirators for gases and vapors with adequate warning properties has already been established (Letter to All Respirator Manufacturers from Dr. Elliott Harris, June 18, 1975).

Use of ESLI's on chemical cartridge respirators for use against gases and vapors with poor warning properties could also be approved, because 30 CFR 11; Sec. 11.150; footnote 7 states:

> "Not for use against gases or vapors with poor warning properties (except where MSHA or Occupational Safety and Health Administration standards may permit such use for a specific gas or vapor)...." Thus, air-purifying respirators with ESLI's could be approved for substances such as acrylonitrile, because the OSHA acrylonitrile standard permits the use of chemical cartridge respirators.

Under the present regulations, NIOSH can also require "any additional requirements deemed necessary to establish the quality, effectiveness, and safety of any respirator used as protection against hazardous atmospheres" [30 CFR 11; Sec. 11.63 (c)]. NIOSH must notify the applicants in writing of these additional requirements [30 CFR 11; Sec. 11.63 (d)].

The purpose of this notification is to inform respirator manufacturers and users of the NIOSH requirements for approving air-purifying respirators with

either effective passive or active ESLI's for use against gases and vapors with adequate warning properties or for use against gases and vapors with inadequate warning properties whenever there is a regulatory standard already permitting the use of air-purifying respirators.

For additional information, contact: Chief, Certification Branch, 944 Chestnut Ridge Road, Morgantown, WV 26505, (304) 291-4331.

Supplemental Information

Because human senses are not foolproof in detecting gases and vapors and because many gases and vapors found in the workplace do not have adequate warning properties, NIOSH has been investigating alternate means of detection for respirator wearers. In 1976, NIOSH adopted its current policy which allows acceptance of applications for certification of air-purifying respirators, provided that the respirators are equipped with active ESLI's for use against gases and vapors with poor warning properties and are not specifically listed in 30 CFR 11.

An active ESLI is defined as an indicator that invokes an automatic and spontaneous warning signal (e.g., flashing lights, ringing bells, etc.). An active indicator does not require monitoring by the wearer although a passive indicator (normally color change indicator) does.

During the past several years, NIOSH has received notices of concern from respirator manufacturers, regulatory agencies, and general industry regarding the Institute's policy of accepting only active ESLI's for certification. At the October 1983 Mine Health Research Advisory Council (MHRAC) meeting, NIOSH presented a document briefing on "Consideration of Use of End-of-Service-Life Indicators in Respiratory Protective Devices," and requested that MHRAC provide recommendations to the Institute with regard to the appropriateness of the use of both active and passive ESLI's. MHRAC asked their Respirator Subcommittee to review the issue.

The Respirator Subcommittee held a public meeting in Washington, D.C., on December 19, 1983, to solicit comments from interested parties. The Subcommittee reviewed the comments and then reported back to the full committee at the February 2, 1984, MHRAC meeting. Based on the public comments, the Subcommittee also suggested a few additions or modifications be made to the NIOSH proposed evaluation criteria. NIOSH incorporated the recommendations. MHRAC also recommended that active and passive ESLI's are appropriate for use with respiratory protective devices provided that criteria are established for their certification and use to ensure that the user is not exposed to increased risk as a consequence of relying upon such ESLI's.

In order for NIOSH to determine the potential effects of ESLI's on user safety and health, NIOSH recommends that all applications for approval of gas and vapor respirators with ESLI's contain the following information:

CRITERIA FOR CERTIFICATION OF END-OF-SERVICE-LIFE INDICATORS

An applicant for certification of an ESLI for use against substances with poor warning properties must provide NIOSH with the following information:

1. Data demonstrating that the ESLI is a reliable indicator of sorbent depletion ($\leq$ 90% of service life). These shall include a flow-temperature study at low and high temperatures, humidities, and contaminant concentrations which are representative of actual workplace conditions where a given respirator will be used. A minimum of two contaminant levels must be utilized: the exposure limit (PEL, REL, TLV®, etc.) and the exposure limit multiplied by the assigned protection factor for the respirator type.

2. Data on desorption of any impregnating agents used in the indicator, including a flow-temperature study at low and high temperatures and humidities which are representative of actual workplace conditions where a given respirator will be used. Data shall be sufficient to demonstrate safe levels of desorbed agents.

3. Data on the effects of industrial interferences which are commonly found in workplaces where a given respirator will be used. Data should be sufficient to show which interferences could impair the effectiveness of the indicator and the degree of impairment, and which substances will not affect the indicator.

4. Data on any reaction products produced in the reaction between the sorbent and the contaminant gases and vapors, including the concentrations and toxicities of such products.

5. Data which predict the storage life of the indicator. (Simulated aging tests will be acceptable).

In addition to the foregoing, all passive ESLI's shall meet the following criteria:

1. A passive ESLI shall be placed on the respirator so that the ESLI is visible to the wearer.

2. If the passive indicator utilizes color change, the change shall be such that it is detectable to people with physical impairments such as color blindness.

3. If the passive indicator utilizes color change, reference colors for the initial color of the indicator and the final (end point) color of the indicator shall be placed adjacent to the indicator.

All ESLI's shall meet the following criteria:

1. The ESLI shall not interfere with the effectiveness of the face seal.

2. The ESLI shall not change the weight distribution of the respirator to the detriment of the facepiece fit.

3. The ESLI shall not interfere with required lines of sight.

4. Any ESLI that is permanently installed in the respirator facepiece shall be capable of withstanding cleaning and a drop from a height of 6 feet. Replaceable ESLI must be capable of being easily removed and shall also be capable of withstanding a drop from a height of 6 feet.

5. A respirator with an ESLI shall still meet all other applicable requirements set forth in 30 CFR 11.

6. If the ESLI uses any electrical components, they shall conform to the provisions of the National Electrical Code and be "intrinsically safe." Where permissibility is required, the respirator shall meet the requirements for permissibility and intrinsic safety set forth in 30 CFR 18, Subpart D. Also, the electrical system shall include an automatic warning mechanism that indicates a loss of power.

7. Effects of industrial substances interferences which are commonly found where a given respirator will be used and which hinder ESLI performance, shall be identified. Substances which are commonly found where the respirator is to be used must be investigated. Data sufficient to indicate whether the performance of the respirator would be affected must be submitted to NIOSH. The user shall be made aware of use conditions that could cause false positive and negative ESLI responses.

8. The ESLI shall not create any hazard to the wearer's health or safety.

9. Consideration shall be given to the potential impact of common human physical impairments on the effectiveness of the ESLI.

APPENDIX B. NIOSH POLICY STATEMENT ON USE OF SINGLE-USE AND DUST AND MIST RESPIRATORS FOR PROTECTION AGAINST ASBESTOS

June 21, 1984, OSHA Public Hearings

Under Title 30, Code of Federal Regulations, Part 11 (30 CFR 11), NIOSH is required to test and certify respirators within the categories specified therein when such devices are submitted to NIOSH by applicants. Currently, 30 CFR 11, Subpart K defines a number of dust, fume, and mist respirators which may be used for protection against certain hazardous particulate atmospheres. Among the respirators defined in Subpart K are single-use dust respirators designed as respiratory protection against pneumoconiosis-producing and fibrosis-producing dusts, or dusts and mists. Subpart K lists asbestos as one of the dusts against which the single-use dust respirator is designed to protect [Subpart K, Sec. 11.130(H)]. Although at the time of the promulgation of Subpart K, it may have been assumed appropriate to list asbestos as a fibrosis-producing particulate against which the single-use disposable respirator could be reasonably expected to provide adequate protection, NIOSH is no longer confident that such an assumption is reasonable because asbestos is also a potent carcinogen.

The current requirements as (specified in 30 CFR 11) for approval of a single-use dust respirator or dust and mist respirator do not include any tests with fibrous challenge aerosol. NIOSH is currently in the process of doing a comprehensive revision of 30 CFR 11 and intends to address the issue of appropriate respiratory protection for use against asbestos, and to require that any respirator for which such approval is sought be proven to provide effective protection against asbestos. NIOSH may change the regulations included in 30 CFR 11 only in accordance with procedures set forth in the Administrative Procedures Act. In the interim, NIOSH will continue to consider applications for approval of single-use and replaceable dust/mist respirators for use against asbestos only because of the legal requirement in the current approval regulations. However, NIOSH does not recommend the use of such respirators where exposures to asbestos may occur because such a recommendation would not be prudent based on the occupational health risk.

This policy position is contained in "The Statement of the National Institute for Occupational Safety and Health--The Public Hearings on Occupational Exposure to Asbestos."

APPENDIX C. ODOR WARNING: BACKGROUND INFORMATION

It is important to realize that 30 CFR 11 prohibits the use of MSHA/NIOSH approved air-purifying (organic vapor) respirators for protection against organic vapors with poor warning properties unless there is an OSHA standard that permits such use. Specifically, 30 CFR 11, Section 11.90(b), footnote 4 gives the standards for gas masks (canister devices), while 30 CFR 11, Section 11.150, footnote 7 gives the standards for chemical cartridge respirators. Thus the "organic vapor respirator" shall be approved only for organic vapors with adequate warning properties. In addition, the requirement for adequate warning properties also applies to all MSHA/NIOSH-approved air-purifying respirators for protection against organic gases and vapors.

A recent policy decision by NIOSH allows the use of respirators for protection against contaminants with poor warning properties, provided that certain conditions are met. These conditions are outlined in the policy statement in Appendix A. MSHA/NIOSH approval may be granted for a respirator designed for use against gases and vapors with poor warning properties if the respirator incorporates an effective end-of-service-life indicator (ESLI).

However, unless the respirator incorporates an ESLI, wearers of air-purifying chemical cartridge/canister respirators must rely on adequate warning properties to alert them to the breakthrough of the sorbent in the cartridge or canister. Amoore and Hautala [33] have noted:

> The ability of members of the population to detect a given odor is strongly influenced by the innate variability of different persons' olfactory powers, their prior experience with that odor, and by the degree of attention they accord to the matter.

Amoore and Hautala [33] found that on the average, 95% of a population will have a personal odor threshold that lies within the range from about one-sixteenth to sixteen times the reported mean "odor threshold" for a substance. That is, about 2.5% of a population will be able to detect a substance's odor at concentrations less than one-sixteenth of the "odor threshold" for a substance. Correspondingly, about 2.5% of the individuals will need to be exposed to concentrations exceeding by a factor of 16 the "odor threshold" in order to perceive the odor. Thus for many substances the width of distribution of personal odor threshold is over two orders of magnitude of concentration. The "odor thresholds" reported in the literature generally are the median values for wide population distributions. Also, 50% of prospective respirator wearers can detect a substance's odor only at levels that must exceed the reported "odor threshold," and about 15% cannot detect the odor at levels that exceed the "odor threshold" by fourfold [33].

OSHA incorporated into the lead standard a new isoamyl acetate qualitative fit test protocol, developed by Du Pont, which requires odor threshold

screening [29 CFR 1910.1025, Appendix D (I)(A)]. Du Pont realized that a qualitative fit test depending on odor recognition would be ineffective if every individual were not first screened for the ability to detect the odor of isoamyl acetate at some minimum concentration. This is also true for detection of the odor of the gas or vapor used to alert the wearer of sorbent element (cartridge or canister) breakthrough. Thus NIOSH recommends screening tests for workers who wear air-purifying gas or vapor respirators to determine their ability to detect the odor below the exposure limit for that gas or vapor.

APPENDIX D. PROTECTION FACTOR: BACKGROUND INFORMATION

The U.S. Bureau of Mines referred to the term "Decontamination Factor" in their Approval Schedule 21B, first issued in 1965, and defined it to be "the ratio of the concentration of dust, fume, or mist present in the ambient atmosphere to the concentration of dust, fume, or mist within the facepiece while the respirator is being worn." The decontamination factor is now referred to as the respirator protection factor. The original definition and application given in schedule 21B has been somewhat generalized over the years.

The protection factor of a respirator is an expression of performance based on the ratio of two measured variables, C_I and C_O. The variable C_I is defined only as the measured concentration of a contaminant inside the respirator facepiece cavity, and C_O is defined only as the measured contaminant concentration outside the respirator facepiece. The relationship between these two variables can be expressed not only as the protection factor (C_O/C_I) but also as the penetration (C_I/C_O) or efficiency [$(C_O-C_I)/C_O$].

The protection factor can be related to the penetration (p) and efficiency (E) as follows:

$$PF = C_O/C_I = 1/p = 1/(1-E)$$

A further implicit condition on the PF function is that $C_I \leq C_O$; therefore, the PF will always be greater than unity.

Protection factor assessments are made almost exclusively on man/respirator systems, while penetration and efficiency assessments are made only on component parts of the respirator system. It is important to recognize that on a man/respirator system, the measured variable C_I becomes a complicated function of many individual sources of penetration (e.g., air-purifying element penetration, exhalation valve penetration, face seal penetration, and other inboard penetration) and those environmental conditions that would effect penetration. To deal with the multiple methods for determining and applying protection factors, a number of definitions have been proposed [13]. These definitions, described below in greater detail than in the Glossary, are as follows:

ASSIGNED PROTECTION FACTOR (APF): A special application of the general protection factor concept, APF is defined as a measure of the minimum anticipated workplace level of respiratory protection that would be provided by a properly functioning respirator or class of respirators to a percentage of properly fitted and trained users. The maximum specified use concentration for a respirator is generally determined by multiplying the exposure limit for the contaminant by the protection factor assigned to a specific class of respirators [13].

SIMULATED WORKPLACE PROTECTION FACTOR (SWPF): A surrogate measure of the workplace protection factor (WPF) of a respirator, SWPF differs from the WPF only in that it is measured in a laboratory simulation of a workplace setting rather than in the actual workplace. The definitions and restrictions of C_0 and C_I are as described for the WPF. For laboratory protection factor testing to reliably estimate WPF's, a relationship must be demonstrated between the two tests. No such relationship has been identified in the literature. Until such a relationship can be shown to exist, the laboratory protection factor is of questionable use in determining or predicting the WPF [13].

WORKPLACE PROTECTION FACTOR (WPF): A measure of the actual protection provided in the workplace under the conditions of that workplace by a properly functioning respirator when correctly worn and used, WPF is defined as the ratio of the estimated contaminant concentration outside the respirator facepiece (C_0) to the contaminant concentration inside the respirator facepiece (C_I). The sampling restrictions placed on C_0 and C_I are that both C_0 and C_I should be TWA samples taken simultaneously while the respirator is being properly worn and used during normal work activities. In practice, the WPF would be determined by measuring the concentration inside and outside the facepiece during the activities of a normal workday [13].

FIT FACTOR: A special application of the protection factor ratio that represents a quantitative measure of the fit of a particular respirator facepiece to a particular individual, the fit factor is defined under the conditions of quantitative fit testing as the aerosol concentration in the test chamber (C_0) divided by the penetration that occurs through the respirator face seal interface (C_I) [34]. For C_I to reflect only face seal leakage, high efficiency filters [greater than 99.97% efficient against 0.3 μm aerodynamic mass median diameter (AMMD) dioctylphthalate aerosol] are installed on the respirator. It is assumed that either no leakage or only a negligible amount of leakage into the facepiece occurs through the exhalation valve or any source other than the face seal. The fit factor is measured on a complete respirator worn by a test subject who follows a regimen of slow head movements, deep breathing, and talking; a polydispersed oil mist or sodium chloride aerosol is used that has an AMMD of approximately 0.6 $\pm$ 0.1 μm (with a geometric standard deviation of approximately 2 to 2.4).

APPENDIX E. MEDICAL ASPECTS OF WEARING RESPIRATORS: BACKGROUND INFORMATION

In recommending medical evaluation criteria for respirator use, one should apply rigorous decision-making principles [35], using knowledge of screening test sensitivity, predictive value, etc. Unfortunately, many gaps in knowledge in this area exist. The problem is complicated by the large variety of respirators, their conditions of use, and individual differences in the physiologic and psychologic responses to them. For these reasons, the preceding guidelines (see Subparagraph 10) are to be considered as informed suggestions rather than established NIOSH policy recommendations. The following information is intended primarily to assist the physician in developing medical evaluation criteria for respirator use.

Health Effects of Wearing Respirators

Brief descriptions of the health effects associated with wearing respirators are summarized below. Interested readers are referred to recent reviews for more detailed analyses of the data [36,37].

Pulmonary: In general, the added inspiratory and expiratory resistances and dead space of most respirators cause an increased tidal volume and decreased respiratory rate and ventilation (including a small decrease in alveolar ventilation). These respirator effects have usually been small both among healthy individuals and, in limited studies, among individuals with impaired lung function [38-42]. This generalization is applicable to most respirators meeting Federal regulations when resistances (particularly expiratory resistance) are low [1,43,44]. While most studies report minimal physiologic effects during submaximal exercise, the resistances commonly lead to reduced endurance and reduced maximal exercise performance [45-49]. The dead space of a respirator (reflecting the amount of expired air that must be rebreathed before fresh air is obtained) tends to cause increased ventilation. At least one study has shown substantially increased ventilation with a full-face respirator, a type which can have a large effective dead space [50]. However, the net effect of a respirator's added resistances and dead space is usually a small decrease in ventilation [39,45,46-48,51].

The potential for adverse effects, particularly decreased cardiac output, from the positive pressure feature of some respirators has been reported [52]. Howeve-, several recent studies suggest that this is not a practical concern, at least not in healthy individuals [53-55].

Theoretically, the increased fluctuations in thoracic pressure while breathing with a respirator might constitute an increased risk to subjects with a history of spontaneous pneumothorax. Few data are available in this area. While an individual is using a negative pressure respirator with relatively high resistance during very heavy exercise, the usual maximal peak negative oral pressure during inhalation is about 15-17 cm of water [53]. Similarly, the usual maximal peak positive oral pressure

during exhalation is about 15-17 cm of water, which might occur with a respirator in a positive pressure mode, again during very heavy exercise [53]. By comparison, maximal positive pressures, such as those during a vigorous cough, can generate 200 cm of water pressure [56]. The normal maximal negative pleural pressure at full inspiration is -40 cm of water [57], and normal subjects can generate -80 to -160 cm of negative water pressure [56]. Thus while vigorous exercise with a respirator does alter pleural pressures, the risk of barotrauma would seem to be substantially less than that of the cough maneuver.

In some asthmatics, an asthmatic attack may be exacerbated or induced by a variety of factors including exercise, cold air, and stress, all of which may be associated with wearing a respirator. While most asthmatics who are able to control their condition should not have problems with respirators, a physician's judgment and a field trial may be needed in selected cases.

Cardiac: The added work of breathing from respirators is small and could not be detected in several studies [38,39]. A typical respirator might double the work of breathing from 3 to 6% of the oxygen consumption, but this is probably not of clinical significance [38]. In concordance with this view is the finding of several studies that at the same workloads heart rate does not change with the wearing of a respirator [39,54,58-60].

In contrast, the added cardiac stress due to the weight of a heavy respirator may be considerable. A self-contained breathing apparatus (SCBA), particularly one that uses compressed air cylinders, may weigh up to 35 pounds. Heavier respirators have been shown to reduce maximum external workloads by 20% and similarly increase heart rate at a given submaximal workload [46]. In addition, it should be appreciated that many uses of SCBA (e.g., for firefighting and hazardous waste site work) also necessitate the wearing of 10-25 pounds of protective clothing.

Raven et al. [40,58] found significantly higher systolic and/or diastolic blood pressures during exercise for persons wearing respirators (although increases were minimal, i.e., $\leq$10 mmHg systolic, 0-2 mmHg diastolic). Arborelius et al. [54] did not find significant differences for persons wearing respirators during exercise.

Body Temperature: Proper regulation of body temperature is primarily of concern with the closed circuit, self-contained breathing apparatus that produces oxygen via an exothermic chemical reaction. Inspired air within these respirators may reach 120°F (49°C), thus depriving the wearer of a minor cooling mechanism and causing discomfort. Obviously this can be more of a problem with heavy exercise and when ambient conditions and/or protective clothing further reduce the body's ability to lose heat. The increase in heart rate due to increasing temperature represents an additional cardiac stress.

Closed-circuit breathing units of any type have the potential for heat stress since warm expired gases (after exothermic carbon dioxide removal with or without oxygen addition) are rebreathed. Respirators with large dead space also have this potential problem, again because of partial rebreathing of warmed expired air [50].

Diminished Senses: Respirators may reduce visual fields, decrease voice clarity and loudness, and decrease hearing. Besides the potential for reduced productivity, these effects may result in reduced industrial safety. These factors may also contribute to a general feeling of stress [61].

Psychologic: This important topic is discussed in recent reviews by Morgan [61,62]. There is little doubt that virtually everyone suffers some discomfort when wearing a respirator. The large variability and the subjective nature of the psycho-physiologic aspects of wearing a respirator, however, make studies and specific recommendations difficult. Fit testing obviously serves an important additional function in providing a trial to determine if the wearer can psychologically tolerate the respirator. General experience indicates that the great majority of workers can tolerate respirators and that experience aids in this tolerance [62]. However, some individuals are likely to remain psychologically unfit for wearing respirators.

Local Irritation: Allergic skin reactions may occur occasionally from wearing a respirator, and skin occlusion may cause irritation or exacerbation of preexisting conditions such as pseudofolliculitis barbae. Facial discomfort from the pressure of the mask may occur, particularly when the fit is unsatisfactory.

In addition to the health effects associated with wearing respirators (described above) specific groups of respirator wearers may be affected by the following factors:

Perforated Tympanic Membrane: While inhalation of toxic materials through a perforated tympanic membrane (ear drum) is possible, recent evidence indicates that the airflow would be minimal and rarely if ever of clinical importance [63,64]. In highly toxic or unknown atmospheres, use of positive pressure respirators should ensure adequate protection [63].

Contact Lens: Contact lenses are generally not recommended for use with respirators, although little documented evidence exists to support this viewpoint [65]. Several possible reasons for this recommendation are noted below:

a. Corneal irritation or abrasion might occur with the exposure. This would, of course, be a problem primarily with quarter- and half-face masks, especially with particulate exposures. However, exposures could occur with full-face respirators due to leaks or

inadvisable removal of the respirator for any reason. While corneal irritation or abrasion might also occur without contact lenses, their presence is known to substantially increase this risk.

b. The loss or misplacement of a contact lens by an individual wearing a respirator might prompt the wearer to remove the respirator, thereby resulting in exposure to the hazard as well as to the potential problems noted in "a." above.

c. The constant airflow of some respirators, such as powered air-purifying respirators (PAPR) or continuous flow air-line respirators, might irritate a contact lens wearer.

SECTION 5

PERSONAL PROTECTIVE EQUIPMENT

PART 5

RESPIRATORY PROTECTION PROGRAM GUIDELINES

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RESPIRATORY PROTECTION PROGRAM GUIDELINE

1. PURPOSE AND OBJECTIVE. The purpose and objective of this guideline are to provide management personnel with sufficient information to establish and operate a respiratory protection program to adequately protect its employees as required by EPA Order 1440.3, Respiratory Protection, and by the Occupational Safety and Health Administration (OSHA) Regulations 29 CFR 1910.134.

2. BACKGROUND. OSHA has set maximum exposure standards for many airborne toxic materials. If employee exposure to these substances exceeds the standards, the regulations requires that feasible engineering controls and/or administrative controls be installed or instituted to reduce employee exposure to acceptable levels. If these controls do not prove feasible, or while they are being installed/instituted, the Agency is required to provide appropriate, approved respiratory protection for its employees. Respirators are the least acceptable means for reducing personnel exposures; they only provide good protection if properly selected and fitted, worn by employees when needed, and replaced when their service life is over. Additionally, some employees may not be able to wear a respiratory protective device. Despite these difficulties, respiratory protective devices are the only means of protection available to employees when engineering and work practice controls are not feasible or inadequate, i.e., during field operations.

3. DEFINITIONS.

a. Approved. Approved means that a respiratory protective device has been tested and listed as satisfactory by the Bureau of Mines (BOM) of the U.S. Department of Interior, or jointly by the Mine Safety and Health Administration (MSHA) of the U.S. Department of Labor and the National Institute for Occupational Safety and Health (NIOSH) of the U.S. Department of Health and Human Services.

b. Canister (air-purifying). An air-purifying canister is a container with a filter, and/or sorbent, and/or catalyst which removes specific contaminants from the air drawn through it.

c. Canister (oxygen-generating). An oxygen-generating canister is a container filled with a chemical which generates oxygen by chemical reaction.

d. Ceiling concentration. The ceiling concentration means the concentration of an airborne substance that shall not be exceeded.

e. Confined space. A confined space is a space defined by the concurrent existence of the following conditions:

- Existing ventilation is insufficient to remove dangerous air contamination and/or oxygen deficiency which may exist or develop.

Ready access or egress for the removal of a suddenly disabled employee is difficult due to the location and/or size of the opening(s).

f. Contaminant. A contaminant is a harmful, irritating, or nuisance material that is foreign to the normal atmosphere.

g. Corrective lens. A corrective lens is a lens ground to the wearer's individual corrective prescription to permit normal visual acuity.

h. Emergency respirator use. Emergency respirator use means wearing a respirator when a hazardous atmosphere suddenly occurs which requires immediate use of a respirator either for escape only from the hazardous atmosphere or for entry into the hazardous atmosphere to carry out maintenance or some other task or for rescue purposes.

i. Hazardous atmosphere. A hazardous atmosphere is any atmosphere, either immediately or not immediately dangerous to life or health, which is either oxygen deficient or which contains a toxic or disease-producing contaminant exceeding the legally established permissible exposure limit (PEL), or where applicable, the Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH).

j. Immediately dangerous to life or health. Immediately dangerous to life or health refers to any atmosphere that poses an immediate hazard to life or produces immediate irreversible effects on health that will be debilitating.

k. Not immediately dangerous to life or health. Not immediately dangerous to life or health refers to any hazardous atmosphere which may produce physical discomfort immediately, chronic poisoning after repeated exposure, or acute adverse physiological symptoms after prolonged exposure.

l. Odor threshold limit. The lowest concentration of a contaminant in air that can be detected by the olfactory sense.

m. Permissible exposure limit (PEL). Permissible exposure limit is the legally established time-weighted average (TWA) concentration or ceiling concentration of a contaminant that shall not be exceeded.

n. Protection factor. Protection factor is the ratio of the ambient concentration of an airborne substance to the concentration of the substance inside the respirator at the breathing zone of the wearer. The protection factor is a measure of the degree of protection provided to the wearer.

o. Time-weighted average (TWA). Time-weighted average is the average concentration of a contaminant in air during a specific time period.

4. THE RESPIRATORY PROTECTION PROGRAM. EPA Order 1440.3, Respiratory Protection, sets out the Agency policy, responsibilities, and basic requirements for a respiratory protection program to protect its employees whose jobs require the use of respiratory protective devices. EPA management is required to establish and implement a respiratory protection program at each Agency location where the activities of employees may cause them to encounter atmospheres that contain or are suspected of containing unhealthy quantities of airborne contaminants or atmospheres with insufficient oxygen content, or where there is the threat of an imminent release of toxic agents. Respiratory protection may also be necessary for routine but infrequent operations and for non-routine operations in which the employee is exposed briefly to high concentrations of a hazardous substance, i.e., during maintenance or repair activities, or during emergency conditions.

As a minimum, a respiratory protection program must contain all the elements outlined in EPA Order 1440.3. These requirements are:

a. Approved respiratory protective devices must be properly selected.

b. There must be a determination of the need for respiratory protective devices.

c. An employee training program must be established in which the employee becomes familiar with the respiratory protective devices and is trained in the proper selection and use of respirators and their limitations.

d. There must be provisions for:

- Proper inspection, maintenance, storage and repair of respiratory protective devices.
- Assigning respiratory protective equipment to employees for their exclusive use, where practical.
- Testing for the proper fit of the respiratory protective equipment.
- Surveillance of the work area and for employee exposure and stress.
- Medical screening of each employee assigned to wear respiratory protective devices to determine if he/she is physically and psychologically able to wear a respirator.

e. Written standard operating procedures must exist for the selection and use of respiratory protective devices.

5. ESTABLISHMENT OF THE RESPIRATORY PROTECTION PROGRAM. Management at each EPA location where it has been determined a Respiratory Protection Program is required should designate one person responsible for administering the program at that location. This person should have the responsibility for the

entire respirator program and develop the standard operating procedures. To administer effectively the respiratory protection program, the designated person must have:

a. Sufficient training in all aspects of respiratory protection to adequately manage the program.

b. The ability to make sound judgments based on hazard evaluation and an understanding of the workplace hazards.

c. The knowledge and authority to coordinate equipment purchasing, maintenance, cleaning and repair.

d. The knowledge and authority to assure that written operating procedures are prepared for specific operations and that these procedures are being followed.

e. The knowledge and authority to assure compliance with OSHA and Agency respiratory protection requirements.

f. The resources to maintain all records associated with the program, i.e., monitoring, medical surveillance and job assignment data, respirator care and maintenance records, emergency equipment inspection/maintenance tags, training records, etc.

The individual assigned the respiratory program responsibility may be a safety specialist/manager, safety engineer, industrial hygienist, or supervisory person. This individual must have the full support of management at the workplace regardless of who assumes the program responsibility.

6. SELECTION OF RESPIRATORY PROTECTIVE DEVICES. The proper selection of respiratory protective devices basically involves three steps:

a. Identification of the hazard.

b. Evaluation of the hazard.

c. The selection of the appropriate approved respiratory protective device based on the first two considerations. (See Appendix A, Respiratory Protective Device Recommendation.)

Respiratory protective devices that will provide greater protection than required may be selected, but the device selected must always be approved.

a. Identification of the Hazard. It is important to know something about the different kinds of hazardous atmospheres which may require the use of respirators.

o Contaminated Atmospheres

. Gaseous Contaminants - These contaminants are of two types.

.. Gases are aeriform fluids which are in the gaseous state at ordinary temperature and pressure., e.g., carbon dioxide. Such substances are solids or liquids only at much lower temperatures or much higher pressures than are commonly found in the work environment. Carbon dioxide, is a gas at room temperature, but it occurs as solid "dry ice" at low temperature, or as a liquid in pressurized tanks.

.. Vapors are the gaseous state of a substance that is solid or liquid at ordinary temperature and pressure. Vapors are formed by the evaporation of substances, i.e., acetone or trichloroethylene, which ordinarily occur as liquid.

. Particulate Contaminants - Particulate contaminants are suspended particles or droplets of a substance. Many of these particles can remain suspended in air indefinitely and are easily inhaled. There are three types of particulates:

.. Dusts are solid particles produced by such processes as grinding, crushing, and mixing of powder compounds.

.. Mists are tiny liquid droplets dispersed whenever a liquid is sprayed, vigorously mixed, or otherwise agitated.

.. Fumes are solid condensation particles of extremely small particle size.

. Combination Contaminants - The two basic forms of contaminated atmospheres - gaseous and particulate - frequently occur together.

o Oxygen Deficient Atmospheres - In an oxygen deficient atmosphere, the problem is not the presence of something harmful, but the absence of something essential. These atmospheres are most commonly found in confined and usually poorly ventilated spaces. Oxygen deficient atmospheres are classified as either immediately dangerous to life or health or not immediately dangerous to life or health depending on the oxygen concentration in the atmosphere. (An oxygen deficient atmosphere immediately dangerous to life and health is an atmosphere that contains less than 16 volume percent of oxygen in the atmosphere at sea level. An oxygen deficient atmosphere not immediately dangerous to life and health is an atmosphere having an oxygen concentration between 16 and 19.5 volume percent of oxygen in the atmosphere at sea level.)

Oxygen deficient atmospheres occur in two different ways: (1) Oxygen may be "used up" by a chemical reaction, and (2) Oxygen is displaced by another gas. There is no definition of oxygen deficient atmosphere that has been universally accepted. OSHA has adopted and EPA accepts an oxygen deficient atmosphere as one that contains less than 19.5 volume percent of oxygen in the atmosphere at sea level. The following table is a partial listing of definitions of oxygen deficient atmospheres, their source and conditions of determination.

Definitions of Oxygen Deficient Atmospheres

Source	Oxygen Content (Vol.%)	Conditions for Determination
ACGIH Threshold Limit Values for 1973	18.0	". . . under normal atmosphere pressure. . . ."
Federal Regulations 29 CFR Part 1915.S1 (Maritime Standards)	16.5	(not specified)
29 CFR Part 1910.94		
(Ventilation Standards)	19.5	(not specified)
(Respirator Approval Tests)	19.5	". . . by volume at sea level...."
ANSI Standards Z88.2-1969 (Respirator Practices)	16.0	". . . normal air. . . ."
ANSI Standards Z88.2-1980 (Practices for Respiratory Protection)	19.8	". . . normal air. . . ."
Z88.5-1973 (Firefighting)	19.5	". . .at sea level. . . ."
K13.1-1973 (Marketing of air-purifying canisters and cartridges)	19.5	". . .at sea level. . . ."

It is difficult to visualize the effect of oxygen deficient atmospheres on the individual. He/she is not aware of the nature of their situation. Gradual depression of the central nervous system affects powers of discrimination, logic, and auditory acuity, with muscular weakness and lack of coordination. Since no distressful sensations are produced, the entire experience is comfortable and even pleasant. In reality, however, breathing in an oxygen deficient atmosphere is like breathing under water. The symptoms of oxygen deficiency also depend on the oxygen concentration present. The following table presents the physiological effects of atmospheres at and below 16 volume percent of the oxygen at sea level.

Effects of Oxygen Deficiency

O_2 Vol % at Sea Level	Physiological Effect
16-12	Increased breathing volume. Accelerated heartbeat. Impaired attention and thinking. Impaired coordination.
14-10	Very faulty judgment. Very poor muscular coordination. Muscular exertion causes rapid fatigue that may cause permanent heart damage. Intermittent respiration.
10-6	Nausea. Vomiting. Inability to perform vigorous movement, or loss of all movement. Unconsciousness, followed by death.
Less than 6	Spasmatic breathing. Convulsive movements. Death in minutes.

b. Evaluation of the Hazard. The person who evaluates respiratory hazards must have the cooperation of others in obtaining information on the work area, work activities and materials to properly evaluate and determine the appropriate respiratory protective device that will provide the best protection for the employee. Consideration of these questions will help in the selection of the correct equipment.

1) Does the atmosphere oxygen level meet standards? Is the atmosphere oxygen level expected to remain constant or decrease?

2) What is the contaminant? Is it a gas, vapor, mist, dust, or fume?

3) What is the estimated concentration of the contaminant? Have measurements been taken?

4) Could the contaminant be considered immediately dangerous to life or health?

5) Is the contaminant flammable? Does the concentration approach the lower explosive limit? Do dust concentrations create a potential explosion problem?

6) Does the contaminant have adequate warning properties, e.g., smell, irritation?

7) Will the contaminant irritate the eyes at the estimated concentration? Is eye protection also needed?

8) What type(s) of respirators will provide the required degree of employee protection?

9) Is the recognized contaminant the only contaminant present?

10) If the contaminant is a gas or vapor, is there an effective sorbent for the respirator cannister?

11) Can the contaminant be absorbed through the skin? If it can, will it result in a serious injury?

c. Selection of Approved Respiratory Protective Devices. The person designated as the respiratory protection program manager should have an approval authority for the purchase of respiratory protective devices. Any respiratory protective devices purchased should be approved for the particular contaminants for which they will be used. If only one brand of respirator is approved for a particular hazard, then that brand is considered to be "available" and must be used. The NIOSH approval on a respirator has the following information:

o An assigned identification number placed on each unit.

o A label identifying the type of hazard for which the respirator is approved.

o Additional information on the label which gives limitations and identifies the component parts approved for use with the basic unit.

In the past, the BOM approved respirators. The BOM no longer grants approval; however, some older respirators which were BOM-approved may still be used.

o BOM-approved self-contained breathing apparatus (SCBA) may be used until further notice.

o BOM-approved gas masks may be used until further notice.

d. Categories of Respiratory Protective Devices. Respiratory protective devices fall into two broad categories - air purifying and atmosphere supplying.

1) Air-purifying respirators - These devices remove the contaminant from the breathing air before it is inhaled. For each model of air-purifying respirator, there are usually many air-purifying cartridges available for protection against specific contaminants. Combination cartridges for protection against both particulates and organic vapors are also available.

o Particulate removing filter respirators - These are generally called "dust," "mist," or "fume" respirators and by a filtering action remove particulates before they can be inhaled.

. Single use, dust - The single-use respirator is a respirator which is completely disposed of after use. They are for individual use and should be discarded when resistance becomes excessive or the respirator is damaged. Generally these respirators are approved only for pneumoconiosis or fibrosis producing dust such as coal dust, silica dust, and asbestos.

. Quarter-mask, dust and mist; half-mask, dust and mist - The quarter-mask covers the mouth and nose; the half-mask fits over the nose and under the chin. The half-mask usually produces a better facepiece to face seal than does the quarter-mask and is therefore preferred for use against more toxic materials. Dust and mist respirators are approved for protection against dusts and mists whose TLV is greater than 0.05 milligram particulate matter per cubic meter of air (mg/M^3).

. Quarter-mask, fume; half-mask, fume - These masks, similar to the quarter-mask dust and mist; half-mask dust and mist, utilize a filter element which can remove metal fumes in addition to dusts and mists from the inhaled air. The filters are approved for metal fumes having a TLV above 0.05 mg/M^3.

. Half-mask, high efficiency - These masks are the same as the units mentioned in the two previous paragraphs above, but use a high efficiency filter. Because of this high efficiency filter, they can be used against dusts, mists, fumes, and combinations of those whose TLV is less than 0.05 mg/M^3.

. Full facepiece - Full facepiece respirators cover the face from the hairline to below the chin. In addition to providing more protection to the face and also a measure of eye protection, the full-facepiece gives a better seal than the half- or quarter-masks. The protection these respirators provide against dusts, mists, fumes, or any combination of these contaminants depends upon the type of filter used.

. Powered air-purifying respirators - These respirators use a blower that passes the contaminated air through the cartridge or canister where the contaminant is removed and passes the purified air into the facepiece. The air purifying element can be a filter to remove particulates, a cartridge or canister to remove gases or vapors, or a combination to remove both. The face covering can be a half-mask, full-face mask, or hood or helmet. The advantage to using a powered air-purifying respirator is that it supplies air at a positive pressure within the facepiece, hood or helmet, so that any leakage is outward.

The protection provided depends on the air-purifying element and the type and concentration of the contaminants. Powered air-purifying respirators must deliver at least 4 cubic feet per minute (CFM) to a tight fitting facepiece such as a mask and at least 7 cfm to a loose fitting helmet or hood. If the powered air-purifying respirator is battery operated, it should provide the airflows mentioned for at least 4 hours without having to recharge the battery.

o Limitations - air purifying respirators for particulates -

. Air-purifying respirators do not provide oxygen, so they must never be worn in oxygen deficient atmospheres.

. Air-purifying respirators for particulates offer no protection against atmospheres containing contaminant gases or vapors.

.. These respirators are not NIOSH approved for abrasive blasting operations and should not be used.

o Problems - air purifying respirators for particulates -

. The air flow resistance of a particulate-removing respirator filter element increases as the quantity of particles it retains increases, thus increasing the breathing resistance. As a rule of thumb, when comfortable breathing is impaired because of dust build-up, the filter should be replaced.

. The performance of some filter materials is affected by open storage in very humid atmospheres. Care should be taken in storing filter elements.

o Chemical Cartridge and Canister Respirators, Gas and Vapors - Vapor and gas-removing respirators use cartridges or canisters containing chemicals to trap or react with specific vapors and gases and remove them from the air breathed. The basic difference between a cartridge and a canister is the volume of the sorbent. Generally, a "cartridge" refers to a chemical adsorbing element which attaches directly to the facepiece, whereas a "canister" refers to the chemical adsorbing element held in a harness and which is connected to the facepiece via a corrugated breathing tube. Some of the typical chemical cartridge or canister respirators are:

. Half-mask and quarter-mask respirators - These are available for protection against single chemicals such as ammonia or against entire classes such as organic vapors. Be sure to read the label on the cartridge or canister since it tells what the cartridge or canister protects against, what the maximum concentration is for which the element can be used, and in some instances, the service life or expiration date of the element.

. Full facepiece - The full facepiece respirator may use a canister or cartridge(s) as the protective element. The front, back, and chin-mounted full-facepiece canister respirators are also referred to as "gas masks."

o Limitations - chemical cartridge or canister, gas and vapor -

. These respirators do not supply oxygen, so they must never be worn in oxygen deficient atmospheres.

. They must not be used if the hazardous chemical lacks adequate warning properties - odor, taste, or irritation, unless their use is permitted by applicable OSHA or MSHA standards. These warning properties are necessary

to alert the user that the sorbent is saturated and that the contaminant is passing through the cartridge or canister into the respiratory tract.

. They must not be used in atmospheres immediately dangerous to life or health, except for escape.

. They are intended for use only for the specific gases or vapors for which they were tested and approved. (They may be worthless for other gases or vapors.)

2) Atmosphere Supplying Respirators - Atmosphere supplying respirators, rather than removing the hazardous material from the air, exclude the workplace air altogether and provide clean air from an independent source. There are two kinds of atmosphere supplying respirators: (1) A supplied-air respirator in which the user is supplied with respirable air through a hose and (2) A self-contained respirator in which the user carries a supply of respirable air.

o Supplied-air respirator - Supplied-air respirators use a central source of breathing air that is delivered to the wearer through an air supply line or hose.

. Airline respirator devices - Airline respirator devices use a stationary source of compressed air delivered through a high-pressure hose. Airline respirator devices can be equipped with a half- or full-facepiece masks, helmets, or hoods, or the device can come as a complete suit. Airline respirators can be used for protection against either particulates, gases, or vapors. They provide a high degree of protection against these contaminants but they cannot be used in atmospheres immediately dangerous to life or health because the user is completely dependent on the integrity of the air supply hose and the air source. If something were to happen to either the hose or air supply, the user could not escape from the contaminated area without endangering his/her life, since the user is not guaranteed a supply of breathing air for escape. A great advantage of the airline respirator is that it can be used for long continuous periods. There are three types of airline respirators.

.. Demand Airline Respirator Devices - In a demand device, the air enters the facepiece only on demand of the user, i.e., when the user inhales. This is due to the nature of the valve and pressure regulator. During inhalation there is a negative pressure in the mask, so if there is leakage, contaminated air may enter the mask and be breathed by the user. The leakage problem is a major drawback of the demand device. Full face masks provide a better seal than the half-mask against leakage.

.. Pressure Demand Airline Devices - The pressure demand device has a regulator and valve design such that there is a continuous flow of air into the facepiece at all times. The air flow into the mask creates a positive pressure in the mask, therefore, there is no problem of contaminant leakage into the facepiece. This is the significant advantage of this type of device.

.. Continuous-flow Airline Devices - The continuous-flow airline respirator maintains a constant airflow at all times and does not use a regulator. Instead an airflow control valve or orifice regulates the flow of air. The continuous-flow device creates a positive pressure in the facepiece. There is no problem of inward leakage of contaminant.

o Air Supply System - Supply air sources (compressor or tanks) for the supplied-air respirators must meet the following requirements.

. The air compressor must be located where contaminated air cannot enter the system.

. The air receiver must be of sufficient capacity to enable the wearer to escape in the event of compressor failure.

. The system must have alarms to indicate compressor failure or overheating.

. If the compressor is oil-lubricated it must have a high temperature and/or carbon monoxide (CO) alarm. If there is no CO alarm, frequent carbon monoxide tests of the air must be made to insure that the CO level does not exceed 20 parts per million.

. All airline couplings must be incompatible with outlets for other gas systems.

. Breathing air quality must meet the requirements of Grade D breathing air as described by the Compressed Gas Association. Grade D requirements are:

.. The oxygen content of the compressed air should be between 19.5 - 23.5 percent oxygen and the remainder mainly nitrogen;

.. Hydrocarbon concentrations must not exceed 5 parts per million;

.. Carbon monoxide concentration must not exceed 20 parts per million;

.. Carbon dioxide concentrations must not exceed 1000 parts per million; and

.. There must not be any pronounced odor.

o Limitations - Supplied-air respirators -

. These devices <u>must not</u> be used in atmospheres immediately dangerous to life or health since the user is dependent upon an air hose which, if cut, crushed, or damaged, leaves him/her with little or no protection.

. The trailing air supply hose of the airline respirator severely restricts the wearer's mobility. This makes the airline respirator unsuitable for the user who must move frequently between work stations that are separated or cover a large area, i.e., during field work.

o Self-Contained Breathing Apparatus (SCBA). The self-contained breathing apparatus (SCBA) allows the user to carry a respirable breathing supply with him/her, and does not need a stationary air source such as a compressor to provide breathable air. The air supply may last from 3 minutes to 4 hours depending on the device.

. Closed Circuit SCBA - In a closed circuit SCBA the air is rebreathed after the exhaled carbon dioxide has been removed and the oxygen content restored by a compressed oxygen source or an oxygen-generating solid. These devices are designed primarily for 1-4 hour use in toxic atmospheres. Because negative pressure is created in the facepiece during inhalation, there is increased leakage potential. Therefore, the devices should be used in atmospheres immediately hazardous to life and health only when long-duration use of an SCBA is indicated, i.e., in mine rescue. Two types of closed circuit SCBA are available.

.. Compressed Oxygen Cylinder Type - In this device, breathable air is supplied from an inflatable bag. Exhaled air from the user goes through an adsorber to remove carbon dioxide, and the oxygen consumed is replenished from an oxygen cylinder.

.. Oxygen-generating Type - This type of SCBA uses an oxygen-generating solid which reacts with water vapor and carbon dioxide from the exhaled breath, to release oxygen. The oxygen then passes to the inflatable bag. This device is lighter, simpler, and less expensive than the cylinder type. However, it is useful for only about 1 hour and, once initiated, cannot be turned off.

. Open Circuit SCBA - An open circuit SCBA exhausts the exhaled air to the atmosphere instead of recirculating it. A tank of compressed air carried on the user supplies air via a regulator to the facepiece. Because there is no recirculation of air, the service life of the open circuit SCBA is shorter than a closed circuit device. Two types of open circuit SCBA's are available.

.. Demand SCBA - In a demand SCBA, air flows into the facepiece only on the demand of the user, i.e., when the user inhales. This is due to the nature of the valves and pressure regulator. During inhalation there is a negative pressure in the mask, so if there is leakage, contaminated air can enter the mask and be breathed by the user. The leakage problem is a major drawback of the demand device. Because of this problem, a demand type open circuit SCBA should not be used in atmospheres immediately dangerous to life or health.

.. Pressure Demand SCBA - The pressure demand open circuit SCBA has a regulator and valve design which maintains a positive pressure

in the facepiece at all times regardless of the demand of the user. Because of this, there is no problem of contaminant leakage into the facepiece. This is a significant advantage of the pressure demand device. The use time of this device, though, may be reduced considerably by air leakage outward from the facepiece.

o Combination Atmosphere Supplying Respirator - Supplied Air and SCBA - Designed primarily as a long duration device, this respirator combines an airline respirator with an auxiliary air supply (usually compressed air) to protect against the possible failure of the primary air supply (the airline). The additional supply can be approved for 15 minutes or even longer. The choice depends upon how long it would take to escape from the toxic atmosphere if the primary air supply failed. This modification, therefore, allows these devices to be used in atmospheres immediately dangerous to life and health.

o Limitations of atmosphere supplying respirators -

. The air supply is limited to the amount in the cylinder (SCBA's using a compressed air tank) and therefore the respirator cannot be used for extended periods without recharging or replacing the cylinders.

. Because these respirators are bulky and heavy, they are often unsuitable for strenuous work or use in confined spaces.

. Because of the short service time of the auxiliary air supply, the escape portion of the combination unit can be used only for escape from atmospheres immediately hazardous to life or health unless the escape portion has a minimum of 15 minutes service life. Such devices can then be used for entry into immediately dangerous to life or health atmospheres provided not more than 20 percent of the available breathing supply is used. These devices may always be used for entry into immediately dangerous to life or health atmospheres when utilized with the external air supply.

. Because the outward air leakage from the facepiece of the pressure demand device can cause loss of air the use time may be shortened.

7. RESPIRATOR USE. All employees required to wear respiratory protective devices should, if practical, be assigned their protective equipment for their exclusive use. A system should be established to facilitate the accounting of users and of the equipment. When a respirator is assigned to a user it should be permanently marked to indicate to whom it is assigned. The marking must be done in such a way that it does not hurt the respirator performance. Records should indicate the date of initial issue, the dates of reissue, and a listing of repairs.

a. Employee Responsibilities. As a respiratory protective device user, employees have these responsibilities:

1) Use respiratory protective equipment as instructed.

2) Guard against damaging the respirator.

3) Go immediately to an area of "clean" air if the respirator malfunctions.

4) Report any malfunctioning of respiratory protective devices to their supervisor. These malfunctions would include but not be limited to:

- Discomfort;
- Resistance to breathing;
- Fatigue due to respirator usage;
- Interference with vision or communication;
- Restriction of movement.

b. Supervision of Respirator Use. Respirators in use must be randomly inspected at frequent intervals to ensure that those selected for the job are being used and that they are in good condition. This periodic monitoring should include:

1) A determination that the proper respirators are being used.

2) Determination that respirators are being worn properly.

3) Consultation with users about:

- Discomfort
- Resistance to breathing
- Fatigue
- Interference with vision
- Interference with communications
- Restriction of movement
- Interference with job performance
- Confidence in the respirator

If problems are discovered during the random inspection, they should be rectified.

c. Respirator Use Under Special Conditions. There are several conditions where the use of respiratory protective devices require special preparations.

1) Dangerous Atmospheres - If respiratory protective devices are to be used in atmospheres immediately dangerous to life or health, a standard operating procedure for work in high hazard areas must be written. (See Appendix B, Model Standard Operating Procedure, Respirator Use, High Hazard Areas.) The standard operating procedure must as a minimum cover the following points.

. Individuals designated to enter into dangerous atmospheres must have training with the proper equipment. These individuals must be equipped with safety harnesses and safety lines so that they can be removed from the atmosphere if necessary.

. Designation and provision of a standby individual, equipped with proper rescue equipment, who must be present in a nearby safe area for possible emergency rescue.

. Provision for communication between persons in the dangerous atmosphere and the standby person must be made. Communication may be visual or by voice, signal line, telephone, radio, or other suitable means.

Other important data such as toxicological information and emergency phone numbers should be included.

2) Confined Spaces - Confined spaces are defined as enclosures where the existing ventilation is insufficient to remove dangerous air contamination and/or oxygen deficiency which may exist or develop and ready access or egress for the removal of a suddenly disabled employee is difficult due to the location and/or size of the opening(s). These special precautions must be taken:

. Before entering a confined space, tests should be made to determine the presence and concentration of any flammable gas, toxic airborne particulate, vapor, gas, and oxygen concentration.

. If the concentration of a flammable substance exceeds 25 percent of the lower explosive limit, the confined space must be force ventilated to keep the concentration well below the lower explosive limit. The concentration of contaminant or oxygen percent should be continuously monitored while individuals are working in the confined space.

. Only individuals specially trained should be allowed to enter confined spaces and the proper respiratory protective devices must be worn.

.. Air-purifying respirators and airline type supplied-air respirators may be worn in a confined space only if the tests show that the atmosphere contains adequate oxygen and that air contaminants are well below levels immediately dangerous to life or health. While employees wearing these types of respirators are in a confined space, the atmosphere must be monitored continuously.

.. If the atmosphere in a confined space is immediately dangerous to life or health due to a high concentration of air contaminant or oxygen deficiency, employees entering the space must wear a positive pressure SCBA or a combination airline and a positive pressure SCBA.

. A standby individual with proper rescue equipment, including an SCBA, must be present outside the confined space for possible emergency rescue. Communication must be maintained via voice, signal line, telephone,

etc., between employees in the confined space and the standby person. The employee inside the confined space must be equipped with safety harnesses and safety lines to allow removal in case of an emergency.

3) Low and High Temperatures - The use of respiratory protective devices in low temperatures can create several problems. The lenses of the full facepiece equipment may fog due to condensation of the water vapor in the exhaled breath. (Coating the inner surface of the lens with an anti-fogging compound will reduce fogging. Nose cups that direct the warm, moist exhaled air through the exhalation valve without touching the lens are available from manufacturers for insertion into the full facepiece.) The exhalation valve can freeze onto the valve seat due to the moisture in the exhaled air. The user will be aware when this situation occurs by the increased pressure in the facepiece. (When unsticking the valve, care should be taken so as not to tear the rubber diaphragm.)

Respirator usage in hot environments can put additional stress on the user. The stress can be minimized by using a light-weight respirator with low breathing resistance. An airline type atmosphere-supplying respirator equipped with a vortex tube can be used. The vortex tube may either cool or warm the supplied air (depending on the connection and setting). This protection scheme can be used in both hot and cold environments.

d. Special Problems in Respirator Use

1) Facial Hair - Facial hair lying between the sealing surface of a respirator facepiece and the wearer's skin will prevent a good seal. If the respirator permits negative air pressure inside the facepiece during inhalation, there will be excessive penetration by an air contaminant. Even a few days growth of stubble will permit excessive contaminant penetration. Any employee who has stubble, a moustache, sideburns, or a beard that passes between his face and the sealing surface must not wear a respirator that allows negative pressure inside the facepiece during inhalation.

2) Corrective Lenses - Spectacle temple bars or straps that pass between the sealing surface of a full facepiece and the wearer's face prevent a good seal. Therefore, spectacles that have temple bars or straps must not be used when a full-facepiece respirator must be worn. Spectacles with short temple bars that do not protrude between the sealing surface and the user's face, or spectacles without temple bars which are taped to the wearer's face may be used temporarily. Special corrective lenses that can be mounted inside the full facepiece are available and should be used by employees who need them. The special corrective lenses must be mounted in the full facepiece by a qualified person to ensure good vision, comfort, and proper sealing of the facepiece. Spectacles or goggles may also interfère with quarter- or half-masks. They must be worn so as not to interfere with the seal of the facepiece. If there is interference, a full facepiece respirator should be worn to avoid sealing problems.

Contact lenses must not be worn while wearing a respirator in a contaminated atmosphere. A properly fitted respirator may stretch the skin around the

eyes, creating the possibility that the contact lens will fall out. Also, contaminants that do penetrate the respirator could get underneath the contact lens and cause severe discomfort. The user's first reaction would be to remove the facepiece to remedy the situation - which could be fatal in a lethal environment.

3) Other Sealing Problems - Scars, hollow temples, very prominent cheekbones, deep skin creases, and lack of teeth or dentures may cause respiratory facepiece sealing problems. Full dentures should be retained when wearing a respirator, but partial dentures may or may not have to be removed, depending upon the possibility of swallowing them. With full lower dentures, problems in fitting quarter-masks can be expected, as the lower part of the mask tends to unseat the denture. Persons with punctured ear drums also should not wear respirators.

8. TRAINING AND FITTING

a. Training. Selecting the respirator appropriate for a given hazard is important, but equally important is using the selected device properly. Proper use can be ensured by carefully training both supervisors and users in selection, use, and maintenance of respiratory protective devices. The content of a training program can vary widely, depending on the needs, however, OSHA requires that the training of both users and supervisors include the following, no matter what the circumstances:

1) An opportunity to handle the respirator,

2) Proper fitting,

3) Test of facepiece to face seal,

4) A long familiarizing period of wear in normal air.

The training of users and supervisors for specific use situations should also include:

1) A discussion of the engineering and administrative controls in use and why respirators are needed.

2) Explanation of the nature of the respiratory hazard and what would happen if the respirator is not used properly,

3) Explanation of why a particular type of respirator has been selected,

4) A discussion of how to recognize and handle emergencies.

The training requirements apply to both large and small groups or units of employees required to wear respiratory protective devices, with no differentiation to meet individual needs.

1) Supervisor - Supervisors who oversee the daily activities of one or more employees who wear respirators frequently should have a knowledge of respirators and respiratory protection practices. Supervisory training should include, but not be limited to, the following areas.

. Basic respiratory protection practices,

. Selection and use of respirators to protect each employee against every respiratory hazard to which he/she may be exposed,

. The nature and extent of the respiratory hazards to which the employees may be exposed,

. The structure and operation of the entire respirator program. The supervisor should understand his/her responsibility to facilitate the implementation of the program, including maintenance that the employee may be expected to do, issuance of respirators, control of their use, and evaluation of the program's effectiveness.

. The legal requirements pertinent to use of respirators in his/her area of jurisdiction.

These supervisory training requirements apply to the large groups or field units with employees required to use respiratory protective devices. A smaller group or field unit may have to combine the supervisor training with that of the employee. This will benefit the employees because they will receive more comprehensive training.

2) Employee Instruction and Training - EPA Order 1440.3 requires that employees receive a minimum of six hours of initial training, and two to four hours annually thereafter. This is a minimum requirement. The extent and frequency of the employee's training will depend on the nature and extent of the hazard. If the hazard is a nuisance particulate, for example, the danger from misuse of the respirator is not likely to be serious. However, against highly toxic particulates, a single misuse may have serious consequences. The same is true for gases and vapors. If the respirator is to be used in an emergency, training in its use should be very thorough and complete. In any case, the employee must be given some instruction and training in respiratory protection practices. Because proper respirator use depends upon the employee's motivation, it is important that the need for respiratory protection be explained fully. The following points should be included in a minimum acceptable respiratory protection training program.

. Instruction in the nature of the hazard, whether acute, chronic, or both, and an honest appraisal of what may happen if the respirator is not used.

. Explanation of why more positive control is not immediately feasible. This should include recognition that every reasonable effort is being made to reduce or eliminate the need for respirators.

. Discussion of why the proper type of respirator must be used for each particular hazard.

. Discussion of respirator capabilities and limitations.

. Instruction and training in actual use of the respirator.

. Classroom and field training in recognizing and coping with emergencies.

. Proper fitting.

. Other special training as needed.

The major thrust of the training is toward explaining as much as possible the reasons for wearing a respirator. This is to motivate the user to accept the fact that protection is necessary, and to instill in him/her the desire to wear and maintain his/her respirator properly. Just giving a respirator to an employee with orders that it must be worn because OSHA says so is one of the easiest ways to ensure its misuse. It is also a cop-out by management. (See Appendix C, Employee Training Program.)

At best, a respirator may cause discomfort and inconvenience, so there is a natural resistance toward wearing it conscientiously. Most of an employee's natural resistance can be overcome by taking the time and effort to inform the user why he/she needs the respirator. This effort will create easier acceptance of respirators and contribute to correct use.

b. Fitting. The proper fitting of respiratory protective devices requires the use of some type of fit test. The fit test is needed to determine a proper match between the facepiece of the respirator and the face of the user.

1) Test Atmospheres - It is required that the user be allowed to test the facepiece to face seal of the respirator and wear it in a test atmosphere. The test atmosphere amounts to an enclosure in which the user can enter with the equipment on, and a "test" atmosphere (of low toxicity) can be generated.

Elaborate enclosures are available commercially, but a "do it yourself" qualitative fit test enclosure can be put together by the use of a plastic bag, several hangers, and some cotton. This enclosure is illustrated on the following page.

2) Test Methods - There are two types of tests: Qualitative tests and quantitative tests. The selection of one or both types of tests depends on the severity and extent of the respiratory hazard and the size of the unit or number of employees involved in wearing respiratory protective devices. During any fitting test, the respirator headstraps must be as comfortable as possible. Tightening the straps will sometimes reduce facepiece leakage, but the user may be unable to tolerate the respirator for any length of time.

. Qualitative Tests - Qualitative tests are fast, require no complicated expensive equipment, and are easily performed. However, these tests rely on the user's subjective response, and so are not entirely reliable. There are two major qualitative tests:

.. Isoamyl Acetate - Isoamyl acetate, a low toxicity substance with a banana oil like odor, is used widely in testing the facepiece fit of organic vapor cartridge/canister respirators. The substance is applied to the cotton wad inside the enclosure. The user should put on the respiratory protective device in an area away from the test enclosure so that there is no prior contamination of the cartridge or "pre-exposure" to the isoamyl acetate. The user should perform the following.

... Normal breathing.

... Deep breathing, as during heavy exertion. This should not be done long enough to cause hyperventilation.

... Side-to-side and up-and-down head movements. These movements should be exaggerated, but should approximate those that take place on the job.

... Talking. This is most easily accomplished by reading a prepared text loudly enough to be understood by someone standing nearby.

... Other exercises may be added depending upon the need.

The major drawback of the isoamyl acetate test is that the odor threshold varies widely among individuals. Also, the sense of smell is easily dulled and may deteriorate during the test so that the user can detect only high vapor concentrations. Another disadvantage is that isoamyl acetate smells pleasant, even in high concentrations. Therefore, a user may say that the respirator fits although it has a leak. A user may say that a respirator fits because he/she likes the fit of the particular respirator or is following the respirator selection of another employee. Conversely, a user may claim that a particular respirator leaks if it is uncomfortable, etc. Therefore, unless the employee is highly motivated toward wearing respirators, the results of this test must sometimes be suspect.

.. Irritant Smoke Test - The irritant smoke test, similar to the isoamyl acetate test in concept, is used widely in testing the facepiece fit of particulate filter respirators. This test can be used for both air-purifying and atmosphere-supplying respirators, but an air-purifying respirator must have a high-efficiency filter. The test substance is an irritant (stannic chloride or titanium tetrachloride) which is available commercially in sealed glass tubes. When the tube ends are broken and air passed through them, a dense irritating smoke is emitted. In this test, the user steps into the test enclosure and the irritant smoke is sprayed into the test hole. If the user detects any of the irritant smoke, it means a defective fit, and adjustment or replacement of the respirator is required. The irritant smoke test must be performed with caution because the aerosol is highly irritating to the eyes, skin, and mucous membrane. As a qualitative means of determining respirator fit, this test has a distinct advantage in that the wearer usually reacts involuntarily to leakage by coughing or sneezing. The likelihood of giving a false indication of proper fit is reduced.

.. Negative Pressure Test - This test (and the positive pressure test) should be used only as a very gross determination of fit. The wearer should use this test just before entering the hazardous atmosphere. In this test, the user closes off the inlet of the canister, cartridge(s) or filter(s) by covering with the palm(s) or squeezing the breathing tube so that it does not pass air; inhales gently so that the facepiece collapses slightly; and holds his/her breath for about 10 seconds.

If the facepiece remains slightly collapsed and no inward leakage is detected, the respirator is probably tight enough. This test, of course,

can only be used on respirators with tight-fitting facepieces. Although this test is simple, it has severe drawbacks; primarily that the wearer must handle the respirator after it has supposedly been positioned on his face. This handling can modify the facepiece seal. A second drawback is that, with a negative pressure in the facepiece, a leaking facepiece may be drawn tightly to the face to form a good seal, giving a false reading of a good seal.

.. Positive Pressure Test - This test, similar to the negative pressure test, is conducted by closing off the exhalation valve and exhaling gently into the facepiece. The fit is considered satisfactory if slight positive pressure can be built up inside the facepiece without any evidence of outward leakage. For some respirators, this method requires that the wearer remove the exhalation valve cover; this often disturbs the respirator fit even more than does the negative pressure test. Therefore, this test should be used sparingly if it requires removing and replacing a valve cover. The test is easy for respirators whose valve cover has a single small port that can be closed by the palm or a finger.

2) Quantitative Tests - Quantitative respirator performance tests involve placing the user wearing the device in an atmosphere containing an easily detectable, relatively nontoxic gas, vapor, or aerosol. The atmosphere inside the respirator is sampled continuously through a probe in the respiratory-inlet covering. The leakage is expressed as a percentage of the test atmosphere outside the respirator, called "percent of penetration," or simply "penetration." The greatest advantage of a quantitative test is that it indicates respirator fit numerically, and does not rely on a subjective response. The quantitative fit test is highly recommended when facepiece leakage must be minimized for work in highly toxic atmospheres or those immediately dangerous to life or health. (See Appendix D, Respirator Protection Factors.)

The quantitative tests require expensive (up to $10,000) equipment that can be operated only by highly trained personnel. Also, it is difficult to use because of its complexity and bulk. Each test respirator must be equipped with a sampling probe to allow continual removal of an air sample from the facepiece so the same facepiece cannot be worn in actual service, since the test orifice negates the approval of the respirator.

.. Sodium Chloride (NaCl) Test - In this test, a liquid aerosol is generated continuously from a salt water solution, dried to produce discrete submicron salt particles, and dispersed into a test chamber or hood. A means is provided for sampling the atmosphere in the chamber or hood and inside the respirator. These samples are fed to the analyzing section where the aerosol's penetration inside the respirator is determined. The amount of penetration is displayed on a meter or recorder.

.. Dioctyl Phthalate (DOP) Test - The dioctyl phthalate (DOP) quantitative fitting test, which uses an air-generated DOP serosol, differs from the NaCl test only in that the aerosol particle is liquid. The aerosol

is generated using a nozzle-type atomizer, but being an oil, DOP does not dry into solid particles when injected into a diluting air stream.

9. RESPIRATORY PROTECTIVE DEVICE INSPECTION, CLEANING, MAINTENANCE, AND STORAGE. Scrupulous respirator maintenance must be made an integral part of the overall respirator program. Wearing poorly maintained or malfunctioning respirators is, in one sense, more dangerous than not wearing a respirator at all. The employee wearing a defective device thinks he/she is protected when, in reality, he/she is not. Emergency escape and rescue devices are particularly vulnerable to poor maintenance as they generally are used infrequently, and then in the most hazardous and demanding circumstances. The possible consequences of a user wearing a defective emergency escape and rescue device are lethal.

A proper maintenance program ensures that the user's respirator remains as effective as when it was new. All programs are required to include as a minimum:

a. Inspection for defects (including a leak check),

b. Cleaning and disinfecting,

c. Repair,

d. Storage.

a. Inspection of Respiratory Protective Devices. An important part of a respirator maintenance program is the inspection of the devices. If performed carefully, inspections will identify damaged or malfunctioning respirators.

1) Inspection Schedules - All respiratory protective devices must be inspected:

- o Before and after each use; and
- o During cleaning.

Equipment designated for emergency use must be inspected:

- o After each use;
- o During cleaning; and
- o At least monthly.

Self-contained breathing apparatus must be inspected:

- o At least monthly.

2) Recordkeeping - A record must be kept of inspection dates and findings for respirators maintained for emergency use.

3) Inspection Considerations - The primary defects to look for in the inspection of the components of the respirator are itemized below. Information within the parentheses are suggested actions to be taken.

o Disposable respirator

. Holes in the filter (obtain new disposable respirator);

. Straps for elasticity and deterioration (replace straps - contact manufacturer); and

. Metal nose clip for deterioration, if applicable (obtain new disposable respirator).

o Air-purifying respirators (quarter-mask, half-mask, full facepiece and gas mask)

. Rubber facepiece - check for:

.. Excessive dirt (clean all dirt from facepiece);

.. Cracks, tears, or holes (obtain new facepiece);

.. Distortion (allow facepiece to "sit" free from any constraints and see if distortion disappears; if not, obtain new facepiece); and

.. Cracked, scratched, or loose fitting lenses (contact respirator manufacturer to see if replacement is possible; otherwise obtain new facepiece).

. Headstraps - check for

.. Breaks or tears (replace headstraps);

.. Loss of elasticity (replace headstraps);

.. Broken or malfunctioning buckles or attachments (obtain new buckles); and

.. Excessively worn serrations on the head harness which might allow the facepiece to slip (replace headstrap).

. Inhalation valve, exhalation valve - check for:

.. Detergent residue, dust particles, or dirt on valve or valve seat (clean residue with soap and water);

.. Cracks, tears, or distortion in the valve material or valve seat (contact manufacturer for instructions); and

.. Missing or defective valve cover (obtain valve cover from manufacturer).

. Filter element(s) - check for:

.. Proper filter for the hazard;

.. Approval designation;

.. Missing or worn gaskets (contact manufacturer for replacement);

.. Worn threads - both filter threads and facepiece threads (replace filter or facepiece, whichever is applicable);

.. Cracks or dents in filter housing (replace filter);

.. Deterioration of gas mask cannister harness (replace harness); and

.. Service life indicator, or end of service date - for expiration, gas mask (contact manufacturer to find out if filter element has one; if not ask what will indicate the "end of service").

. Corrugated beathing tube (gas mask) - check for:

.. Cracks or holes (replace tube);

.. Missing or loose hose clamps (obtain new clamps); and

.. Broken or missing end connectors (obtain new connectors).

o Atmosphere Supplying Respirators

. Facepiece, headstraps, valves, and breathing tube - These items should be checked as for the air-purifying respirators.

. Hood, helmet, blouse, or full suit, if applicable - check for:

.. Rips and torn seams (if unable to repair the tear adequately, replace);

.. Headgear suspension (adjust properly for you);

.. Cracks or breaks in faceshield (replace faceshield); and

.. Protective screen to see that it is intact and fits correctly over the faceshield, abrasive blasting hoods, and blouses (obtain new screen).

. Air supply system - check for:

.. Breathing air quality;

.. Breaks or kinks in air supply hoses and end fitting attachments (replace hose and/or fitting);

.. Tightness of connections;

.. Proper setting of regulators and valves (consult manufacturer's recommendations); and

.. Correct operation of air-purifying elements and carbon monoxide or high temperature alarms.

o Self-contained breathing apparatus (SCBA) - (See Appendix E.)

b. Cleaning and Disinfecting. When respiratory protective devices are used routinely, the respirators should be cleaned and disinfected daily. If respirators are used only occasionally, periodic cleaning and disinfecting is appropriate.

1) Methods - The actual cleaning may be done in a variety of ways.

o The respiratory protective device should be washed with detergent in warm water using a brush, thoroughly rinsed in clean water, and then air dried in a clean place. Care should be taken to prevent damage from rough handling. This method is an accepted procedure for a small group or unit of employees where each employee cleans his/her own respirator.

o A standard domestic-type dish or clothes washer may be used if a rack is installed to hold the facepieces in a fixed position. (If the facepieces are placed loose in the washer they may be damaged.) This method is especially useful in a large unit or group and where respirator usage is extensive.

2) Detergents and disinfectants - If possible, detergents containing a bactericide should be used. Organic solvents should not be used, as they can deteriorate the rubber facepiece. If the above combination is not available, a detergent may be used, followed by a disinfecting rinse. Reliable disinfectants may be made from some available household solutions.

o Hypochlorite solution (50 parts per million (ppm) of chlorine) made by adding approximately two tablespoons of chlorine bleach per gallon of water. A two-minute immersion disinfects the respirators.

o Aqueous solution of iodine (50 ppm made by adding approximately one teaspoon of tincture of iodine per gallon of water). Again, a two-minute immersion is sufficient and will not damage the rubber and plastic in the respirator facepieces. Check with the manufacturer to find out the proper temperature for the solutions.

3) If the respirators are washed by hand, a separate disinfecting rinse may be provided. If a dish or clothes washing machine is used the disinfectant must be added to the rinse cycle, and the amount of water in the machine at that time will have to be measured to determine the correct amount of disinfectant to be added.

4) Rinsing - The cleaned and disinfected respirators should be rinsed thoroughly in clean water (120° F maximum) to remove all traces of detergent, cleaner and sanitizer, and disinfectant. This is very important to prevent dermatitis.

5) Drying - The respirators may be allowed to dry by themselves on a clean surface. They also may be hung from a horizontal wire, like drying clothes, but care must be taken not to damage the facepieces.

c. Maintenance. Continued usage of respiratory protective devices may require periodic repair or replacement of component parts of the equipment. Such repairs and parts replacement must be done by a qualified individual(s).

Replacement of parts and repair of air-purifying respirators, in most cases, present little problem. Most equipment manufacturers supply literature which details the component parts of their respirator and include servicing information. The manufacturer will also provide replacements parts. Replacement parts for respiratory protective devices must be those of the manufacturer of the equipment. Substitution of parts from a different brand or type of respirator will invalidate the approval of the respirator.

Defective air-supplying respiratory protective equipment, with the exception of the SCBA, can be repaired and worn if broken parts are replaced by a qualified individual - again with the aid of the manufacturer's literature and parts. Maintenance of SCBA equipment is more difficult, primarily because of the valve and regulator assembly. Because of this, regulations require that SCBA equipment be returned to the manufacturer for adjustment or repair.

d. Storage. All the care that has gone into cleaning and maintenance of a respirator can be negated by improper storage. Respiratory protective equipment must be stored to protect it from dust, sunlight, heat, extreme cold, excessive moisture, and damaging chemicals. Leaving a respirator unprotected can lead to damage of the working parts or permanent distortion of the facepiece, thus making it ineffective.

After cleaning and disinfecting the respirators, they should be placed individually in heat-sealed or resealable plastic bags until reissue. They should be stored in a single layer with the facepiece and exhalation valve in a more or less normal position to prevent the rubber or plastic from taking a permanent distorted "set".

1) Air-purifying respirators - Air purifying respirators kept ready for nonroutine or emergency use should be stored in a cabinet in individual compartments.

2) Air-supplying respiratory protective equipment - A storage chest for self-contained breathing apparatus may be purchased from the manufacturer. All storage cabinets should be located in noncontaminated, but readily accessible, areas.

10. MEDICAL ASPECTS OF RESPIRATORY EQUIPMENT USAGE. EPA Order 1440.3, Respiratory Protection, requires that employees assigned to tasks requiring the use of respiratory protective devices must have a medical evaluation, defined by the Agency's Occupational Medical Monitoring Guidelines. There must be a determination that employees are physically capable of performing the work while wearing the devices. These requirements are necessary because the use of any type of respirator may impose some physiological stress on the user. Air-purifying respirators, for example, make breathing more difficult because the filter or cartridge impedes the flow of air. The special exhalation valve on an open circuit pressure demand respirator requires the user to exhale against significant resistance. The bulk and weight of an SCBA can be a burden. If the employee is using an airline respirator, he/she might have to drag up to 300 feet of hose around. All of these factors can significantly increase the employee's workload.

So that the examining physician can give a qualified opinion regarding whether an employee can use a respirator, the Agency should provide the following information. (See Appendix F, Duty Status Report.)

a. Type of respiratory protection equipment to be used, and its modes of operation;

b. The tasks that the employee will perform while wearing the respirator;

c. Visual and audio requirements associated with the task;

d. Length of time that the employee will wear the respiratory protective equipment; and

e. The substance(s) to which the employee will be exposed, and the related toxicity data.

The following checklist will give the Respiratory Protection Program Manager a good indication of the employee's ability to wear a respirator.

a. Lung

___ History of asthma or emphysema.

___ Difficulty in breathing.

___ Previously documented lung problems.

b. Heart

___ High blood pressure.

___ Artery diseases.

___ Documented heart problems.

c. Other

___ Missing or arthritic fingers.

___ Facial scars.

___ Claustrophobia.

___ Poor eyesight.

___ Perforated ear drum(s).

A "yes" answer to any of these questions would constitute a warning sign regarding the use of respirators by an employee. A medical opinion to confirm any of these situations should then be obtained.

11. EVALUATION OF THE RESPIRATORY PROTECTION PROGRAM. Two important aspects of the respirator program are the periodic surveillance of the work areas which require use of respirators, and an evaluation of the program for effectiveness.

a. Surveillance of the Work Area. Many things can affect the need to use respirators. To determine the continued necessity of respiratory protection or need for additional protection, there should be appropriate surveillance of the work area conditions and the degree of employee exposure or stress to allow for program changes as needed.

b. Program Evaluation. The respirator program at each Agency unit should be evaluated at least annually, with program adjustments, as appropriate, made to reflect the evaluation results. The following are areas of the Respiratory Protection Program that should be evaluated.

1) Program Administration

o Program responsibility is vested in one individual who is knowledgeable and who can coordinate all aspects of the program.

o The implementation of engineering controls, if feasible, to alleviate the need for respirators is in progress.

o There are written procedures/statements covering these aspects of the respirator program.

. A Program Manager has been designated.

. Procedures for respirator selection are developed.

. The purchase of approved equipment is assured.

. The procedures for issuing respiratory equipment are in place.

. The medical aspects of respirator usage are defined and a program is in place.

. Employees are properly fitted for respiratory protective devices.

. Provisions for the maintenance, storage, and repair of respiratory protective equipment are being followed.

. There is a program for regular inspection of respiratory protective equipment, and

. The provisions for use of respiratory protective equipment under special conditions are defined.

2) Program Operation

o The selection of respiratory protective equipment consider these factors:

. The work area conditions and employee exposures.

. Respirators are selected on the basis of hazards to which the employee is exposed.

. The selection of respirators is made by knowledgeable individuals.

o Only approved respirators are purchased and used to provide adequate protection for specific hazards and concentrations of contaminants.

o Respirators are issued to users for their exclusive use, where practical, and records are maintained covering the issuance.

o The fitting of respiratory protective equipment taken into consideration these factors:

. Users are given the opportunity to try on several different brands of respirators to assure that the make of respirator they will be wearing is the best fitting one.

. Respiratory protective equipment is fit tested at appropriate intervals.

. Respiratory protective equipment users who require corrective lenses are properly fitted.

. Respiratory protective equipment users are prohibited from wearing contact lenses when using the respirator.

. Facepiece to face seal is tested in a test atmosphere.

o The maintenance of respiratory protective equipment covers these factors.

. Cleaning and Disinfecting -

.. Respirators are cleaned and disinfected after each use when different employees use the same device or as frequently as necessary for devices issued to individual users.

.. Proper methods of cleaning and disinfecting are utilized.

. Storage

.. Respirators are stored in a manner so as to protect them from dust, sunlight, heat, excessive cold or moisture, and damaging chemicals.

.. Respirators are stored properly to prevent them from deforming.

. Inspection

.. Respirators are inspected before and after each use and during cleaning.

.. Employees/users are instructed in inspection techniques.

.. Respiratory protective equipment designated for emergency use is inspected at least monthly (in addition to after each use).

.. Records are kept of the inspection of emergency use respiratory protective equipment.

. Repair

.. The replacement parts used for repairing respirators are those of the manufacturer of the respirator.

.. Repairs are made by knowledgeable individuals.

.. Repairs of SCBA's are made by certified personnel or by a manufacturer's representative.

. Special Use Conditions

.. Procedures are developed for the use of respiratory protective equipment in atmospheres immediately dangerous to life or health.

.. Procedures are developed for equipment usage for entry into confined spaces.

. Training

.. Employees are trained in proper usage of respiratory protective equipment.

.. Employees are trained in the basis for respirator selection.

REFERENCES

1. EPA Order 1440.3, Respiratory Protection, July 24, 1981.

2. Department of Labor, OSHA, Occupational Health and Safety Standards, 29 CFR Part 1910.134, General Respirator Requirements, Federal Register, Volume 37, Number 202, October 18, 1972.

3. Department of Labor, OSHA, Occupational Health and Safety Standards, 29 CFR 1910.94, 111, 252, 261, 262, 265, 266, 1001-1029, Specific Respirator Requirements, Federal Register, Volume 37, Number 202, October 18, 1972.

4. Department of the Interior, Bureau of Mines, Respiratory Protective Devices; Tests for Permissibility; Fees, 30 CFR Part 11, Federal Register, Volume 37, Number 59, March 25, 1972.

5. American National Standards Institute, Standard Z88.2-1969, Respirator Practices, ANSI, 1430 Broadway, New York, N. Y. 10018.

6. American National Standards Institute, Standard Z88.2-1980, Practices for Respiratory Protection, ANSI, 1430 Broadway, New York, N. Y. 10018.

7. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for 1973 (and current year), ACGIH, 1014 Broadway, Cincinnati, Ohio 45202.

NOTE: Information from these references is either used or referred to in this guideline. A copy of the complete text of the references is valuable in setting up and managing a respiratory protection program. It is recommended that copies of these references be obtained and filed with this guideline.

34.

Respiratory Protective Device Recommendation

Name of Employee/User _____

Program Office _____ Telephone Number _____

Anticipated Hazards

1. Materials

   a. Chemical Name _____

   b. Trade Name _____

   c. Formula _____

   d. TLV or TWA _____ OSHA 1910.1000 _____ Other _____

2. Form of Materials

   a. Liquid? _____ b. Solid? _____ c. Gaseous? _____

   d. If gaseous, is it an organic vapor? _____ or acid gas? _____

   other? _____

3. Maximum expected concentration

   a. _____parts per million, or

   b. _____milligrams per cubic meter

4. Will material be heated? _____ If so, to what temperature? _____°F

5. What is the odor threshold of the material?_____

6. At what concentration is the material considered to be immediately dangerous to life or health? _____

7. Can the substance be absorbed through the skin? _____

8. Irritant to eyes? _____ respiratory tract? _____ skin? _____

9. At what concentration is it an irritant? _____

10. If the substance is known to be flammable, what are the lower and upper flammable limits, in per cent by volume? _____

11. What is the vapor pressure of the material? _____

12. Will the material be mixed with other chemicals? _____ If so, give details _____

_____

_____

_____

13. Any possibility of oxygen deficiency? _____

14. Can good ventilation of the area be maintained? _____

15. Will exposure be continuous?_____ or intermittent? _____

16. Will the respiratory device be used for routine exposures, or will it be used as an escape device? _____

_____

Respiratory Protective Device(s) Recommended: _____

_____

_____

Other Personal Protective Clothing or Equipment Recommended: _____

_____

_____

_____

_____ Date

_____ Respiratory Protection Program Manager

MODEL

STANDARD OPERATING PROCEDURE
RESPIRATOR USE
HIGH HAZARD AREAS

1. Location: _____

2. Date of Preparation _____

3. Prepared by _____

4. Operation or Procedures where respirators are required _____

_____

_____

_____

5. Type(s) of respirator to be used _____

_____

6. Other Protective clothing and equipment required:

Harness _____ Skin _____

Safety Lines _____ Head _____

Eye Protection _____ Other _____

Body _____ (full) _____ (partial)

7. Training required: _____

_____

_____

8. Provisions for Standby person: _____

9. Provisions for communication _____

10. Conditions under which respirator is to be used :

Oxygen deficient? _____

Type(s) of contaminants ? _____

Expected Concentrations? _____

Peak Concentrations? _____

11. Type and Frequency of Monitoring: _____

_____

12. Emergency Procedures (include type of respirator, protective clothing, cleanup procedures, etc.,

_____

_____

_____

_____

Comments _____

_____

_____

_____

NOTES TO INSTRUCTOR

EMPLOYEE TRAINING PROGRAM

A. Why is respiratory protective equipment required?

1. The Occupational Safety and Health Administration

OSHA has set maximum exposure standards for many airborne toxic materials and has set standards governing specific working environments to protect your health. A recent evaluation of your working environment revealed that:

Name work area
List substances
Describe activities
Describe chemical exposure

a. In work areas (****), atmospheric concentrations of substances (****) were found to be above acceptable limits.

b. Maintenance activities (****) during which you are exposed to (****) a high concentration for a short period of time, lead to excessive exposure.

Describe areas

c. Several areas (****) were found to be "oxygen deficient." (See Appendix II)

Name storage areas
Describe emergency situation which could exist in your plant

d. Hazardous substances are stored at (****) and if these substances spill, etc., an emergency condition will exist, or (****).

2. Status of Engineering Controls

Suggested phraseology

(****) Since the company recognizes that respiratory protection is not the accepted method for control of airborne hazards, we are taking steps to implement *engineering* control solutions.

Plan to have . . .
Describe what controls are to be/being implemented
Discuss administrative controls (rotating work schedules, spreading work over two shifts, etc.)

a. We (****) installed the following engineering controls (****)

b. And the following administrative controls (****).

However, while the above steps are being implemented, respiratory protection will be required.

B. Respirator Selection and Procedure

Selection procedure of the proper equipment normally involves three steps: the *identification* of the hazard; the *evaluation* of the hazard; and finally the *selection* of the appropriate respiratory equipment based on the first two steps.

NOTES TO INSTRUCTOR

EMPLOYEE TRAINING PROGRAM

1. Identification of the Hazard

Before we get into the "specifics" about the respiratory protective equipment you will be wearing, a few statements about hazard identification.

Discuss only those contaminant atmospheres representing problems in your facility. See following discussion.

There are several kinds of hazardous atmospheres which may require the use of respirators. (****)

a. Gaseous Contaminants

Gases are the normal form of substances like carbon dioxide or hydrogen sulfide. These substances are solids or liquids only at very low temperatures or extremely high pressures. Carbon dioxide, for instance, is a gas at room temperature. But it also occurs as solid "dry ice" formed at low temperatures.

Vapors are exactly like gases except that they are formed by the evaporation of substances, such as acetone or trichlorethylene, which ordinarily occur as liquids.

b. Particulate Contaminants

Particulates are tiny particles, solid or liquid, generated by such processes as grinding, crushing, and mixing of a compound, either a solid or a liquid. There are three types of particulates.

Dusts are solid particles produced by such processes as grinding, crushing, and mixing of powder compounds. Examples are sand and plaster dust. By comparison to the following two types of particulates, dust particles are usually large.

Mists are tiny liquid droplets, usually formed whenever a liquid is sprayed, vigorously mixed, or otherwise agitated. Acid mists around diptanks used for metal cleaning, and oil mists near newspaper printing presses, are two examples.

Fumes are solid condensation particles of extremely small particle size. Fumes are found in the air near soldering, welding, and brazing operations, as well as near molten metal processes such as casting and galvanizing.

Two basic forms — gaseous and particulate — frequently occur together. Paint spraying operations, for example, produce both paint mist (particulate) and solvent vapors (gases).

A further discussion of ODA's can be found in Appendix II.

a. Oxygen Deficient Atmospheres (****). Oxygen deficient atmospheres (ODA) are most commonly found in confined spaces which have poor ventilation. Examples are silos, petrochemical tanks, degreasers, and the holds of ships.

NOTES TO INSTRUCTOR	EMPLOYEE TRAINING PROGRAM
After explaining to the employee the *type* of hazardous atmosphere (*a* and/or *b* and/or *c*) requiring respiratory protection, you should then discuss the hazard specifics. Check vendor literature, toxicologic references, or Material Safety Data Sheet (or contact OSHA or NIOSH regional offices).	*2. Hazard Specifics (****)* *a.* Hazard Name • Organic vapor (name) • Particulate (name) • Gas (name) *b.* Toxicity Data (****) • Effects
See Figure I. Refer to Appendix I to describe the type instrument used (optional). See Appendix V.	*3. Evaluation of the Hazard (****)* *a.* To determine the concentration of the hazard, as identified above, measurements were made. (****) The concentration and/or work environment examined were compared with the published Federal Standards (****).
See Appendix IV.	*4. Selection of the Respirator* *a.* After it was determined that respirators were required, the Standards Completion Program (SCP) was consulted to find out the required respiratory protection equipment (****).
	C. Use and Proper Fitting of Respiratory Protective Equipment
	1. Use of Respiratory Protective Equipment
Using Appendix VII and information supplied by the manufacturer, show the employee how to put on the selected respirator. Show the various components of the respirator, and how the respirator functions to remove the contaminants.	*2. Proper Fitting*
At this time, you should have available at least two different types (different manufacturers) of selected respiratory equipment — for the employee to try on.	So that respiratory protective devices, which use tight fitting facepieces, give maximum protection, there must be a proper "match" between the facepiece and your face. A poor face seal can cause contaminants to be inhaled through the respirator sealing surfaces, instead of through the canister, filter, or air supply system. (****) *a.* In most cases, there are several different brands of the same type of respiratory protection equipment approved for use against a specific hazard or work environment. (****)

NOTES TO INSTRUCTOR

EMPLOYEE TRAINING PROGRAM

Refer to Appendix VIII for discussion of fitting tests. The qualitative fit tests can be used as a quick test to ascertain the proper fit. However, if respirator use will be in an extremely hazardous atmosphere, or for emergencies, the quantitative fit test should be used.
Demonstrate how the qualitative fit test works. Show illustration of a quantitative test set-up (if there is not an actual set-up on the premises).

b. However, just because a respirator "feels comfortable" it does not mean that it is protecting you to the fullest extent from the hazard. The key word is *proper* fit. To determine if the fit is proper, several tests can be used. (****)

Consult Appendix VII and the specific respiratory protective equipment — under Limitations.

D. Limitations of Respiratory Equipment (****)

However, the respiratory protective equipment that you will use does have some limitations on its usage.

E. Maintenance and Storage of Respiratory Equipment

To maintain the proper functioning of respirators requires that they be regularly cleaned and disinfected, and stored in a convenient and clear location.

Refer to Section VII(A) for details concerning cleaning of equipment. Several suggested cleaning methods are given. Discuss provisions.

1. Cleaning (****)

Your respiratory protective equipment should be cleaned daily after use. The company has made provisions for doing this. (****)

Refer to Section VII(B) and discuss storage provisions by company.

2. Storage (****)

Equipment must be stored properly at the conclusion of the work shift.

Refer to Section VIII for discussion on inspection for defects.

3. Inspection for Defects (****)

This is one of the most important functions associated with respirator usage. These inspections can identify damage to malfunctioning respiratory protective equipment.

NOTES TO INSTRUCTOR

Before you discuss this section with the user, you should first prepare the summary — as it applies to your usage.

EMPLOYEE TRAINING PROGRAM

F. Summary(****)

A summary of those aspects of the proper use of respiratory protective equipment. Reasons for Respiratory Protective Equipment.

1. *Respirator Selection Procedure*
   a. Identification of hazard.
   b. Hazard specifics.
   c. Evaluation of the hazard.
   d. Selection of the respirator.

2. *Proper Fitting and Usage*
   a. Use.
   b. Fitting.

3. *Limitations*

4. *Maintenance and Storage*

RESPIRATOR PROTECTION FACTORS[1]

Type Respirator	Facepiece[2] Pressure	Protection Factor
I. Air-Purifying		
A. Particulate[3] removing		
Single-use,[4] dust[5]	–	5
Quarter-mask, dust[6]	–	5
Half-mask, dust[6]	–	10
Half- or Quarter-mask, fume[7]	–	10
Half- or Quarter-mask, High-Efficiency[8]	–	10
Full Facepiece, High-Efficiency	–	50
Powered, High-Efficiency, all enclosures	+	1000
Powered, dust or fume, all enclosures	+	X[9]
B. Gas and Vapor-Removing[10]		
Half-Mask	–	10
Full Facepiece	–	50
II. Atmosphere-Supplying		
A. Supplied-Air		
Demand, Half-mask	–	10
Demand, Full Facepiece	–	50
Hose Mask Without Blower, Full Facepiece	–	50
Pressure-Demand, Half-Mask[11]	+	1000
Pressure-Demand, Full Facepiece[12]	+	2000
Hose Mask With Blower, Full Facepiece	–	50
Continuous Flow, Half-Mask[11]	+	1000
Continuous Flow, Full Facepiece[12]	+	2000
Continuous Flow, Hood, Helmet, or Suit[13]	+	2000
B. Self-Contained Breathing Apparatus (SCBA)		
Open-Circuit, Demand, Full Facepiece	–	50
Open-Circuit, Pressure-demand Full Facepiece	+	10,000[14]
Closed-Circuit, Oxygen Tank-type, Full Facepiece	–	50
III. Combination Respirator		
A. Any combination of air-purifying and atmosphere-supplying respirator.	Use minimum protection factor listed above for type of mode of operation.	
B. Any combination of supplied-air respirator and an SCBA		

Exception: Combination supplied-air respirators, in pressure-demand or other positive pressure mode, with an auxiliary self-contained air supply, and a full facepiece, should use the PF for pressure-demand SCBA.

NOTE: Reference "A Guide to Industrial Respiratory Protection", NIOSH, June 1976

[1] The overall protection afforded by a given respirator design (and mode of operation) may be defined in terms of its protection factor (PF). The PF is a measure of the degree of protection afforded by a respirator, defined as the ratio of the concentration of contaminant in the ambient atmosphere to that inside the enclosure (usually inside the facepiece) under conditions of use. Respirators should be selected so that the concentration inhaled by the wearer will not exceed the appropriate limit. The recommended respirator PF's are selection and use guides, and should only be used when the employer has established a minimal acceptable respirator program as defined in Section 3 of the ANSI Z88.2-1969 Standard.

[2] In addition to facepieces, this includes any type of enclosure or covering of the wearer's breathing zone, such as supplied-air hoods helmets, or suits.

[3] Includes dusts, mists, and fumes only. Does not apply when gases or vapors are absorbed on particulates and may be volatilized or for particulates volatile at room temperature. Example: Coke oven emissions.

[4] Any single-use dust respirator (with or without valve) not specifically tested against a specified contaminant.

[5] Single-use dust respirators have been tested against asbestos and cotton dust and could be assigned a PF of 10 for these particulates.

[6] Dust filter refers to a dust respirator approved by the silica dust test, and includes all types of media, that is, both nondegradable mechanical type media and degradable resin-impregnated wool felt or combination wool-synthetic felt media.

[7] Fume filter refers to a fume respirator approved by the lead fume test. All types of media are included.

[8] High-efficiency filter refers to a high-efficiency particulate respirator. The filter must be at least 99.97% efficient against 0.3 μm DOP to be approved.

[9] To be assigned, based on dust or fume filter efficiency for specific contaminant.

[10] For gases and vapors, a PF should only be assigned when published test data indicate the cartridge or canister has adequate sorbent efficiency and service life for a specific gas or vapor. In addition, the PF should not be applied in gas or vapor concentrations that are: 1) immediately dangerous to life, 2) above the lower explosive limit, and 3) cause eye irritation when using a half-mask.

[11] A positive pressure supplied-air respirator equipped with a half-mask facepiece may not be as stable on the face as a full facepiece. Therefore, the PF recommended is half that for a similar device equipped with a full facepiece.

[12] A positive pressure supplied-air respirator equipped with a full facepiece provides eye protection but is not approved for use in atmospheres immediately dangerous to life. It is recognized that the facepiece leakage, when a positive pressure is maintained, should be the same as an SCBA operated in the positive pressure mode. However, to emphasize that it basically is not for emergency use, the PF is limited to 2,000.

[13]The design of the supplied-air hood, suit, or helmet (with a minimum of 6 cfm of air) may determine its overall efficiency and protection. For example, when working with the arms over the head, some hoods draw the contaminant into the hood breathing zone. This may be overcome by wearing a short hood under a coat or overalls. Other limitations specified by the approval agency must be considered before using in certain types of atmospheres.

[14]The SCBA operated in the positive pressure mode has been tested on a selected 31-man panel and the facepiece leakage recorded as less than 0.01% penetration. Therefore, a PF of 10,000+ is recommended. At this time, the lower limit of detection 0.01% does not warrant listing a higher number. A positive pressure SCBA for an unknown concentration is recommended. This is consistent with the 10,000+ that is listed. It is essential to have an emergency device for use in unknown concentrations. A combination supplied-air respirator in pressure-demand or other positive pressure mode, with auxiliary self-contained air supply is also recommended for use in unknown concentrations of contaminants immediately dangerous to life. Other limitations, such as skin absorption of HCN or tritium, must be considered.

CHECKLIST FOR INSPECTION OF PRESSURE DEMAND SELF-CONTAINED BREATHING APPARATUS WITHOUT MODE SELECT LEVER:

PRIOR TO BEGINNING INSPECTION:

1. *Check to assure that high pressure hose connector is tight on cylinder fitting*
2. *Bypass valve closed*
3. *Mainline valve closed*
4. *No cover or obstruction on regulator outlet*

I. BACK PACK & HARNESS ASSEMBLY

A. Straps

1. *Visually inspect for complete set*
2. *Visually inspect for frayed or damaged straps that may break during use*

B. Buckles

1. *Visually inspect for mating ends*
2. *Check locking function*

C. Backplate & Cylinder Lock

1. *Visually inspect backplate for cracks and for missing rivets or screws.*
2. *Visually inspect cylinder hold-down strap and physically check strap tightener and lock to assure that it is fully engaged*

II. CYLINDER & CYLINDER VALVE ASSEMBLY

A. Cylinder

1. *Physically check cylinder to assure that it is tightly fastened to back plate*

(M) 2. *Check Hydrostatic Test Date to assure it is current*

(M) 3. *Visually inspect cylinder for large dents or gouges inmetal*

B. Bead & Valve Assembly

(M) 1. *Visually inspect cylinder valve lock for presence*

(M) 2. *Visually inspect cylinder gauge for condition of face, needle, and lens*

3. *Open cylinder valve and listen or feel for leakage aroung packing. (If leakage is noted, do not use until repaired.) Note function of valve lock*

III. REGULATOR & HIGH PRESSURE HOSE

A. High Pressure Hose & Connector

1. Listen or feel for leakage in hose or at hose to cylinder connector. (Bubble in outer hose covering may be caused by seepage of air through hose when stored under pressure. This does not necessarily mean a faulty hose.

B. Regulator & Low Pressure Alarm

1. Cover outlet of regulator with palm of hand. Open mainline valve and read regulator gauge (must read at least 1800 PSI and not more than rated cylinder pressure)

2. Close cylinder valve and slowly move hand from regulator outlet to allow slow flow of air. Gauge should begin to show immediate loss of pressure as air flows. Low pressure alarm should sound between 650 and 550 PSI. Remove hand completely from outlet and close mainline valve.

3. Place mouth onto or over regulator outlet and blow. A positive pressure should be created and maintained for 5-10 seconds without any loss of air. Next suck a slight negative on regulator and hold for 5-10 seconds. Vacuum should remain constant. This tests the integrity of the diaphragm. Any loss of pressure or vacuum during this test indicates a leak in the apparatus.

4. Open cylinder valve.

5. Place hand over regulator outlet and open mainline valve. Remove hand from outlet and replace in rapid movement. Repeat twice. Air should escape when hand is removed each time, indicating a positive pressure in chamber. Close mainline valve and remove hand from outlet.

6. Ascertain that no obstruction is in or over the regulator outlet. Open and close bypass valve momentarily to assure flow of air through bypass system.

IV. FACEPIECE & CORRUGATED BREATHING TUBE

A. Facepiece

1. Visually inspect head harness for damaged serrations and deteriorated rubber. Visually inspect rubber facepiece body for signs of deterioration or extreme distortion.

2. Visually inspect lens for proper seal in rubber facepiece, retaining clamp properly in place, and cracks or large scratches.

3. Visually inspect exhalation valve for visible deterioration or foreign materials build-up.

B. Breathing Tube & Connector

1. Stretch breathing tube and visually inspect for deterioration and holes.

2. Visually inspect connector to assure good condition of threads and for presence and proper condition of "O" ring or rubber gasket seal.

NOTE: Final test of facepiece would involve a negative pressure test for overall seal and check of exhalation valve. If monthly inspection, mask may now be placed against face and following tests performed. If preparing for use, don backpack, then don facepiece and use following procedure.

C. Negative Pressure Test on Facepiece

1. With facepiece held tightly to face or facepiece properly donned, stretch breathing tube to open corrugations and place thumb or hand over end of connector. Inhale. Negative pressure should be created inside mask, causing it to pull tightly to face. This negative pressure should be maintained for 5-10 seconds. If negative pressure leaks down, the facepiece assembly is not adequate and should not be worn.

V. STORAGE OF UNITS

1. Cylinder refilled as necessary and unit cleaned and inspected.

2. Cylinder valve closed.

3. High pressure hose connector tight on cylinder

4. Pressure bled off of high pressure hose and regulator

5. Bypass valve closed.

6. Mainline valve closed

7. All straps completely loosened and laid straight.

8. Facepiece properly stored to protect against dust, sunlight, heat, extreme cold, excessive moisture, and damaging chemicals.

ITEMS MARKED (M) would be done only on monthly inspection.

NOTE: Any descrepance found should be cause to set unit aside until repair can ce done by certified repair-person.

INSPECTION AND MAINTENANCE CHECK LISTS

Self-Contained Breathing Apparatus Serial Number _____

Issued To _____ Date of Issue _____

Location _____

WEEKLY INSPECTION

DATE INSPECTED	CYLINDER OK	CYLINDER CHANGED	DATE INSPECTED	CYLINDER OK	CYLINDER CHANGED	DATE INSPECTED	CYLINDER OK	CYLINDER CHANGED

MONTHLY INSPECTION

DATE INSPECTED	CYLINDER OK	CYLINDER CHANGED	REGULATOR OK	FACEPIECE & BREATHING TUBE OK	CLEANED AND SANITIZED	ENTIRE APPARATUS OK	REMARKS	INSPECTED BY

INSPECTION AFTER EACH USE									
DATE USED	CYLINDER OK	CYLINDER CHANGED	FACEPIECE AND BREATHING TUBE OK	ENTIRE APPARATUS OK	CLEANED AND SANITIZED	CONNECTORS OK	REMARKS	INSPECTED BY	DATE INSPECTED

MODEL
DUTY STATUS REPORT

1. Employee's Name _____

2. Work Location _____

3. Occupation _____

4. Date _____

5. Use of Respiratory Protective Devices

   a. Type of Respirator _____

   b. Mode of Operation _____

   c. Tasks Employee will perform _____

   _____

   d. Visual requirements _____

   e. Audio requirements _____

   f. How long employee is expected to wear the device _____

   _____

   g. What substance(s) will employee be exposed to (include toxicity data _____

   _____

   _____

_____
Signature of Supervisor

Medical Surveillance

At this examination on _____ no contraindications to the use of the equipment described above have been identified.

_____
Physician's Signature

SECTION 5

PERSONAL PROTECTIVE EQUIPMENT

PART 6

CHEMICAL PROTECTIVE CLOTHING

I. INTRODUCTION

Chemical protective clothing (CPC) is worn to prevent harmful chemicals from coming in contact with the skin (or eyes). It provides a barrier between the body and chemicals which have a detrimental effect on the skin or which can be absorbed through the skin affecting other organs. Used with respiratory protection, properly selected chemical protective clothing can protect personnel who must work in a hostile chemical environment from injury.

Protecting workers against skin exposure requires using the most effective chemical protective clothing. Of primary importance is selecting clothing made from a material which is most resistance to the attack chemical. The style of clothing is also important and depends on whether the attack substance is in the air or skin exposure will be from splash or direct contact with solids or semi-solids. Other selection criteria which should be considered include the probability of being exposed, ease of decontamination, mobility while wearing clothing, durability of clothing, and to a lesser degree, cost.

A variety of manufactured materials exists which are used to make the fabric for chemical protective clothing. Each of these materials provides a degree of skin protection against a range of chemicals. But no one material affords maximum protection against all chemicals. The chemical protective clothing selected must be made from a material which affords the greatest deterrent against the chemicals known or expected to be encountered.

Properly selected chemical protective clothing can minimize risk of exposure to chemical substances, but may not protect against physical hazards, i.e. fire, radiation, electrical. The use of other personal protective equipment must also be determined for a complete ensemble. Head protection is provided by hard hats; eye and face protection by goggles or impact resistant lenses in spectacles; hearing protection by earmuffs or earplugs; and foot protection by impact resistant and chemically-resistant boots.

II. CLASSIFICATION OF CHEMICAL PROTECTIVE CLOTHING

Chemical protective clothing is classified by style, protective material from which the fabric is made, and whether the clothing is single use (disposable).

A. Style

- Fully Encapsulating Suit (FES): Fully encapsulating, chemical protective clothing is a one piece garment that completely encloses the wearer. Boots,

gloves and facepiece 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 insure integrity.

Respiratory protection and breathing air is provided to the wearer by a positive-pressure, self-contained breathing apparatus worn under the suit, or by an air-line respirator which maintains a positive-pressure inside the suit.

Fully encapsulating suits are primarily for protecting the wearer against toxic vapors, gases, mists, or particulates in air. Concomitantly, they protect against splashes of liquids. The protection they provide against a specific chemical depends upon the material from which they are constructed.

- Non-Encapsulating Suit: Non-encapsulating chemical protective clothing (frequently called splash suits) does not have a facepiece as an integral part of the suit. A positive pressure self-contained breathing apparatus or air-line respirator is worn outside the suit, or an air-purifying respirator is used. Splash suits are of two types: a one-piece, "coverall" or a two piece, "pants and coat". Either type may include a hood and other accessories.

  Non-encapsulating suits are not designed to provide maximum protection against vapors, gases, or other airborne substances but against splashes. In effect, splash suits can be made (by taping wrist, ankle and neck joints) to totally enclose the wearer such that no part of the body is exposed but they still are not considered to be gas tight. They may be an acceptable substitute for a fully encapsulating suit if the concentration of airborne contamination is low and the material is not extremely toxic to the skin.

B. Protective Material

Chemical protective clothing also is classified based on the material from which it is made. All materials fall into two general categories, elastomers and non-elastomers.

- Elastomers: polymeric (plastic-like) materials, that after being stretched, return to about their original shape. Most protective materials are elastomers. These include: polyvinyl chloride, neoprene, polyethylene, nitrile, polyvinyl alcohol, viton, teflon, butyl rubber and others. Elastomers may be supported (layered on to cloth-like material) or unsupported.

- Non-elastomers: materials that do not have the quality of stretchability. Non-elastomers include tyvek, tyvek coated garments and other materials.

C. Single-Use

A third classification is single use or disposable garment. This classification is relative and based on cost, ease of decontamination and quality of construction. Disposable chemical protective clothing is commonly considered to be less than $25.00 per garment. In situations where decontamination is a problem, more expensive clothing may be considered disposable.

III. PERFORMANCE REQUIREMENTS FOR CHEMICAL PROTECTIVE CLOTHING

There are a number of performance requirements that must be considered in selecting the appropriate protective material. Their relative importance is determined by the particular work activity and site specific conditions.

- Chemical Resistance: The ability of a material to withstand chemical and physical change. A material's chemical resistance is the most important performance requirement. The material must maintain its structural integrity and protective qualities upon contact with a hazardous substance. This requirement is discussed in detail in Section IV.

- Durability: The ability to withstand wear. The ability to resist punctures, abrasions, and tears. The materials' inherent strength.

- Flexibility: The ability to bend or flex; pliable. It is extremely important both for glove and full-body suit materials, for it directly impacts the worker's mobility, agility, and range of motion.

- Temperature Resistance: The ability of a material to maintain its chemical resistance during temperature extremes (especially heat), and to remain flexible in cold weather. A general tendency for most materials is that higher temperatures reduce their chemical resistance; lower temperatures reduce flexibility.

- Service Life: The ability of a material to resist aging and deterioration. Factors such as chemicals, extreme temperatures, moisture, ultraviolet light, oxidizing agents, and others decrease a material's service life. Storage away from and proper care against these conditions can help prevent aging. Manufacturers should be consulted regarding any recommendations on a suit's shelf-life.

- Cleanability: The ability to effectively decontaminate protective materials. Cleanability is a relative measure of the ability of a material to release the contact substance. Some materials are nearly impossible to decontaminate, so it may be important to cover those materials with disposable garments to prevent gross contamination.

- Design: The way a suit is constructed which includes the general type and specific features it has. A variety of suit styles and features are manufactured including:

  - Fully encapsulating or non-encapsulating
  - One, two, or three piece suits
  - Hoods, facepieces, gloves, and boots (attached or unattached)
  - Location of zipper, buttons, storm flaps, and seams (front, side and back)
  - Pockets, cloth collars, and velcro straps
  - Exhalation valves or ventilation ports
  - Ease of compatibility with wearing respiratory protection

- Size: The physical dimensions or proportions of clothing. 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 for both men and women, however standard suit sizes for women are not available.

- Color: Brightly colored suit material make it easier to maintain visual contact between personnel. Suits of darker colors (black, green) absorb radiant heat from external sources and transfer it to the worker increasing heat related problems.

- Cost: The cost of chemical protective clothing varies considerably. Cost will often play a role in the selection and frequency of use of CPC. In many situations, less expensive, single use garments are more appropriate and as safe as more costly clothing. Other situations require high quality, costly clothing which may have to be discarded after limited use.

IV. CHEMICAL RESISTANCE

The effectiveness of materials to protect against chemicals is based on their resistance to penetration, degradation, and permeation. Each of these properties must be evaluated when selecting the style of chemical protective clothing and the material from which it is made. In choosing protective materials:

- There is no protective material that is impermeable.

- There is no one material that affords protection against all chemicals, and

- For certain contaminants and chemical mixtures there are no materials available that will protect for more than an hour after initial contact.

Penetration is the transport of chemicals through openings in a garment. A chemical may penetrate due to design or garment imperfections. Stitched seams, button holes, 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 selfsealing zippers, seams overlayed with tape, flap closures, and nonwoven fabrics. Rips, tears, punctures, or abrasions to the garment also allow penetration.

Degradation is a chemical action involving the molecular breakdown of the material due to chemical contact. Degradation is evidenced by physical changes to the material. The action 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.

Degradation test data for specific chemical or generic classes of chemical (**TABLE 7**) is available from product manufacturers, suppliers, or other sources. The published data provides the user with a general degradation resistance rating. The rating is subjectively expressed as excellent, good, fair, or poor. 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 on which degradation changes the rating is based.

Permeation is a chemical action involving the movement of chemicals, on a molecular level, through intact material. Permeation is a process which involves the sorption of the chemical on the outside surface, diffusion through, and desorption of the chemical from the inside surface of the protective material. A concentration gradient (high on the outside: low on the inside) is established. Because the tendency is to achieve concentration equilibrium, molecular forces "drive" the chemical into the material toward the area of no or lower concentration. Eventually the highest flow of permeating chemical exists and is referred to as the steady flow state.

Permeation is measured as a rate. Permeation rate is the quantity of chemical that will move through an area of protective material in a given time. It is usually expressed in micrograms of chemical permeated per square centimeter per minute of exposure ($ug/cm^2/min$). Several factors influence the rate of permeation including the type of material and thickness. A general rule of thumb is that the permeation rate is inversely proportional to the thickness (2 x thickness = 1/2 x permeation rate). Other important factors are chemical concentration, contact time, temperature, material grade, humidity, and solubility of the material in the chemical.

TABLE 7				
EFFECTIVENESS OF PROTECTIVE MATERIALS AGAINST CHEMICAL DEGRADATION (BY GENERIC CLASS)[1]				
Generic Class	**Butyl Rubber**	**Polyvinyl Chloride**	**Neoprene**	**Natural Rubber**
Alcohols	E	E	E	E
Aldehydes	E-G	G-F	E-G	E-F
Amines	E-F	G-F	E-G	G-F
Esters	G-F	P	G	F-P
Esters	G-F	G	E-G	G-F
Halogenated hydrocarbons	G-P	G-P	G-F	F-P
Hyrocarbons	F-P	F	G-F	F-P
Inorganic acids	G-F	E	E-G	F-P
Inorganic bases and salts	E	E	E	E
Ketones	E	P	G-F	E-F
Natural fats and oil	G-F	G	E-G	G-F
Organic acids	E	E	E	E

[1] E - Excellent F - Fair
G - Good P - Poor

Source: Survey of Personal Protective Clothing and Respiratory Apparatus. DOT, USCG, Office of Research and Development (September, 1974).of material and thickness. A general rule of thumb is that the permeation rate is inversely proportional to the thickness (2 x thickness = 1/2 x permeation rate). Other important factors are chemical concentration, contact time, temperature, material grade, humidity, and solubility of the material in the chemical.

Another measure of permeation is breakthrough time, expressed in minutes. Breakthrough is the elapsed time between initial contact of a chemical with the outside surface and detection at the inside surface of the material. 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 x thickness = 4 x break-through time).

Permeation and breakthrough test data is available from manufacturers which gives specific rates and times (**TABLE 8**). A given manufacturer's recommendations serve as a relative guideline to properly selecting their products. This data is obtained using the American

Society for Testing and Materials (ASTM) standard test method F739-81. Although ASTM has a standard method for permeation testing, considerable variation exists between manufacturer's test data. The differences are due to material thickness and grade, manufacturing processes, temperature, chemical concentrations, and analytical detection method. Therefore, caution should be used when comparing different manufacturers results. The results for the same material/chemical combination will differ considerably between manufacturers. ASTM also has test methods for penetration and degradation resistance.

The best protective material against a specific chemical is one that has a low permeation rate (if any) and a long breakthrough time. However, these properties do not always correlate. Compare propyl acetate **(TABLE 8)** and 1,1,1-trichloromethane against nitrile NBR or dimethyl sulfoxide and methyl alcohol against neoprene. As indicated, a long breakthrough time does not always correlate with a low permeation rate or vice versa. A long breakthrough time is usually desired.

The literature on material testing also notes that permeation rates and breakthrough times are not tested for those materials which receive a poor degradation rating; only breakthrough time is measured for those chemicals (especially corrosives) which are known to be direct skin hazards. The data also reflects the testing of pure substances and not mixtures.

In addition to the manufacturer's chemical resistance data, the best general reference for selection of CPC is Guidelines For The Selection Of Chemical Protective Clothing, ACGIH (1985). This reference compiles degradation and permeation test data from manufacturers, vendors, and independent laboratories with recommendations for over 300 chemicals.

Specific chemicals are rated against a variety of protective materials. The ratings (RR, rr, NN, nn) are based on two criteria; breakthrough times and vendor chemical resistance data. Each rating represents a combination of performance, number of sources confirming that performance, and consistency of the data. The number and size of the letters indicate this.

The available test data and recommendations for all chemical protective clothing is extremely limited in scope and use. The user must consider these restrictions when selecting CPC and use the guidelines in the way they were intended to be used.

TABLE 8
PERMEATION/DEGRADATION RESISTANCE FOR EDMONT GLOVES*

	NITRILE NBR			NEOPRENE			PVC		
	Degradation Rating	Permeation Break-through	Permeation Rate	Degradation Rating	Permeation Break-through	Permeation Rate	Degradation Rating	Permeation Break-though	Permeation Rate
Acetone	NR	-	-	G	5 min.	F	NR	3 hr.	-
Cellosolve Acetate	F	1.5 hr.	G	G	1.25 hr.	VG	NR	-	-
Dimethyl Solfoxide (DMSO)	E	<4 hr.	VG	E	ND	E	NR	-	-
Hydroflouric Acid, 48%	E	2 hr.	-	E	1 hr.	-	G	40 min.	-
Propyl Acetate	F	20 min.	G	P	-	-	NR	-	-
Toulene	F	10 min.	F	NR	-	-	NR	-	-
1,1,1-Trichloro-ethane	F	1.5 hr.	P	NR	-	-	NR	-	-

KEY TO PERMEATION RATE:			Simply Stated Drops Per Hour Through a Glove (Eyedropper size drop)
ND	-	None detected during a six hour test	None
E	-	Excellent; permeation rate of less than .09 ug/cm^2/min.	0 to 1/2 drop
VG	-	Very Good; permeation rate of less than 90 ug/cm^2/min.	1 to 5 drops
G	-	Good; permeation rate of less than 90 ug/cm^2/min.	6 to 50 drops
F	-	Fair; permeation rate of less than 900 ug/cm^2/min.	51 to 500 drops
P	-	Poor; permeation rate of less than 9000 ug/cm^2/min.	501 to 5000 drops
NR	-	Not Recommended; permeation rate greater than 9000 ug/cm^2/min.	5001 drops up

Note: The current revision to the ASTM standard permeation test calls for permeation to be reported in micrograms of chemical permeated per square centimeter of gamet exposed per minute of exposure, *ug/cm^2/min.*.

V. PROTECTIVE MATERIALS

There is a wide variety of protective materials. The following is a list cf the more common materials used in CPC segregated as elastomers or non-elastomers. The elastomers are not listed in any particular priority. The classes of chemicals rated as "good for" or "poor for" represent test data for both permeation breakthrough and permeation rate. They are general recommendations; there are many exceptions within each chemical class. Sources consulted for this information included Guidelines for the Selection of Chemical Protective Clothing (ACGIH, Vol. 1, 1985) and manufacturer's literature. The costs are recent estimates and are subject to change.

A. Elastomers

Butyl Rubber: (Isobutylene/Isoprene Copolymer)

Good for: bases and many organics
heat and ozone resistance decontamination

Poor for: aliphatic and aromatic hydrocarbons
gasoline
halogenated hydrocarbons abrasion resistance

Cost: Gloves - $10/pr.
Boots - $25/pr.
FES - $900 - $1,350

Chlorinated Polyethylene: (Cloropel, CPE)

Good for: aliphatic hydrocarbons
acids and bases
alcohols, phenols
abrasion and ozone

Poor for: amines, esters, ketones
halogenated hydrocarbons
cold temperature (becomes rigid)

Cost: splash suit - $60
FES - $600

Natural Rubber: (Polyisoprene)

Good for: alcohols
dilute acids and bases flexibility

Poor for: organic chemicals
aging (affected by ozone)

Cost: Gloves - $10-$15/doz.
Boot Covers - $5/pr.

Neoprene: (Chloroprene)

Good for: bases and dilute acids
peroxides
fuels and oils
aliphatic hydrocarbons
alcohols
glycols
phenols
abrasion and cut resistance

Poor for: halogenated hydrocarbons
aromatic hydrocarbons
ketones
concentrated acids

Cost: Gloves - $70/doz. (supported)
- $13/doz. (unsupported)
Boots - $35/pr.

Splash Suit - $40-$60

Nitrile Rubber:(Acrylonitrile rubber, Buna-N, NBR, hycar, paracril, krynac)

Good for: phenols
PCBs
oils and fuels
alcohols
amines
bases
peroxides
abrasion and cut resistance flexibility

Poor for: aromatic & halogenated hydrocarbons
amides
ketones
esters
cold temperature

Cost: Gloves - $2/pr.
Boots - $18/pr.

Note: The higher the acrylonitrile concentration, the better the chemical resistance; but also increases stiffness.

Polyurethane:

Good for: bases
aliphatic hydrocarbons
alcohols
abrasion resistance
flexibility - especially at cold temperatures

Poor for: halogenated hydrocarbons

Cost: Boots - $25/pr.
Splash Suit - $60

Polyvinyl Alcohol: (PVA)

Good for: almost all organics
ozone resistance

Poor for: esters
ethers
acids and bases
water and water solutions flexibility

Cost: Gloves - $13/pr.

Polyvinyl Chloride: (PVC)

Good for: acids and bases
some organics
amines, peroxides

Poor for: *most organic compounds*
cut and heat resistance decontamination

Cost: Gloves - $17-$25/doz. (outer)
- $6/doz. (inner)
Boots - $15/pr.

Splash Suit - $10-$30
One-pc. Suit - $55
FES - $300-$900

Viton:

Good for: aliphatic and aromatic hydrocarbons
halogenated hydrocarbons
acids
decontamination
physical properties

Poor for: aldehydes
ketones
esters (oxygenated solvents) amines

Cost: Gloves - $27/pr.
FES - $1,600-$3,300

Teflon: Teflon has become available for chemical protective suits. Limited permeation test data is published on teflon. Teflon, similar to viton, is thought to afford excellent chemical resistance against most chemicals. Teflon suits are relatively expensive ($2,000-$3,000).

Blends/Layers

CPC Manufacturers have developed a technique of layering materials to improve chemical resistance. Essentially one suit is designed with multiple layers. Some examples of layered fully encapsulating suits are viton/ butyl (Trelleborg), viton/neoprene (MSA Vautex and Draeger), and butyl/ neoprene (MSA Betex).

B. Non-Elastomers

Tyvek: (non-woven polyethylene fibers)

Good for: dry particulate and dust protection
decontamination (disposable) lightweight

Poor for: chemical resistance (penetration/
degradation) durability

Cost: Standard suit - $3-$5

Recommendations: Used against toxic particulates but provides no chemical protection; worn over other CPC to prevent gross contamination of non-disposable items and under suits to replace cotton.

Polyethylene: (coated tyvek)

Good for: acids and bases
alcohols
phenols
aldehydes
decontamination (disposable)
lightweight

Poor for: halogenated hydrocarbons
aliphatic and aromatic hydrocarbons physical properties
(durability) penetration (stitched seams)

Cost: Suit - $8-$10
Gloves - $1.50/box of 100 (disposable)
Booties - $13/box of 50 (disposable)

Recommendation: Provides limited chemical protection against concentrated liquids and vapors. Useful against low concentrations and those activities which do not create a high risk of splash; also worn over CPC to prevent gross contamination of non-disposables. The disposable poly considered "inner liners" and assist decontamination procedures.

Saranex: (laminated tyvek)

Good for: acids and bases
amines
some organics
PCBs
decontamination (disposable)
lightweight
durability

Poor for: halogenated hydrocarbons
aromatic hydrocarbons
stitched seams (penetration may occur)

Cost: Suit - $15
"OSHA" suit - $26

Recommendation: Provides greater chemical resistance and overall protection compared to polyethylene coated tyvek; used to prevent contamination of non-disposable clothing.

VI. SELECTING CHEMICAL PROTECTIVE CLOTHING

Selecting the most effective chemical protective clothing is easier when the chemical for which protection is necessary is known. Selection becomes more difficult when the presence of chemicals is unknown, multiple chemicals (known or unknown) are involved, or an unidentifiable substance is present. As uncertainties about the substances involved increases, selecting the proper clothing becomes more difficult.

Another major difficulty in selection is that there is not enough available information concerning the protective qualities of commonly used protective materials against the wide range of chemicals that could be encountered.

The selection process consists of:

- Deciding that workers must be in an environment where they could be exposed.
- Identifying the chemical involved and determining its physical, chemical, and toxicological properties.
- Deciding whether, at the concentrations known or expected, the substance is a skin hazard.
- Selecting protective material which provides the least permeation and degradation for the longest period of time.
- Determining whether a fully encapsulating suit or a non-encapsulating is required.

In those incidents where the presence of hazardous substances is not known or they can not be readily identified there are usually clues which can assist in choosing the style of clothing. Observations which could indicate wearing fully encapsulating suits are:

- visible emissions of gases, vapors, dust or smoke.
- indications of airborne hazards on direct-reading instruments.

- configurations of containers or vehicles which indicate they contain gases or pressurized liquids.

- signs, labels, placards, or bills of lading indicating substances that could become airborne and are toxic to the skin.

- enclosed, poorly ventilated areas where toxic vapors, gases and other airborne substances could accumulate.

- work functions required might expose workers to high concentrations of skin toxics.

Unknown situations require considerable judgement as to whether maximum protection to the skin (fully encapsulating clothing) is necessary, or whether splash suits are appropriate.

After determining the type of protective garment to be worn, the next step is to select the protective material. Vendors or manufacturers of materials used to make chemical protective materials can sometimes (but not always) supply information concerning their product's chemical resistance and make recommendations about what chemicals it is good for. The number of chemicals their product is tested against may be limited, for they can not test against the 1000's of chemicals that exist.

Permeation is the primary selection criteria. The best protective material against a specific chemical would be one that has a very low permeation rate (if any), and a long breakthrough time, and has been constructed free of design imperfections.

Less useful information is degradation. This is usually a qualitative determination of a materials ability to standup under the attack of a chemical, usually expressed in subjective units of excellent, good, poor, or similar terms. Degradation data can help in assessing the protective capability of a materials, if no other data is available.

However, a fabric with good degradation resistance may be very permeable to the same chemical. Permeation and degradation are not directly related and cannot be used interchangeably. In those situations where a protective material can not be chosen because of uncertainty of the attack substance, there are some reasonable options.

- Select a protective material which protects against the greatest range of chemicals. These are generally garments made from butyl rubber, viton, or teflon. Chemicals against which these materials (or other materials) do not provide protection could possibly be eliminated as not being present.

- Clothing made of multiple protective material could be used. Garments consisting of butyl-viton, neoprene-viton, and neoprene-butyl are manufactured. If not commercially available, two garments made of different material could be worn with a disposal type garment on the outside.

  Whether fully encapsulating or non-encapsulating clothing should be worn may not be self-evident. If based on an assessment of the situation it is determined that either style would provide effective protection other factors to consider would be:

- Ease in wearing: Non-encapsulating suits are easier to wear. Wearers are less prone to accidents for they have better visibility and the clothing is less cumbersome.

  Communications: It is more difficult to communicate in fully encapsulating suits.

- Decontamination: Fully encapsulating suits protect self-contained breathing apparatus, which are difficult to decontaminate, from being contaminated.

- Heat stress: Non-encapsulating clothing generally causes less heat stress. However as less area of the body is exposed by wearing gloves and hoods and taping hoods to respirator masks, there is little difference in the heat build-up of either style.

- Cost: Non-encapsulating garments are less expensive.

VII. PHYSICAL STRESS

Wearing chemical protective clothing can cause problems. These involve heat stress, accident proneness, and fatigue. The major problem is heat stress caused by protective clothing interfering with the body's ability to cool itself. Clothing that provides a barrier against chemicals contacting the skin, prevents the efficient dissipation of body heat. Evaporation, the body's primary cooling mechanism is reduced, since ambient air is not in contact with the skin's surface. Other heat exchange mechanisms (convection and radiation) are also impeded. Additional strain is put on the body as it attempts to maintain it's heat balance. This added stress can result in health effects ranging from transient heat fatigue to serious illness or death.

The smaller the area of the body exposed to the air, the greater the probability for heat stress. Fully encapsulating suits allow no ambient air to contact the skin's surfaces to aid in the evaporation of moisture. Heat in these suits builds up quickly. Splash suits may allow more body surface (head, neck, and hands) to be cooled by the air, but if those areas are covered by hoods, gloves and respirators and the joints taped, the same conditions will exist as if wearing a fully encapsulating suit. Heat-related problems become more common as the ambient temperature rises above 70'F., but can occur at much lower temperatures. Although wearing protective clothing establishes conditions that are conducive to heat-related illness, individuals vary in their susceptibility to heat stress and their ability to withstand high temperatures.

Accident proneness also increases when wearing chemical protective clothing. Suits are heavy, cumbersome, decrease mobility and dexterity, lessen visual and audio acuity, and increase physical exertion. The severity of the problems depend on the style of clothing worn. These negative qualities increase the risk of common accidental injury, for example slips, falls, or being struck.

Increased physical exertion caused by working in protective clothing can in itself cause problems. Worker performance may decrease due to increased fatigue levels. Other more serious illnesses such as stroke or heart attack could occur.

To minimize the adverse effects of physical stress, workers wearing protective clothing must change their normal work regimen. A medical surveillance program, including baseline physicals and routine medical monitoring, should be instituted. Personnel must be allowed to acclimatize to stressful environmental factors by varying work and rest periods as needed. Projects should be scheduled for cooler periods of the day when possible. The intake of fluids must be maintained at levels to prevent dehydration, and body electrolytes replaced through added salting at mealtimes. Compensatory efforts such as these must be established as part of Standard Operating Safety Procedures on a site-specific basis to reduce the risks associated with wearing protective clothing.

VIII. INSPECTION OF PROTECTIVE CLOTHING

Before wearing chemical protective clothing it must be properly inspected. The following is a checklist for visually inspecting all types of chemical protective suits. Chemical suits should be inspected immediately before use and monthly when not in use.

A. Inspection Procedures:

- Spread suit out on a flat surface.

- Examine the outside for the following:

  -- fabric for abrasions, cuts, holes, or tears
  -- fabric has retained the original flexibility and durability
  -- seams for separations, or holes
  -- zippers, buttons, storm flaps, and other connecting devices for proper sealing and operation
  -- signs of previous chemical attack or incomplete decontamination (unusual discoloration, rough surface, gummy feeling, cracks)
  -- elastic around wrists and ankles and the draw strings on hoods are in good condition (if applicable)

  Fully encapsulating suits require additional inspection which include (if applicable):

  -- Exhalation valves (positive pressure) for debris and proper functioning.
  -- Suit facepiece for poor visibility (cuts, scratches, dirt) and an adequate facepiece to suit seal.
  -- Presence and condition of waist belts, velcro adjustments (head and hips), and ankle straps.
  -- Condition of integral gloves, boots, and leg gaiters.
  -- Presence of hard hat or ratchet head suspension.
  -- Presence and condition of airline attachment and hoses for cooling system.
  -- Leak detection and pinholes.

1. If an air source is available, secure the suit and inflate it, then using a mild soap solution observe for bubbles on the surface or around seams, or

2. Inside a dark room, run a flashlight inside the suit and look for pinpoints of light from outside the suit.

3. OSHA 1910.120 Standard has an Appendix A attachment which outlines two test methods for evaluating the integrity of totally encapsulating chemical suits. One is an Air Pressure test and the other is an Ammonia Leak Test. These tests are non-mandatory under the standard.

   Records should be maintained on each suit's inspection, use conditions, and repair status. These records are especially important for fully encapsulating suits (FES) which are usually not individually assigned but shared. Suggestions for maintaining records include:

   1. Inspection - who, when,and any problems.

   2. Use conditions - where, activity, and chemicals if known.

   3. Repair status - what is the problem, who repaired it (in-house or manufacturer), date of repair, and tag the suit "out of service" if not repaired.

**Always refer to manufacturer recommendations for routine or any special inspection procedures.

IX. PERSONAL COOLING DEVICES

A. INTRODUCTION

Wearing chemical resistant clothing and respirators increases the risk for heat stress. They cause additional strain on the body by adding weight, increasing breathing resistance and restricting movement. They can also reduce the body's natural cooling mechanism. The body releases heat by convecting heat to cooler air, radiating heat to cooler surfaces in the surroundings, and evaporating moisture from the skin. Chemical resistant clothing interferes with these processes. This can lead to heat illness, heat fatigue, heat rash, heat cramps, heat syncope (fainting), heat exhaustion or even heat stroke. Methods used to prevent heat illness include frequent rest breaks, reduced work loads, increased consumption of fluids, acclimatization, and working during the cooler times of the day. Another method that is available is the use of personal cooling devices to remove heat from the user's body. These devices are divided into two types: those that use a coolant source external to the wearer (an umbilical system) or self-contained systems that are not connected to an outside source.

B. EXTERNAL COOLANT SYSTEMS

Devices using an external cooling source need a connection between the wearer and the coolant source. The coolant can be compressed air or a liquid.

1. Compressed air systems

Compressed air systems use cool, dry air to aid in cooling the body. Generally the air is distributed to the ankles, wrists, and head by an arrangement of air tubes worn on the body or attached to the protective clothing **(FIGURE 7)**. Some systems can be found in the form of a hood or vest. Many manufacturers of fully encapsulating suits have air distribution systems built into their suits.

The air is delivered to the units comes from a compressor or a large compressed air container (like a cascade system). The air acts as an insulator from external heat and increases evaporation of sweat because of the constant flow of dry air. If additional cooling is needed, a vortex cooler to chill the air can be connected into the airline at the user's end. The vortex cooler **(FIGURE 8)** takes compressed air, increases its velocity, directs it into an outer "hot" tube, and forms a vortex. The air spirals down the tube and a fraction escapes through a valve in the end. The remaining air forms a second vortex which passes through the center of the outer vortex -flowing in the opposite direction - and exits from the "cold" tube. The outer vortex takes heat from the inner vortex. How much heat is transferred is determined by how much air the valve releases; more hot air out, more cold air to user. The vortex cooler is attached to a belt or other support. It must be worn on the outside of any protective clothing so that the heat can be vented.

It is important to remember that NIOSH does not have a specific testing and certification schedule for supplied air suits. Thus, the suits should not be used for respiratory protection. Some suits and hoods have a NIOSH/MSHA respiratory approval under the SCBA or airline testing schedules. If a vortex tube is used with a unit for respirator protection, then the respirator must be tested and approved with the vortex tube.

Compressed air systems have two advantages. They are able to cool the whole body and they allow the wearer to work as long as desired. However, they have several disadvantages. They restrict mobility because of the airline umbilical. Since the system is continuous flow, they use a lot of air - especially if using a vortex cooler. One unit with a vortex cooler uses 25 cubic feet of air per minute to deliver 15 cubic feet of useable air to the wearer. A normal airline respirator uses 6 - 8 cubic feet per minute. Also, the hot air from the vortex tube - as hot as 162 F - can add heat to the environment or to the outside surface of the protective clothing.

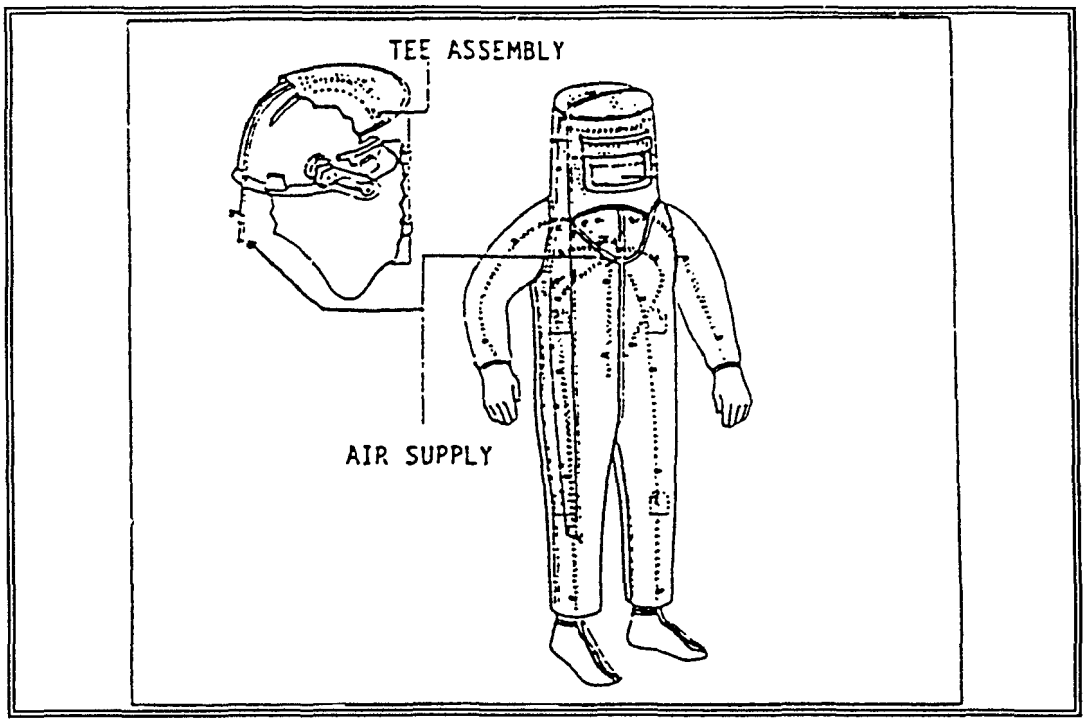

FIGURE 7
FULLY ENCAPSULATING SUIT WITH AIR DISTRIBUTION SYSTEM

Used with permission of Mine Safety Appliances, Pittsburgh, PA.

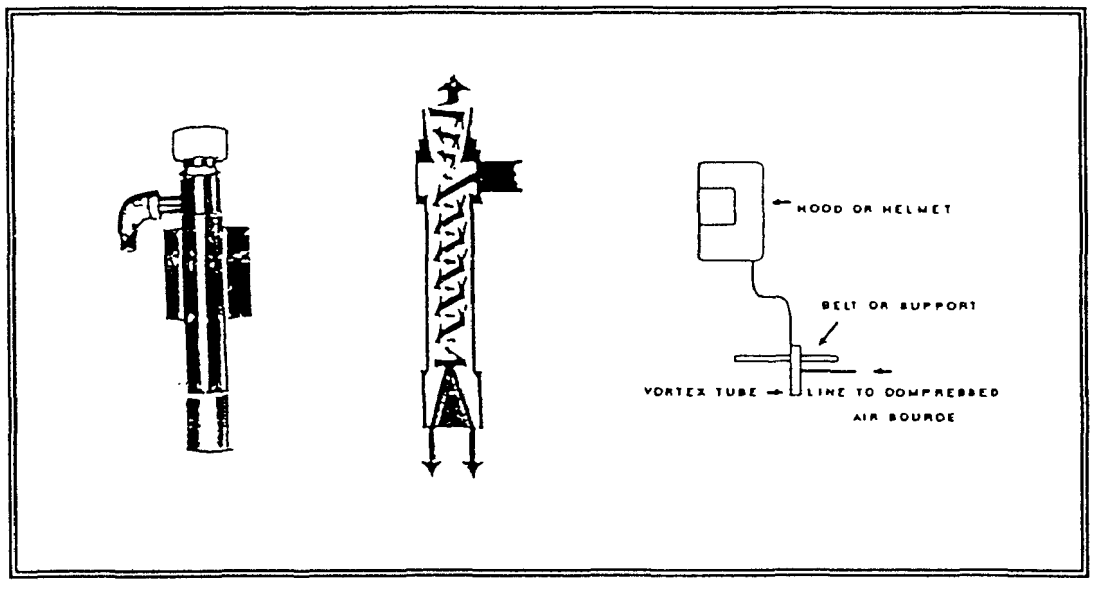

FIGURE 8

VORTEX TUBE; SCHEMATIC OF VORTEX TUBE; VORTEX TUBE CONNECT TO AIR-SUPPLIED HOOD

Used with permission of Fyrepel Products, Inc., Newark, OH.

2. LIQUID-COOLED DEVICES

There is only one device in this category. Water is circulated through tubing in a garment resembling long johns. It can use an external water supply - which can be chilled - or a portable chilling unit for recirculated water.

This unit has the same advantages and disadvantages of the air-supplied systems. It has additional disadvantages. There is additional weight due to the water in the system. At the present, fully encapsulating suits do not have liquid line connections. One advantage is that the cooling system can be located away from the user and thus not add heat to the user's immediate area.

C. SELF-CONTAINED SYSTEMS

Self-contained systems have all of the heat exchanging elements as part of the wearer's ensemble. Thus, they are not hooked to an outside coolant source. These systems are usually of two types - those that use ice to cool the wearer and those that circulated a liquid cooled by a heat exchange system.

1. Ice Vests/Jackets

These systems use ice in a vest/jacket or in removable packets. The size and number of packets vary form manufacturer to manufacturer. Some systems come with a inner vest to prevent direct contact with the skin. Some have an outer vest to reduce external heat effects on the ice. (See **FIGURE 9**)

These systems have several advantages. They are simple to use, have no moving parts, and do not restrict mobility. They can be worn under protective clothing or an SCBA. They also have disadvantages. They are usually limited to a maximum of 1 hour of cooling. If more time is needed, extra packets are needed. If the unit has no removable packets, the whole vest has to be refrozen. After the ice melts, the wearer is carrying extra weight with no cooling benefit. They weigh from 12 to 15 pounds. If there is no inner insulation, they may be too cold.

2. Circulating Systems

Circulating systems use a water or a water/alcohol mixture circulated through the vest to cool the wearer. The liquid is cooled by ice or other frozen liquid contained in a pouch or container carried by the wearer (see **FIGURE 10**). In some cases, the melting ice becomes part of the circulating system. There are a couple of experimental models that use dry ice to cool the circulating liquid.

The circulating systems have some of the same advantages and disadvantages as the ice vests. They have the additional disadvantage of using an electric circulator. This requires battery pack to power the circulator. Thus, more weight is added. Also, while the units have waterproof and sparkproof connections, none have received an inherent safety rating. Their main

advantage is that the cooling rate can be controlled by controlling the flow of the liquid through the vest. They can be worn under protective clothing and a SCBA. There is one model that is incorporated into a fully encapsulating suit. The ice can be replenished without removing the suit.

D. CONCLUSION

There are many different types of personal cooling devices. At the end of this section is a list of manufacturers and the types they make. When selecting a unit, one main consideration is whether it is compatible with the other protective equipment worn. Mobility, weight and duration of use must also be considered. Worker acceptance is also an important consideration. Whatever device is used, it must be remembered that the device reduces but doesn't eliminate the heat stress.

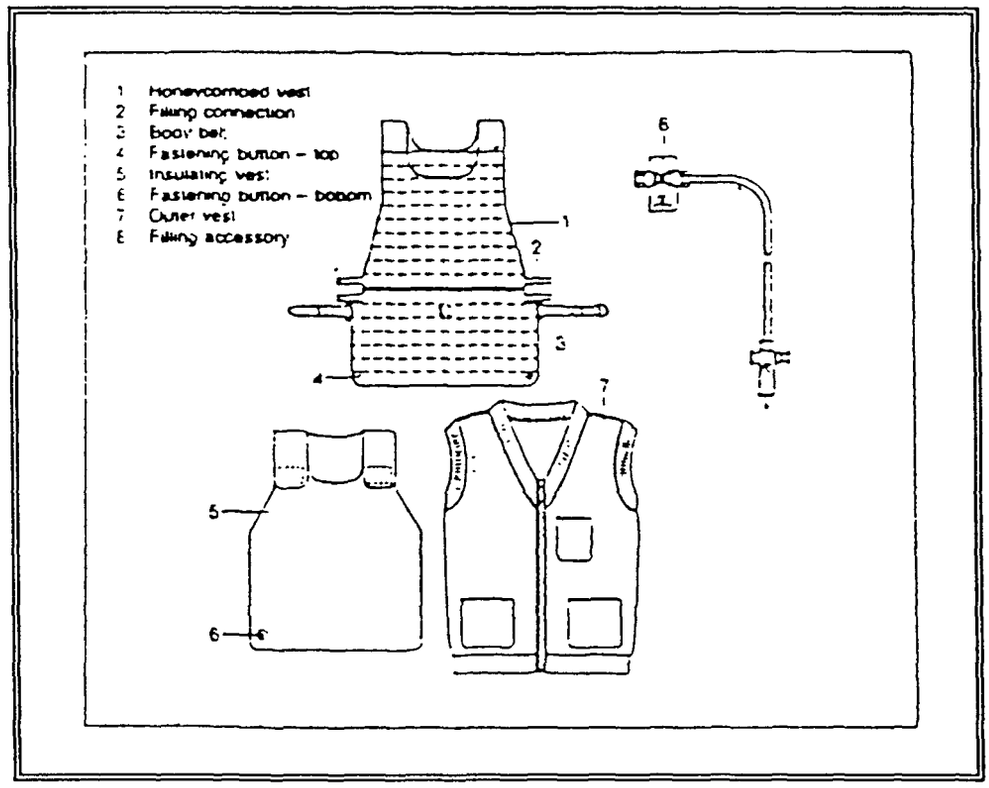

FIGURE 9

WATER FILLED ICE VEST

(Whole jacket is frozen prior to use) Used with permission of National Draeger, Pittsburgh, PA.

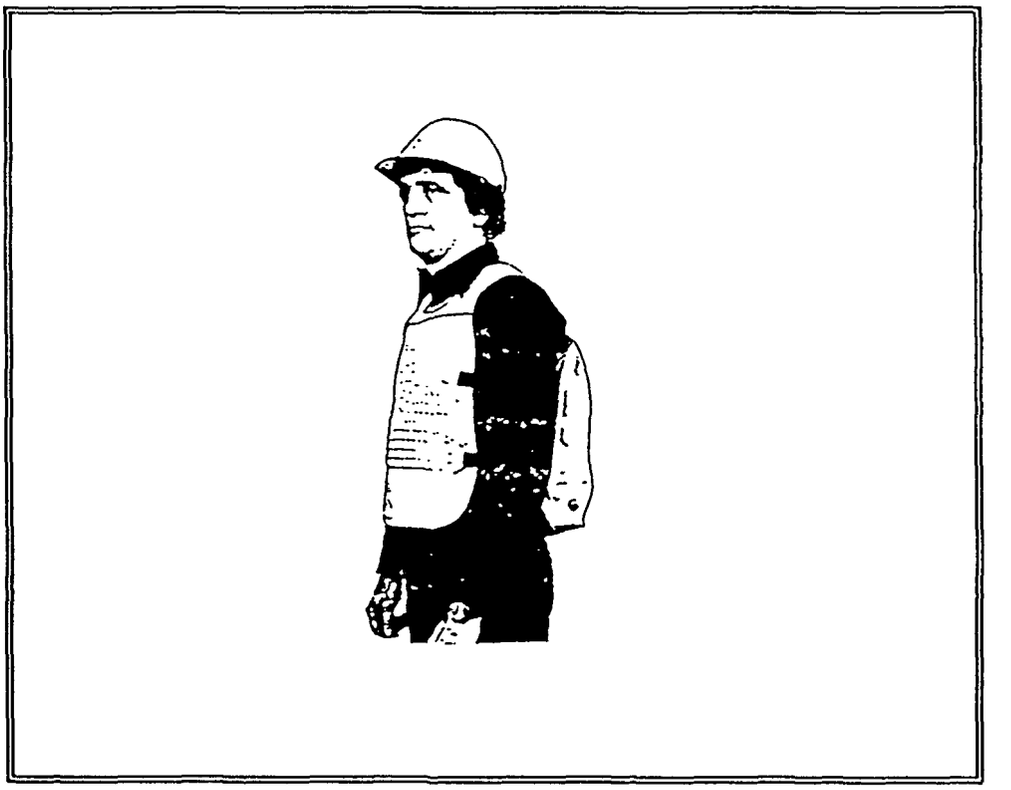

FIGURE 10
COOL VEST® Model 19.

(The back of unit has battery operated pump and pouch containing ice and circulating water) Used with permission of ILC Dover, Frederica, DE.

X. MANUFACTURERS AND SUPPLIERS OF PERSONAL COOLING DEVICES*

KEY:
A = airline cooling system
C = self contained circulating vest
W = water line cooling system
I = ice vest
V = vortex cooler

Encon Manufacturing Co.
13333 Northwest Freeway
Houston, TX 77040
713/462-4723
(A)

Fyrepel Products Inc.
P.O. Box 518
Newark, OH 43055
614/344-0391
(V, I)

ILC Dover
P.O. Box 26
Frederica, DE 19946
302/335-3911
(A, C, V, W)

Life Support Systems Inc.
1400 Stierlin Road
Mountain View, CA 94043
415/962-9800
(C)

Mine Safety Appliances
600 Penn Center Boulevard
Pittsburgh, PA 15235
412/273-5000
1-800-MSA-2222
(A, I)

National Draeger, Inc.
401 Parkway View Drive
Pittsburgh, PA 15205
412/787-8383
(I)

Racal Health & Safety, Inc.
Racal Airstream Division
7309 Grove Road, Frederick, MD 21701
301/695-8200
800/682-9500
(V)

Standard Safety Equipment (StaSafe)
431 North Quentin Road
Palatine, IL 60067
312/359-1400
(A)

Steele Incorporated
First and Washington
P.O. Box 7304
Kingston, WA 98346
206/297-4555
(I)

3M
220-7W
St. Paul, MN 55144
612/733-6234
(V)

Trusafe
9369 8th Avenue South
Seattle, WA 98108
206/762-7407
(I)

Wheeler Protective Apparel, Inc.
4330 W. Belmont
Chicago, IL 60641
312/685-5551
(A)

***Mention of a particular manufacturer or product does not imply endorsement by the U.S. Environmental Protection Agency. Omission of a manufacturer or product is not intentional.**

APPENDIX I

PERMEATION REFERENCES

1. Development of Performance Criteria for Protective Clothing Used Against Carcinogenic Liquids. NIOSH, Technical Report No. 79-106. NTIS.

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6. Nelson, G. O. and C. M. Wong. "Glove Permeation by Organic Solvents". Amer. Ind. Hyg. Assoc. J., 42:217-225 (1981).

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9. Weeks, R. W. Jr., and B. J. Dean. "Permeation of Methanolic Aromatic Amine Solutions through Commercially Available Glove Materials". Amer. Ind. Hyg. Assoc. J., 38:721-725 (1977).

10. Weeks, R. W. Jr., and M. J. McLeod. "Permeation of Protective Garment Material by Liquid Benzene and by Tritiated Water". Amer. Ind. Hyg. Assoc. J., 43:201-211 (1982).

11. Williams, J. R. "Permeation of Glove Materials by Physiologically Harmful Chemicals". Amer. Ind. Hyg. Assoc. J., 40:877-882 (1979).

APPENDIX II

DONNING AND DOFFING OF THE FULLY ENCAPSULATING SUIT

I. INTRODUCTION

In responding to episodes involving hazardous substances, it may be necessary for response personnel to wear self-contained breathing apparatus (SCBA) and fully encapsulating suits to protect against toxic environments. Donning/Doffing of both is a relatively simple task, but a routine must be established and practiced frequently. Not only do correct procedures help instill confidence in the wearer, they reduce the risk of exposure and the possiblity of damage to the suit. It is especially important to remove the equipment systematically so as to prevent or minimize the transfer of contaminants from suit to wearer.

The following procedures for donning/doffing apply to certain types of suits. They should be modified if a different suit or extra boots and gloves are worn. These procedures also assume that:

- The wearer has been trained in the SCBA.
- SCBA has been checked out.
- Appropriate decontamination steps have been taken prior to removal of the suit or other components.
- Sufficient air is available for routine decontamination and doffing of suit.

Donning/doffing an encapsulating suit is more difficult if the user has to do it alone because of the physical effort required. Also the possibility of wearer exposure to contaminants or damaging the suit greatly increases. Therefore, assistance is needed in donning/doffing the equipment.

II. DONNING

A. Before donning suit, thoroughly inspect for deficiencies that will decrease its effectiveness as the primary barrier for protecting the body. Do not use any suit with holes, rips, malfunctioning closures, cracked masks, etc. If suit contains a hoodpiece, or a hard hat is worn, adjust it to fit user's head. If suit has a back enclosure for changing air bottles, open it.

B. Use a moderate amount of talcum powder or cornstarch to prevent chafing and increase comfort. Both also reduce rubber binding.

C. Use antifog on suit and mask facepieces.

D. While sitting (preferably), step into legs, place feet properly, and gather suit around waist.

E. While sitting (preferably), put on chemical-resistant, steel toe and shank boots over feet of suit. Properly attach and affix suit leg over top of boot.

1. For one-piece suits with heavy-soled protective feet, wear leather or short rubber safety boots inside suit.

2. Wear an additional pair of disposable boot protectors if necessary.

F. Put on SCBA airtank and harness assembly. Don facepiece and adjust it securely yet comfortably. Do not connect breathing hose. Open valve to air tank. (The air tank and harness assembly could also be put on before stepping into legs of suit).

G. Depending on type of suit:

1. Put on inner gloves.

2. For suits with detachable gloves, secure gloves to sleeves, if this has not been done prior to entering the suit. (In some cases, extra gloves are worn over suit gloves).

H. While standing, put arms into sleeves, and then head into hood of suit. The helper pulls suit up and over SCBA, resting hood on top of SCBA, adjusting suit around SCBA backpack and user's shoulders to assure unrestricted motion. To facilitate entry into the suit, bend at the knees as hood is placed over wearer's head. Avoid bending at the waist, as this motion tends to use up room in the suit rather that provide slack. For a tall or stout person, it is easier to put on the hood of the suit before getting into the sleeves.

I. Begin to secure suit by closing all fasteners until there is only room to connect the breathing hose. Also, secure all belts and/or adjustable leg, head, and waist bands. Connect breathing hose while opening main valve.

J. When breathing properly in SCBA, complete closing suit.

K. Helper should observe for a time to assure that wearer is comfortable and equipment is functioning properly.

III. DOFFING

Exact procedures must be established and followed to remove the fully encapsulating suit and SCBA. Adherence to these procedures is necessary to minimize or prevent contamination (or possible contamination) of the wearer through contacting the outside surface of the suit.

The following procedures assume that before the suit is removed, it has been properly decontaminated, considering the type and extent of contamination, and that a suitably attired helper is available.

A. Remove any extraneous or disposable clothing, boot covers, or gloves.

B. If possible, wearer kicks off chemical-resistant boots unassisted. To achieve this, oversized boots are often selected. Otherwise, helper loosens and removes chemical-resistant boots.

C. Helper opens front of suit to allow access to SCBA regulator. As long as there is sufficient air pressure, hose is not disconnected.

D. Helper lifts hood of the suit over wearer's head and rests hood on top of SCBA air tank. For a tall or stout person it is easier to remove the arms from the sleeves of the suit prior to removing the hood.

E. Remove external gloves.

F. To minimize contact with contaminated clothing, helper touches only the outside of the suit, and the wearer touches only the inside. Remove arms, one at a time, from suit. Helper lifts suit up and away from SCBA back pack, avoiding any contact between outside surface of suit and wearer's body. Helper lays suit out flat behind wearer.

G. While sitting (preferably), remove both legs from suit.

H. After suit is completely removed, roll internal gloves off hands, inside out.

I. Walk to clean area and follow procedure for doffing SCBA.

J. Remove inner clothing, clean body thoroughly.

IV. ADDITIONAL CONSIDERATIONS

A. If work is at a very dirty site or the potential for contamination is extremely high, wear disposable Tyvek or PVC coveralls over fully encapsulating suit. Make a slit in back to fit around bulge of the SCBA back pack.

B. Wear clothing inside the suit appropriate to outside temperatures. Even in hot weather, wear long cotton underwear, which absorbs perspiration and acts as a wick for evaporation, thus aiding body cooling. Long underwear also protects skin from contact with hot surface of suit, reducing the possibility of burns in hot weather.

C. Monitor wearer for heat stress.

D. If a cooling device is used, modify donning/doffing procedure.

E. If low-pressure warning alarm sounds signifying approximately 5 minutes of air remaining, follow these procedures:

1. Quickly hose off suit and scrub especially around entrance/exit zipper. (Remove any disposable clothing.)

2. Open zipper sufficiently to allow access to regulator and breathing hose.

3. Disconnect breathing hose from regulator as main valve is closed.

4. Immediately attach canister for vapor, acid gas, dust, mist, or fume to breathing hose. This provides protection against contaminants still present.

5. Continue doffing suit as in steps A through J of previous section. Take extra care to avoid contaminating helper and wearer.

SECTION 5

PERSONNEL PROTECTION EQUIPMENT

PART 7

OSHA Regulations for Personal Protective Equipment

29 CFR 1910.132	41 CFR 50-204.7 General Requirements for Personal Protective Equipment
29 CFR 1910.133 (a)	ANSI Z87.1-1968 Eye and Face Protection
29 CFR 1910.134	ANSI Z88.2-1969 Standard Practice for Respiratory Protection
29 CFR 1910.135	ANSI Z89.1-1969 Safety Requirements for Industrial Head Protection
10 CFR 1910.136	ANSI Z41.1-1967 Men's Safety Toe Footwear

ANSI - American National Standards Institute
1430 Broadway
New York, NY 10018

PART 1910

OCCUPATIONAL SAFETY AND HEALTH STANDARDS

SUBPART I—PERSONAL PROTECTIVE EQUIPMENT

1910.132 General requirements.
1910.133 Eye and face protection.
1910.134 Respiratory protection.
1910.135 Occupational head protection.
1910.136 Occupational foot protection.
1910.137 Electrical protective devices.
1910.138 Additional delay in effective date.
1910.139 Sources of standards.
1910.140 Standards organizations.

SUBPART I—PERSONAL PROTECTIVE EQUIPMENT

1910.132—GENERAL REQUIREMENTS INTERP

(a) Application.

Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.

(b) Employee-owned equipment.

Where employees provide their own protective equipment, the employer shall be responsible to assure its adequacy, including proper maintenance, and sanitation of such equipment.

(c) Design.

All personal protective equipment shall be of safe design and construction for the work to be performed.

1910.133—EYE AND FACE PROTECTION

(a) General.

(1) Protective eye and face equipment shall be required where there is a reasonable probability of injury that can be prevented by such equipment. In such cases, employers shall make conveniently available a type of protector suitable for the work to be performed, and employees shall use such protectors. No unprotected person shall knowingly be subjected to a hazardous environmental condition. Suitable eye protectors shall be provided where machines or operations present the hazard of flying objects, glare, liquids, injurious radiation, or a combination of these hazards.

(2) Protectors shall meet the following minimum requirements:

(i) They shall provide adequate protection against the particular hazards for which they are designed.

(ii) They shall be reasonably confortable when worn under the designated conditions.

(iii) They shall fit snugly and shall not unduly interfere with the movements of the wearer.

(iv) They shall be durable.

(v) They shall be capable of being disinfected.

(vi) They shall be easily cleanable.

(vii) Protectors should be kept clean and in good repair.

(3) Persons whose vision requires the use of corrective lenses in spectacles, and who are required by this standard to wear eye protection, shall wear goggles or spectacles of one of the following types:

(i) Spectacles whose protective lenses provide optical correction.

(ii) Goggles that can be worn over corrective spectacles without disturbing the adjustment of the spectacles.

(iii) Goggles that incorporate corrective lenses mounted behind the protective lenses.

(4) Every protector shall be distinctly marked to facilitate identification only of the manufacturer.

(5) When limitations or precautions are indicated by the manufacturer, they shall be transmitted to the user and care taken to see that such limitations and precautions are strictly observed.

(6) Design, construction, testing, and use of devices for eye and face protection shall be in accordance with American National Standard for Occupational and Educational Eye and Face Protection, Z87.1-1968.

1910.134—RESPIRATORY PROTECTION

(a) Permissible practice.

(1) In the control of those occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, the primary objective shall be to prevent atmospheric contamination. This shall be accomplished as far as feasible by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to the following requirements.

(2) Respirators shall be provided by the employer when such equipment is necessary to protect the health of the employee. The employer shall provide the respirators which are applicable and suitable for the purpose intended. The employer shall be responsible for the establishment and maintenance of a respiratory protective program which shall include the requirements outlined in paragraph (b) of this section.

(3) The employee shall use the provided respiratory protection in accordance with instructions and training received.

(b) Requirements for a minimal acceptable program.

(1) Written standard operating procedures governing the selection and use of respirators shall be established.

(2) Respirators shall be selected on the basis of hazards to which the worker is exposed.

(3) The user shall be instructed and trained in the proper use of respirators and their limitations.

(4) Removed

(5) Respirators shall be regularly cleaned and disinfected. Those used by more than one worker shall be thoroughly cleaned and disinfected after each use.

(6) Respirators shall be stored in a convenient, clean, and sanitary location.

(7) Respirators used routinely shall be inspected during cleaning. Worn or deteriorated parts shall be replaced. Respirators for emergency use such as self-contained devices shall be thoroughly inspected at least once a month and after each use.

(8) Appropriate surveillance of work area conditions and degree of employee exposure or stress shall be maintained.

(9) There shall be regular inspection and evaluation to determine the continued effectiveness of the program.

(10) Persons should not be assigned to tasks requiring use of respirators unless it has been determined that they are physically able to perform the work and use the equipment. The local physician shall determine what health and physical conditions are pertinent. The respirator user's medical status should be reviewed periodically (for instance, annually).

(11) Approved or accepted respirators shall be used when they are available. The respirator furnished shall provide adequate respiratory protection against the particular hazard for which it is designed in accordance with standards established by competent authorities. The U.S. Department of Interior, Bureau of Mines, and the U.S. Department of Agriculture are recognized as such authorities. Although respirators listed by the U.S. Department of Agriculture continue to be acceptable for protection against specified pesticides, the U.S. Department of the Interior, Bureau of Mines, is the agency now responsible for testing and approving pesticide respirators.

(c) Selection of respirators.

Proper selection of respirators shall be made according to the guidance of American National Standard Practices for Respiratory Protection Z88.2-1969.

(d) Air quality.

(1) Compressed air, compressed oxygen, liquid air, and liquid oxygen used for respiration shall be of high purity. Oxygen shall meet the requirements of the United States Pharmacopoeia for medical or breathing oxygen. Breathing air shall meet at least the requirements of the specification for Grade D breathing air as described in Compressed Gas Association Commodity Specification G-7.1-1966. Compressed oxygen shall not be used in supplied-air respirators or in open circuit self-contained breathing apparatus that have previously used compressed air. Oxygen must never be used with air line respirators.

(2) Breathing air may be supplied to respirators from cylinders or air compressors.

(i) Cylinders shall be tested and maintained as prescribed in the Shipping Container Specification Regulations of the Department of Transportation (49 CFR Part 178).

(ii) The compressor for supplying air shall be equipped with necessary safety and standby devices. A breathing air-type compressor shall be used. Compressors shall be constructed and situated so as to avoid entry of contaminated air into the system and suitable in-line air purifying sorbent beds and filters installed to further assure breathing air quality. A receiver of sufficient capacity to enable the respirator wearer to escape from a contaminated atmosphere in event of compressor failure, and alarms to indicate compressor failure and overheating shall be installed in the system. If an oil-lubricated compressor is used, it shall have a high-temperature or carbon monoxide alarm, or both. If only a high-temperature alarm is used, the air from the compressor shall be frequently tested for carbon monoxide to insure that it meets the specifications in subparagraph (1) of this paragraph.

(3) Air line couplings shall be incompatible with outlets for other gas systems to prevent inadvertent servicing of air line respirators with nonrespirable gases or oxygen.

(4) Breathing gas containers shall be marked in accordance with American National Standard Method of Marking Portable Compressed Gas Containers to Identify the Material Contained, Z48.1-1954; Federal Specification BB-A-1034a, June 21, 1968, Air, Compressed for Breathing Purposes; or Interim Federal Specification GG-B-00675b, April 27, 1965, Breathing Apparatus, Self-Contained.

(e) Use of respirators.

(1) Standard procedures shall be developed for respirator use. These should include all

information and guidance necessary for their proper selection, use, and care. Possible emergency and routine uses of respirators should be anticipated and planned for.

(2) The correct respirator shall be specified for each job. The respirator type is usually specified in the work procedures by a qualified individual supervising the respiratory protective program. The individual issuing them shall be adequately instructed to insure that the correct respirator is issued.

(3) Written procedures shall be prepared covering safe use of respirators in dangerous atmospheres that might be encountered in normal operations or in emergencies. Personnel shall be familiar with these procedures and the available respirators.

(i) In areas where the wearer, with failure of the respirator, could be overcome by a toxic or oxygen-deficient atmosphere, at least one additional man shall be present. Communications (visual, voice, or signal line) shall be maintained between both or all individuals present. Planning shall be such that one individual will be unaffected by any likely incident and have the proper rescue equipment to be able to assist the other(s) in case of emergency.

(ii) When self-contained breathing apparatus or hose masks with blowers are used in atmospheres immediately dangerous to life or health, standby men must be present with suitable rescue equipment.

(iii) Persons using air line respirators in atmospheres immediately hazardous to life or health shall be equipped with safety harnesses and safety lines for lifting or removing persons from hazardous atmospheres or other and equivalent provisions for the rescue of persons from hazardous atmospheres shall be used. A standby man or men with suitable self-contained breathing apparatus shall be at the nearest fresh air base for emergency rescue.

(4) Respiratory protection is no better than the respirator in use, even though it is worn conscientiously. Frequent random inspections shall be conducted by a qualified individual to assure that respirators are properly selected, used, cleaned, and maintained.

(5) For safe use of any respirator, it is essential that the user be properly instructed in its selection, use, and maintenance. Both supervisors and workers shall be so instructed by competent persons. Training shall provide the men an opportunity to handle the respirator, have it fitted properly, test its face-piece-to-face seal, wear it in normal air for a long familiarity period, and, finally, to wear it in a test atmosphere.

(i) Every respirator wearer shall receive fitting instructions including demonstrations and practice in how the respirator should be worn, how to adjust it, and how to determine if it fits properly. Respirators shall not be worn when conditions prevent a good face seal. Such conditions may be a growth of beard, sideburns, a skull cap that projects under the facepiece, or temple pieces on glasses. Also, the absence of one or both dentures can seriously affect the fit of a facepiece. The worker's diligence in observing these factors shall be evaluated by periodic check. To assure proper protection, the facepiece fit shall be checked by the wearer each time he puts on the respirator. This may be done by following the manufacturer's facepiece fitting instructions.

(ii) Providing respiratory protection for individuals wearing corrective glasses is a serious problem. A proper seal cannot be established if the temple bars of eye glasses extend through the sealing edge of the full facepiece. As a temporary measure, glasses with short temple bars or without temple bars may be taped to the wearer's head. Wearing of contact lenses in contaminated atmospheres with a respirator shall not be allowed. Systems have been developed for mounting correc-

tive lenses inside full facepieces. When a workman must wear corrective lenses as part of the facepiece, the facepiece and lenses shall be fitted by qualified individuals to provide good vision, comfort, and a gas-tight seal.

(iii) If corrective spectacles or goggles are required, they shall be worn so as not to affect the fit of the facepiece. Proper selection of equipment will minimize or avoid this problem.

(f) Maintenance and care of respirators.

(1) A program for maintenance and care of respirators shall be adjusted to the type of plant, working conditions, and hazards involved, and shall include the following basic services:

(i) Inspection for defects (including a leak check),

(ii) Cleaning and disinfecting,

(iii) Repair,

(iv) Storage

Equipment shall be properly maintained to retain its original effectiveness.

(2)

(i) All respirators shall be inspected routinely before and after each use. A respirator that is not routinely used but is kept ready for emergency use shall be inspected after each use and at least monthly to assure that it is in satisfactory working condition.

(ii) Self-contained breathing apparatus shall be inspected monthly. Air and oxygen cylinders shall be fully charged according to the manufacturer's instructions. It shall be determined that the regulator and warning devices function properly.

(iii) Respirator inspection shall include a check of the tightness of connections and the condition of the facepiece, headbands, valves, connecting tube, and canisters. Rubber or elastomer parts shall be inspected for pliability and signs of deterioration. Stretching and manipulating rubber or elastomer parts with a massaging action will keep them pliable and flexible and prevent them from taking a set during storage.

(iv) A record shall be kept of inspection dates and findings for respirators maintained for emergency use.

(3) Routinely used respirators shall be collected, cleaned, and disinfected as frequently as necessary to insure that proper protection is provided for the wearer. Respirators maintained for emergency use shall be cleaned and disinfected after each use.

(4) Replacement or repairs shall be done only by experienced persons with parts designed for the respirator. No attempt shall be made to replace components or to make adjustment or repairs beyond the manufacturer's recommendations. Reducing or admission valves or regulators shall be returned to the manufacturer or to a trained technician for adjustment or repair.

(5)

(i) After inspection, cleaning, and necessary repair, respirators shall be stored to protect against dust, sunlight, heat, extreme cold, excessive moisture, or damaging chemicals. Respirators placed at stations and work areas for emergency use should be quickly accessible at all times and should be stored in compartments built for the purpose. The compartments should be clearly marked. Routinely used respirators, such as dust respirators, may be placed in plastic bags. Respirators should not be stored in such places as lockers or tool boxes unless they are in carrying cases or cartons.

(ii) Respirators should be packed or stored so that the facepiece and exhalation valve will rest in a normal position and function will not be impaired by the elastomer setting in an abnormal position.

(iii) Instructions for proper storage of emergency respirators, such as gas masks and self-contained breathing apparatus, are found in "use and care" instructions usually mounted inside the carrying case lid.

(g) Identification of gas mask canisters.

(1) The primary means of identifying a gas mask canister shall be by means of properly worded labels. The secondary means of identifying a gas mask canister shall be by a color code.

(2) All who issue or use gas masks falling within the scope of this section shall see that all gas mask canisters purchased or used by them are properly labeled and colored in accordance with these requirements before they are placed in service and that the labels and colors are properly maintained at all times thereafter until the canisters have completely served their purpose.

(3) On each canister shall appear in bold letters the following:

(i)

Canister for .....
(Name for atmospheric contaminant)
or
Type N Gas Mask Canister

(ii) In addition, essentially the following wording shall appear beneath the appropriate phase on the canister label: "For respiratory protection in atmospheres containing not more than ..... percent by volume of ...."

(4) Canisters having a special high-efficiency filter for protection against radionuclides and other highly toxic particulates shall be labeled with a statement of the type and degree of protection afforded by the filter. The label shall be affixed to the neck end of, or to the gray stripe which is around and near the top of, the canister. The degree of protection shall be marked as the percent of penetration of the canister by a 0.3-micron-diameter dioctyl phthalate (DOP) smoke at a flow rate of 85 liters per minute.

(5) Each canister shall have a label warning that gas masks should be used only in atmospheres containing sufficient oxygen to support life (at least 16 percent by volume), since gas mask canisters are only designed to neutralize or remove contaminants from the air.

(6) Each gas mask canister shall be painted a distinctive color or combination of colors indicated in Table I–1. All colors used shall be such that they are clearly identifiable by the user and clearly distinguishable from one another. The color coating used shall offer a high degree of resistance to chipping, scaling, peeling, blistering, fading, and the effects of the ordinary atmospheres to which they may be exposed under normal conditions of storage and use. Appropriately colored pressure sensitive tape may be used for the stripes.

TABLE I-1

Atmospheric contaminants to be protected against	*Colors assigned**
Acid gases	White.
Hydrocyanic acid gas	White with ½-inch green stripe completely around the canister near the bottom.
Chlorine gas	White with ½-inch yellow stripe completely around the canister near the bottom.
Organic vapors	Black.
Ammonia gas	Green.
Acid gases and ammonia gas	Green with ½-inch white stripe completely around the canister near the bottom.
Carbon monoxide	Blue.
Acid gases and organic vapors	Yellow.
Hydrocyanic acid gas and chloropicrin vapor	Yellow with ½-inch blue stripe completely around the canister near the bottom.
Acid gases, organic vapors, and ammonia gases.	Brown.
Radioactive materials, excepting tritium and noble gases.	Purple (Magenta).
Particulates (dusts, fumes, mists, fogs, or smokes) in combination with any of the above gases or vapors.	Canister color for contaminant, as designated above, with ½-inch gray stripe completely around the canister near the top.
All of the above atmospheric contaminants	Red with ½-inch gray stripe completely around the canister near the top.

*Gray shall not be assigned as the main color for a canister designed to remove acids or vapors.

NOTE: Orange shall be used as a complete body, or stripe color to represent gases not included in this table. The user will need to refer to the canister label to determine the degree of protection the canister will afford.

1910.135—OCCUPATIONAL HEAD PROTECTION

Helmets for the protection of heads of occupational workers from impact and penetration from falling and flying objects and from limited electric shock and burn shall meet the requirements and specifications established in American National Standard Safety Requirements for Industrial Head Protection, Z89.1-1969.

1910.136—OCCUPATIONAL FOOT PROTECTION

Safety-toe footwear for employees shall meet the requirements and specifications in American National Standard for Men's Safety-Toe Footwear, Z41.1-1967.

SECTION 5

PERSONAL PROTECTIVE EQUIPMENT

PART 8

MANUFACTURERS AND SUPPLIERS OF PERSONNEL PROTECTIVE GEAR

I. RESPIRATOR AND PROTECTIVE CLOTHING MANUFACTURER ADDRESSES

A-Best Products
3865 W. 150th Street
Cleveland, OH 44111
216/941-9400

American Optical Corp.
Safety Products Division
14 Mechanic Street
Southbridge, MA 01550
617/765-9711

Andover Industries, Inc.
10 Railroad Street
Andover, MA 01810
617/475-1302

Barry Manufacturing Co., Inc.
920 Lakeshore Road East
Mississauga, Ontario, Canada
416/274-3691

Bata Shoe Company, Inc.
Industrial Products Division
Belcamp, MD 21017
301/272-2000

Bendix Corp.
12345 Starkey Road
Largo, FL 33543
813/536-6523

Best Manufacturing Co.
Edison Street
Menlo, GA 30713
404/862-2302

Cesco Safety Products
100 E. 16th Street
P.O. Box 1237
Kansas City, MO 64141
816/842-8500

Charkate Glove and Specialty Co.
130 W. 10th Street
Huntington Station, NY 11746
516/427-1802
800/221-0224

Colonial Glove and Garmet
54 Penataquit Avenue
Bay Shore, NY 11706
516/968-8888

Cosmasec
Drawer 10
Niblic Road
Enfield, CT 06082
203/741-2207

Dayton Flexible Products
2210 Arbor Blvd.
Dayton, OH 45439
513/298-7511

Defense Apparel
286 Murphy Road
Hartford, CT 06114
800/243-3847

The DeVilbis Company
300 Phillips Avenue
P.O. Box 913
Toledo, OH 43692
419/470-2169

Boss Manufacturing Co.
221 West First Street
Kewanee, IL 61443
309/852-2131

E. D. Bullard Company
2680 Bridgeway
Sausalito, CA 94965
415/332-0410

Edmont Division of Becton, Dickinson, and Company
1300 Walnut Street
Coshocton, OH 43812
614/622-4311

Encon Manufacturing Co.
4919 Dickson Street
Houston, TX 77007
713/462-4723

Expendables, Inc.
2945 Congressman Lane
Dallas, TX 75220
214/350-6783

Frommelt Industries, Inc.
Safety Products Division
P.O. Box 658
2455 Kerper Boulevard
Dubuque, IA 52001
319/589-2736

Fyrepel Products, Inc.
P.O. Box 518
Newark, OH 43055
614/344-0391

Glendale Optical Co., Inc.
130 Crossway Park Drive
Woodbury, NY 11797
516/921-5800

Globe Safety Products, Inc.
125 Sunrise Place
Dayton, OH 45407
513/2247468

Disposables, Inc.
14 Locust Street
Manhasset, NY 11030
516/627-4554

Durafab, Inc.
P.O. Box 658
Cleurne, TX 76031
817/645-8851

W. L. Gore & Assoc.
Box 1130
Elkton, MD 21921
301/392-3700

Granet Div., ESB, Inc.
25 Loring Drive
P.O. Box 588
Framingham, MA 01701
617/875-3521

H.S. Cover Company
107 E. Alexander Street
Buchanan, MI 49107
616/695-9663

Hodgeman
207 E. Wolf Street
Yorkville, IL 60560
312/553-0100

International Latex, Inc.
213 Hanna Building
Cleveland, OH 44115
216/523-1000

International Safety Instruments, Inc.
16717 Smoketree Street
Hesperia, CA 92345
619/244-9404

ILC Dover
P.O., Box 266
Frederica, DE 19946
302/335-3911

Glover Latex, Inc.
514 South Rose Street
Anaheim, CA 02805
714/535-8920

Jomac Products, Inc.
863 Easton Road
Warrington, PA 18976
215/343-0800

Kappler Disposables, Inc.
Post Office Drawer 218
Guntersville, AL 35976
205/582-2195

Keller Glove Mfg. Co.
Route 611
Plumsteadville, PA 18949
215/343-1135

LRC Safety Products (Surety Rubber)
Rt. 46 West
Little Falls, NJ 07424
201/256-5500 Ext.227

LaCrosse Rubber Mills Co.
Indian Hill
LaCrosse, WI 54601
608/782-3020

Lehigh Safety Shoe Co.
1100 E. Main Street
Endicott, NY 13760
607/754-7980

Life Support System, Inc.
1400 Stierlin Road
Mountain View, CA 94043
415/962-9800

Lion Uniform, Inc.
Industrial Safety Division
P.O. Box 14165
Northridge Branch
Dayton, OH 45414
513/278-6531
800/543-9698

Iron Age Shoe Company
2408 Woodmere Drive
Pittsburgh, PA 15205
412/922/7000

Jordan David Safety Products
P.O. Box 400
Warrington, PA 18976
215/343-6470

Mar-Mac Mfg. Co.,Inc.
Box 278
McBee, SC 29101
803/335-8211

Melco, Inc.
6603 Printz Blvd.
Wilmington, DE 19809
800/441-9749

Mine Safety Appliances
600 Penn Center Blvd.
Pittsburgh, PA 15235
412/273-5000

Monte Glove Company
Monte Lane
Maben, MI 38750
601/263-5353

National Draeger, Inc.
401 Parkway View Drive
Pittsburgh, PA 15205
412/787-8383

National Safety Wear, Inc.
18 East Main Street
Malone, NY 12953
518/483-7246

Neese Industries, Inc.
P.O. Box 628
Gonzales, LA 70737
504/644-6553

Magid Glove Mfg. Co.
2060 N. Kolmar Avenue
Chicago, IL 60639
312/384-2070
800/621-8010

Oak Medical Supply Company
The Oak Rubber Company
219 S. Sycamore Street
Ravenna, OH
216/296-3416

Plastex Protective Products, Inc.
9-T Grand Street
Garfield, NJ 02706
201/779-4946

Plastimayd Corporation
2216 S. E. Seventh Avenue
Portland, OR 97214
503/232-5101

Playtex Industrial Gloves
700 Fairfield Avenue
Stamford, CT 06902
203/356-8000

Protexall Company
Box 307
Green Lake, WI 54941
414/294-6511

Pulmosan Safety Equipment Corp.
30-48 Linden Place
Flushing, NY 111354
212/939-3200

Racal Airstream, Inc.
7309-A Grove Road
Frederick, MD 21701
301/695-8200

Rainfair,Inc.
P.O. Box 1647
Racine, WI 53401
800/558-5990

North Safety Equipment
(formerly Norton)
Division of Siebe North
2000 Plainfield Pike
Cranston, RI 02920
401/943-4400

Pioneer Industrial Products
1831 Olive Street
St. Louis, MO 63103
314/621-7788

Record Industrial Company
P.O. Box 407
King of Prussia, PA 19406
215/337-2500

Red Kap Industries
749 Massman Drive
Nashville, TN 37210
615/889-6800
800/251-1068

Renco Corporation
2060 Fairfax Avenue
Cherry Hill, NJ 08003
609/424-5755

Rexnord Safety Products, Inc.
(Biomarine)
45 Great Valley Corporation Center
Malvern, PA 19355
215/647-7200

Safety Clothing & Equipment Co.
4900 Campbell Road
Willoughby, OH 44094
216/946-1880

Scott Aviation
225 Erie Street
Lancaster, NY 14086
716/683-5100

Sijal, Inc.
P.O. Box 205
205 Roesch Avenue
Oreland, PA 19075
215/572-0216

Ranger Rubber Company
Division of Endicott Johnson
1100 East Main Street
Endicott, NY 13760
607/757-4260

Standard Safety Equipment
(StaSafe)
Box 188
431 N. Quentin Road
Palatine, IL 60067
312/359-1400

Steel Grip Safety
Apparel Co., Inc.
700 Garfield Street
Box 833
Danville, IL 61832
217/442-6240

3M/Occupational Health & Safety
Products Division
220-7W 3M Center
St. Paul, MN 55144
612/733-6234

Tingley Rubber Company
P.O. Box 100
South Plainfield, NJ 07080
201/757-7474

Tracies Company
100 Cabot Street
Holyoke, MA 01040
413/533-7141

United States Safety Service Co.
1535 Walnut Street
P.O. Box 1237
Kansas City, MO 64108
816/842-8500

Vidaro Corporation
333 Martinel Drive
P.O. Box 535
Kent, OH 44240
216/673-7413

Wheeler Protective Apparel,Inc.
224 W. Huron Street
Chicago, IL 60610
312/787-1156

Willson Safety Products
P.O. Box 622
Reading, PA 19603

Survivair Division
U.S. Divers Corporation
3323 W. Warner Avenue
Santa Ana, CA 92702
714/540-8010

SECTION 6

REFERENCES AND GLOSSARY

SECTION 6

REFERENCES AND GLOSSARY

PART 1

REFERENCES AND RESOURCES

I. INTRODUCTION

This list provides the titles of references and organizations which may be of value to those responding to hazardous material incidents. Other resources are available which are not names here. This list can be expanded based on personal preferences and requirements.

The references are categorized by subject. The title, author, publisher, and place of publication are given for each. The year of publication is not always given because many are revised annually. The user should attempt to obtain the most recent edition.

The last section lists sources of these references as well as other information that might be useful. Usually, these agencies or associations will provide a catalogue on request. Where available, phone number are listed.

Items identified with an asterisk (*) may be particularly useful in "first response" situations.

II. REFERENCES

A. Industrial Hygiene (Air Sampling and Monitoring, Respiratory Protection, Toxicology).

1. Air Sampling Instruments for Evaluation of Atmospheric Contamin- ants, American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

2. Basic Industrial Hygiene, Richard Brief, American Industrial Hygiene Association, Akron, OH.

3. Direct Reading Calorimetric Indicator Tubes Manual, American Industrial Hygiene Association, Akron, OH.

4. Documentation of the Threshold Limit Values (TLV), American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

5. Fundamentals of Industrial Hygiene, National Safety Council, Chicago, IL.

6. Health Aspects of the Disposal of Waste Chemicals, Grisham, J.W., Pergamon Press.

7. The Industrial Environment-Its Evaluation and Control, National Institute for Occupational Safety and Health, Rockville, MD.

8. Industrial Hygiene and Toxicology, Frank A. Patty, John Wiley and Sons, Inc., New York, NY.

9. Industrial Toxicology - Safety and Health in the Workplace, Williams and Burson, ACGIH.

10. Manual of Recommended Practice for Combustible Gas Indicators and Portable, Direct Reading Hydrocarbon Detectors, American Industrial Hygiene Association, Akron, OH.

11. NIOSH Manual of Analytical Methods, Volumes 1-7, NIOSH, Department of Health and Human Services, Cincinnati, OH.

* 12. NIOSH/OSHA Pocket Guide to Chemical Hazards, DHHS No. 85-114, NIOSH, Department of Health and Human Services, Cincinnati, OH.

13. Occupational Health Guidelines for Chemical Hazards, DHHS No. 81-123, NIOSH, Department of Health and Human Services, Cincinnati, OH.

14. Registry of Toxic Effects of Chemical Substances, DHHS No. 83107, National Institute for Occupational Safety and Health, Rockville, MD.

15. Respiratory Protective Devices Manual, American Industrial Hygiene Association, Akron, OH.

* 16. TLVs Threshold Limit Values and Biological Exposure Indices (Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment), American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

17. Toxicology - The Basic Science of Poisons, John Doull, Curtis D. Klaasen and Mary O. Amdur, Macmillan Publishing Co., New York, NY (1980).

B. Chemical Data

* 1. Chemical Hazard Response Information System (CHRIS), U.S. Coast Guard, Washington, DC. Commandant Instruction M.16565.12A.

2. CHRIS - A Condensed Guide Chemical Hazards, U.S. Coast Guard, Commandant Instruction M16565.11a.

3. Chemical Hazards of the Workplace, Proctor and Hughes, J. B. Lippincott Company.

4. Chemistry of Hazardous Materials, Eugene Meyer, Prentice-Hall, Englewood Cliffs, NJ.

5. Clinical Toxicology of Commercial Products, Gosselin, R. E., William and Wilkins.

* 6. The Condensed Chemical Dictionary, G. Hawley, Van Nostrand Reinhold Co., New York, NY.

7. CRC Handbook of Chemistry and Physics, CRC Press-Boca Raton, FL.

* 8. Dangerous Properties of Industrial Materials, N. Irving Sax, Van Nostrand Reinhold Co., New York, NY.

* 9. Effects of Exposure to Toxic Gases, Matheson.

* 10. Emergency Handling of Hazardous Materials in Surface Transpor- ation, Student, P.J., Bureau of Explosives, Association of American Railroads.

11. Farm Chemicals Handbook, Farm Chemicals Magazine, Willoughby, OH

* 12. Firefighter's Handbook of Hazardous Materials, Baker, Charles J., Maltese Enterprises, Indianapolis, IN.

* 13. Fire Protection Guide to Hazardous Materials, National Fire Protection Association, Boston, MA.

14. Handbook of Chemical Property Estimation Methods, Lyman, W.J., Reehl, W. F., and Rosenblatt, D.H.; McGraw Hill Book Company.

15. Handbook of Environmental Data on Organic Chemicals, Verschueren, K., Van Nostrand Reinhold Co.

16. Handbook of Reactive Chemical Hazards, Bretherick, L., Butterworths, Boston, MA.

17. Handbook of Toxic and Hazardous Chemicals, Sittig, Marshal, Noyes Publications.

18. Hazardous Materials Handbook, Meidl, J.H., Glencoe Press.

19. Hygienic Guides, American Industrial Hygiene Association, Akron, OH.

20. The Merck Index, Merck and Co., Inc., Rahway, NJ.

21. Toxic and Hazardous Industrial Chemicals Safety Manual, The International Technical Information Institute, Tokyo, Japan.

C. EPA Methods Manuals for Sampling and Analysis

1. Biological Field and Laboratory Methods for Measuring the Quality of Surface Water and Effluents, EPA-670/4-73-001.

2. Emergency Drum Handling at Abandoned Dump Sites, EPA Contract No. 68-03-3113.

3. EPA Solid Waste Manual, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846 (May 1980).

4. Handbook for Analytical Quality Control in Water and Waste-water Laboratories, EPA-600/4-79-019 (March 1979).

5. Methods of Chemical Analysis of Water and Wastes, EPA-600/479020 (March 1979).

6. Microbiological Methods for Monitoring the Environment, Water and Wastes, EPA-600/8-78-017 (December 1978).

7. Procedures Manual for Groundwater Monitoring at Solid Wastes Disposal Facilities, EPA-530/SW-611 (August 1977).

D. Safety and Personnel Protection

1. Best's Safety Directory, A.M. Best Co., Oldwick, NJ.

2. CRC Handbook of Laboratory Safety, Norman V. Steere, CRC Press, Boca Raton, FL.

3. Fire Protection Handbook, National Fire Protection Association, Quincy, MA.

4. Flammable Hazardous Substances Emergency Response Handbook: Control and Safety Procedures, EPA Contract No. 68-03-3014.

5. FM Approval List, Factory Mutual, Norwood, MA.

* 6. Guidelines for the Selection of Chemical Protective Clothing, Vol. 1: Field Guide, A.D. Schwope, P.P. Costas, J.O. Jackson, D. J. Weitzman, Arthur D. Little, Inc., Cambridge, MA (March 1983).

7. I Guidelines for the Selection of Chemical Protective Clothing, Volume 2: Technical and Reference Manual, A.D. Schwope, P.P. Costas, J.O. Jackson, D.J. Weitzman, Arthur D. Little, Inc., Cambridge, MA (March 1983).

8. Handling Radiation Emergencies, Purington and Patterson, NFPA.

9. Hazardous Materials Injuries, A Handbook for Pre-Hospital Care, Douglas R. Stutz, Robert C. Ricks, Michael F. Olsen, Bradford Communications Corp., Greenbelt, MD.

10. National Safety Council Safety Sheets, National Safety Council, Chicago, IL.

11. NIOSH Certified Equipment List, U.S. Dept. of Health and Human Services.

12. Personal Protective Equipment for Hazardous Materials Incidents: A Selection Guide, NIOSH, U. S. Department of Health and Human Services.

13. Protecting Health and Safety at Hazardous Waste Sites: An Overview, U.S. Environmental Protection Agency.

14. Radiation Protection - A Guide for Scientists and Physicians, Shapiro, Jacob, Harvard University Press, Cambridge, MA.

15. Radiological Health Handbook, U.S. Dept. of Health, Education and Welfare.

* 16. Radiological Health - Preparedness and Response in Radiation Accidents, U.S. Dept. of Health and Human Services.

17. A Review of the Department of Transportation Regulations for Transportation of Radioactive Materials, U. S. Department of Transportation.

* 18. SCBA-A Fire Service Guide to the Selection, Use, Care, and Main- tenance of Self-Contained Breathing Apparatus, NFPA, Batterymarch Park, Quincy, MA.

* 19 . Standard First Aid and Personal Safety, American Red Cross.

20. Underwriters Laboratories Testing for Public Safety, Annual Directory, Underwriters Laboratories, Inc., Northbrook, IL.

E. Planning Guides

1. Chemical Emergency Planning Program, U.S. EPA.

2. Detoxification of Hazardous Wastes, Exner, Jurgen H., Ann Arbor Science.

* 3. Federal Motor Carrier Safety Regulations Pocketbook, (U. S. Dept. of Transportation) J.J. Keller and Associates, Inc.

4. Handbook for Remedial Action at Waste Disposal Sites, EPA 625/682-006 (June 1982).

5. Hazardous and Toxic Materials: Safe Handling and Disposal, Fawcett, H.H., John Wiley and Sons.

6. Hazardous Chemical Spill Cleanup, Noyes Datat Corporation, Ridge Park, New Jersey.

7. Hazardous Materials Emergency Planning Guide, National Response Team, U.S. Environmental Protection Agency, 401 M. Street S.W., Washington, DC 20460 (1987).

8. Hazardous Materials Spills Handbook, Gary F. Bennett, Frank S. Feates, Ira Wilder, McGraw-Hill Book Co., New York, NY.

9. Hazardous Waste Regulation-An Interpretive Guide, Mallow, Alex, Van Nostrand Reinhold Company.

10. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH/OSHA/USCG/EPA, U.S. Dept. of Health and Human Services, NIOSH.

11. Standard Operating Safety Guides, Environmental Response Branch, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency.

12. State Decision-Makers Guide for Hazardous Waste Management, SW 612, U.S. EPA (1977).

* 13. 1984 Emergency Response Guidebook - Guidebook for Hazardous Mat-erials Incidents, DOT P 5800.3 USDOT, Materials Transportation tation Bureau, Attn: DMT-11, Washington, DC 20590.

III. TECHNICAL INFORMATION AND POTENTIAL RESPONSE/INFORMATION SOURCES

1. AFX Rail Car Mfgr.
   314/724-7850

2. Agency for Toxic Substances Disease Registry
   Centers for Disease Control
   Shamlee 28 S., Room 9
   Atlanta, GA 30333
   404/452-4100

3. American Conference of Governmental Industrial Hygienists
   6500 Glenway Avenue, Building D-5
   Cincinnati, OH 45211
   513/661-7881

4. American Industrial Hygiene Association
   475 Wolf Ledges Parkway
   Akron, OH 44311-1087
   216/762-7294

5. American Insurance Association (AIA)
   (National Board of Fire Underwriters)
   Engineering and Safety Service
   85 John St.
   New York, NY 10038
   212/533-4400

6. American National Standards Institute, Inc.
   1430 Broadway
   New York, NY 10018
   212/354-3300

7. American Petroleum Institute (API)
1220 L Street N.W., 9th Floor
Washington, DC 20005
202/682-8000

8. American Society of Mechanical Engineering (ASME)
United Engineering Center
345 East 47th Street
New York, NY 10017
212/644-7722

9. ARMY ORDINANCE UNIT

10. Ashland Chemical Company
3849 Risher Road
Columbus, OH 43228
614/276-6143

11. Association of American Railroads (AAR)
50 F Street N.W.
Washington, DC 20001
202/639-2100

12. Association of American Railroads (AAR)
59 East Van Buren Street
Chicago, IL 60650
312/939-0770

13. BOMB HANDLERS

14. Bureau of Explosives
American Association of Railroads
1920 L Street, N.W.
Washington, DC 20036
202/293-4048

15. Center for Disease Control
Atlanta, GA
404/633-5313

16. CHEMICAL INFORMATION

17. CHEMICAL RESPONSE INFORMATION

18. Chemical Manufacturer's Association
2501 M St. N.W.
Washington, DC 20037
202/877-1100

19. CHEMISTS

20. Chemtrec
Washington, DC
800/424-9300

21. CIVIL DEFENSE CLEANUP CONTRACTORS

22. The Clorine Institute
342 Madison Avenue
New York, NY 10017
212/682-4324

23. The Compressed Gas Association, Inc. (CGA)
500 Fifth Avenue
New York, NY 10036
212/354-1130

24. CONSTRUCTION COMPANIES (HEAVY EQUIPMENT)

25. CRC Press, Inc.
2000 Corporate Blvd., N.W.
Boca Raton, FL 33431
305/994-0555, Ext. 330

26. DEPARTMENTS OF ENVIRONMENTAL QUALITY (STATE, LOCAL)

27. DEPARTMENT OF TRANSPORTATION (STATE)

28. Dow Chemical Company
Midland, MI 48640
517/636-4400

29. DuPont Company
1007 Market Street
Wilmington, DE 19898
302/774-7500

30. Energy Research Development Admin.
Albuquerque Office
Albuquerque, NM 87101
505/264-4667(8)

31. ENVIRONMENTAL PROTECTION AGENCY

32. EPIDEMIOLOGISTS

33. Factory Mutual Engineering Corp. Lab
1150 Boston-Providence Turnpike
Norwood, MA 02062
617/762-4300

34. The Fertilizer Institute (TFI)
1015 18th St., N.W.
Washington, DC 20036
202/861-4900

35. FIRE DEPARTMENTS

36. GAS COMPANIES

37. GATX RAIL CAR MFGR.
312/621-6200

38. HAZARDOUS MATERIALS EXPERTS

39. HAZARDOUS MATERIALS TEAMS

40. HEALTH DEPARTMENT

41. HIGHWAY DEPARTMENT

42. HOSPITALS

43. Institute of Makers of Explosives (IME)
420 Lexington Avenue
New York, NY 10017
212/986-6920

44. J. T. Baker Chemical Company
Phillipsburgh, NY 08856
201/859-2151

45. Kerr-McGee Chemical Corp.
Kerr-McGee Center
Oklahoma City, OK 73125
405/270-1313

46. LAW ENFORCEMENT AGENCIES

47. Mallinckrodf, Inc.
P.O. Box 5439
St. Louis, MO 63147
314/895-0123

48. Manufacturing Chemists Association, Inc.
1825 Connecticut Avenue N.W.
Washington, DC 20009
202/483-6126

49. MANUFACTURERS REPRESENTATIVES

50. MOTOR CARRIER SAFETY

51. National Bureau of Standards
U.S. Department of Commerce
Washington, DC 20234
301/921-1000

52. National Fire Protection Association
Batterymarch Park
Quincy, MA 02269
617/328-9290

53. National Institute for Occupational Safety and Health
Division of Technical Services
46765 Columbia Parkway
Cincinnati, OH 45226
513/684-8302

54. National Response Center (USCG and EPA)
800/424-8802

55. National Safety Council
444 North Michigan St.
Chicago, IL 60611
312/527-4800

56. National Tank Truck Carriers, Inc.
1616 P St.
Washington, DC 20036
202/797-5426

57. National Transportation Safety Board
800 Independence Avenue
Washington, DC 20594
202/655-4000

58. NATX Rail Car Mfgr.
312/648-4000

59. Occupational Safety and Health Administration
U.S. Department of Labor
Washington, DC
202/523-9700

60. Oil and Hazardous Material Technical Assistance Data System
202/245-3045

61. Poison Control Center
Charleston, SC
502/432-9516

62. PORT AUTHORITIES

63. PUBLIC INFORMATION MEDIA

64. PUBLIC WORKS

65. RADIOACTIVE MATERIAL HAULERS

66. Radiological Assistance Zone 3
Savannah River Operations Office
Aiken, SC 29801
803/725-6211, x3333

67. RADIO STATIONS

68. RAILROAD DIVISION SUPERINTENDENT

69. RAILROAD MATERIAL HANDLERS

70. RAILROADS

71. REGIONAL RESPONSE TEAMS

72. SANITATION AGENCIES

73. SHERIFF'S OFFICE

74. SHIPPER REPRESENTATIVES

75. STATE FIRE MARSHAL

76. STATE POLICE

77. STEVEDORING COMPANIES

78. STREET DEPARTMENT

79. STRUCTURAL ENGINEERS

80. Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402
202/783-3238

81. TELEVISION STATIONS

82. TOXICOLOGISTS

83. Underwriters' Laboratories
207 East Ohio St.
Chicago, IL 60611
312/642-6969

84. Union Carbide Corp.
Linde Div.
51 Cragwood Road
S. Plainfield, NJ 07080
201/753-5800

85. U.S. Army Explosive and Ordnance Disposal
301/677-5182

86. U.S. COAST GUARD

87. U.S. DEPARTMENT OF AGRICULTURE

88. U.S. Department of Defense
Nuclear Accident Center
505/264-4667

89. U.S. Department of Energy
Washington, DC 20545
202/252-5000

90. U.S. Department of Transportation
Materials Transportation Bureau
Office of Hazardous Materials Operations
400 7th St. S.W.
Washington, DC 20590
202/366-4555

91. U.S. EPA
Office of Research and Development
Publications - CERI
Cincinnati, OH 45268
513/684-7562

92. U.S. EPA
Office of Solid Waste
(WH-562)
Superfund Hotline
401 M. St. SW
Washington, DC 20460
800/424-9346

93. U.S. Mine Safety and Health Administration
Department of Labor
4015 Wilson Blvd. Room 600
Arlington, VA 22203
703/235-1452

94. U.S. National Oceanic and Atmospheric Administration
Hazardous Materials Response Branch
N/OMS 34
7600 Sand Point Way, N.E.
Seattle, WA 98115
206/527-6317

95. U.S. Nuclear Regulatory Commission
Washington, DC 20555
301/492-7000

96. UTLX Rail Car Mfgr.
312/431-3111

97. UTILITIES

98. WASTE DISPOSAL COMPANIES

99. WATER COMPANIES

100. WRECKING COMPANIES

SECTION 6

REFERENCES AND GLOSSARY

PART 2

GLOSSARY AND ACRONYMS

I. GLOSSARY

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.

Air Surveillance - Use of air monitoring and air sampling during a response to identify and quantify airborne contaiminants on and off-site, and monitor changes in air contaminants that occur over the lifetime of the incidents

Aquifer - A water bearing formation of permeable rock, sand, or gravel capable of yielding water to a well or spring.

Chronic Exposure - Low doses repeatedly delivered to a receptor over a long period of time.

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/Contamination - An unwanted and non-beneficial substance.

Control - Chemical or physical methods used to prevent or reduce the hazards associated with a material. Example: Neutralizing an acid spill.

Decontamination - The process of physically removing contaminants from individuals and equipment or changing their chemical nature to innocuous substances

Degree of Hazard - A relative measure of how much harm a substance can do.

Direct-Reading Instruments - A portable device that rapidly measures and displays the concentration of a contaminant in the environment.

Emergency - A sudden and unexpected event calling for immediate action.

Emergency Removal - Action or actions undertaken, in a time-critical situation, to prevent, minimize, or mitigate a release that poses an immediate and/or significant threat(s) to human health or welfare or to the enivronment. (See also Removal Action)

Environmental Assessment - The measurement or prediction of the concentration, transport, dispersion, and final fate of a released hazardous substance in the environment.

Environmental Emergencies - Incidents involving the release (or potential release) of hazardous materials into the environment which require immediate action.

Environmental Hazard - A condition capable of posing an unreasonable risk to air, water, or soil quality, and to plants or wildlife.

Environmental Sample - Samples that are considered to contain no contaminants or low concentrations of contaminants as compared to hazardous samples.

Episode - Incident.

First Responder - The first personnel to arrive on the scene of a hazardous materials incident. Usually officials from local emergency services, firefighters, and police.

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 Evaluation - The impact or risk the hazardous substance poses to public health and the environment.

Hazard Classes - A series of nine descriptive terms that have been established by the UN Committee of Experts to categorize the hazardous nature of chemical, physical, and biological materials. These categories are:

1. Explosives,
2. Non-flammable 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, and
9. Dangerous materials.

Hazardous - Capable of posing an unreasonable risk to health and safety (Department of Transportation). Capable of doing harm.

Hazardous Material - A substance or material which has been determined by the 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. (Department of Transportation)

Hazardous Sample - Samples that are considered to contain high concentrations of contaminants.

Hazardous Substance - 1) A material and its mixtures or solutions that is identified by the letter "E" in Column (1) of 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 the regulation of which under the Solid Waste Disposal Act has been suspended by Act of Congress), (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, and (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 (of mixtures of natural gas and such synthetic gas).

Hazardous Waste - Any material that is subject to the hazardous waste manifest requirements of the Environmental Protection Agency 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.

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 effect it will have on people, property, wildlife and plants, and the disruption of services.

Incident Evaluation - The process of assessing the impact released or potentially released substances pose to public health and the environment.

Information - Knowledge acquired concerning the conditions or circumstances particular to an incident.

Inspection - Same as investigation.

Intelligence - Information obtained from existing records or documentation, placards, labels, signs, special configuration of containers, visual observations, technical records, eye witnesses, and others.

Investigation - On-site and off-site survey(s) conducted to provide a qualitative and quantitative assessment of hazards associated with a site.

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.

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.

National Contingency Plan - Policies and procedures that the Federal Government follows in implementing responses to hazardous substances.

On-Site - Presence within the boundaries of the worksite.

Off-Site - Presence outside of the worksite.

Pathways of Dispersion - The environmental medium (water, groundwater, soil, and air) through which a chemical is transported.

Persistent Chemicals - A substance which resists biodegradation and/or chemical transformation when released into the environment and tends to accumulate on land, in air, in water, or in organic matter.

Planned Removal (Non-Time-Critical Removal) - The removal of released hazardous substances that pose a threat or potential threat to human health or welfare or to the environment from a site within a non-immediate time period. Under CERCLA: Actions intended to minimize increases in exposure such that time and cost commitments are limited to 12 months and/or two million dollars. (See also Emergency Removal)

Pollutant - A substance or mixture which after release into the environment and upon exposure to any organism will or may reasonably be anticipated to cause adverse effects in such organisms or their offspring.

Pollutant Transport - An array of mechanisms by which a substance may migrate outside the immediate location of the release or discharge of the substance. For example, pollution of groundwater by hazardous waste leachate migrating from a landfill.

Qualified Individual - A person who through education, experience, or professional accreditation is competent to make judgements concerning a particular subject matter. A Certified Industrial Hygienist may be a qualified individual for preparing a site safety plan.

Regulated Material - A substance or material that is subject to regulations set forth by the Environmental Protection Agency, the Department of Transportation, or any other federal agency.

Release - Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of hazardous substances into the environment.

Remedial Actions - As in the National Contingency Plan, responses to releases on a National Priority List that are consistent with treatment-oriented remedy that is protective of human health and the environment and that permanently and significantly reduces toxicity, mobility, or volume of hazardous substances.

Removal Actions - Any appropriate actions(s) taken to abate, minimize, stablize, mitigate, or eliminate the release or threat of release 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 - As set forth in the Clean Water Act, 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.

Response Operations - Same as Response Actions.

Risk - The probability that harm will occur.

Risk Assessment - The use of factual base 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 integrating the results of risk assessment with engineering data and with social and economic concerns to reach a decision.

Routes of Exposure - The manner in which a contaminant enters the body through inhalation, ingestion, skin absorption, and injection.

Safety - Freedom from man, equipment, material, and environmental interactions that result in injury or illness.

Sampling - The collection of representative portion of the universe. Example: the collection of a water sample from a contaminated stream.

Severe - A relative term used to describe the degree to which hazardous material releases can cause adverse effects to human health and the environment.

Site - Location.

Site Safety Plan - Written, site-specific safety criteria that establishes requirements for protecting the health and safety of responders during all activities conducted at an incident.

Toxicity - The ability of a substance to produce injury once it reaches a susceptible site in or on the body.

Work Plan - Written directives that specifically describe all work activities that are to take place at a work site.

II. ACRONYMS

ACGIH - American Conference of Governmental Industrial Hygienists

AIHA - American Industrial Hygiene Association

ANSI - American National Standards Institute

ASTM - American Society of Testing and Materials

APR - Air-Purifying respirator

B of M - Bureau of Mines

BOD - Biological oxygen demand

CAG - Carcinogen Assessment Group

CDC - Center for Disease Control

CERCLA - Comprehensive Environmental Response Compensation and Liability Act (1980)

CFR - Code of Federal Regulations

CGI - Combustible Gas Indicator

CHEMTREC - Chemical Transportation Emergency Center

CHRIS - Chemical Hazard Response Information System

CMA - Chemical Manufacturers' Association

CPM - Counts per minute

CRC - CRC Press. A publisher of scientific reference books

CRP - Community Relations Plan

DDT - Dichlorodiphenyltrichloroethane

DECON - Decontamination

DFM - Diesel fuel marine

DHHS - Department of Health and Human Services

DOD - Department of Defense

DOI - Department of the Interior

DOL - Department of Labor

DOT - Department of Transportation

DRI - Direct-reading Instruments

EERU - Environmental Emergency Response Unit

EPA - Environmental Protection Agency

ERCS - Emergency Response Cleanup Services, under EPA contract

ERT - Environmental Response Team

eV - Electron volt

FEMA - Federal Emergency Management Agency

FID - Flame ionization detector

FIT - Field Investigation Team under contract to EPA

FM - Factory Mutual

GC - Gas chromatograph or gas chromatography

HEPA - Common use: "HEPA Filter" High efficiency particulate air filter.

IDLH - Immediately dangerous to life or health

IP - Ionization potential

IR - Infrared radiation

IUPAC - International Union of Pure and Applied Chemists

LC_{50} - Lethal concentration, 50%

LD_{50} - Lethal Dose, 50%

LEL - Lower explosive limit

mg/L - Milligrams per litre

mg/m^3 - Milligrams per cubic meter

MIRAN - Trade name for series of Foxboro miniature infrared analyzers

mR/hr - Milliroentgens per hour

MSDS - Materials Safety Data Sheets

MSHA - Mine Safety and Health Administration

MUC - Maximum use concentration

MUL - Maximum use limits

NBR - Nitrile-Butadiene Rubber (syn. Buna-N)

NCP - National Contingency Plan

NEC - National Electric Code

NFPA - National Fire Protection Association

NIOSH - National Institute for Occupational Safety and Health

NOAA - National Oceanic and Atmospheric Administration

NOS or n.o.s. - Not otherwise specified

NPL - National Priorities List

NRC - Nuclear Regulatory Commission

NRT - National Response Team

OHMTADS - Oil and Hazardous Materials Technical Assistance Data System

ORM - Other regulated material. Various specific classes such as ORM-A, ORM-E, etc.

OSC - On-Scene coordinator

OSHA - Occupational Safety and Health Administration

OVA - Organic Vapor Analyzer

PCB - Polychlorinated Biphenyl

PEL - Permissible exposure limit

PF - Protection factor

PID - Photoionization detector

ppb - Parts per billion

ppm - Parts per million

ppt - Parts per trillion

PVA - Poly Vinyl Alcohol

PVC - Poly Vinyl Chloride

QA/QC - Quality assurance/Quality control

RCRA - Resource Conservation and Recovery Act

REL - Recommended Exposure Limits

REMFIT - Field Investigation Team for remedial actions under contract to EPA

RI/FS - Remedial Investigation/Feasibility Study

RRP - Regional Response Plan

RRT - Regional Response Team

SBR - Styrene-Butadiene rubber

SCBA - Self contained breathing apparatus

SOPs - Standard operating procedures

SOSGs - Standard operating safety guides

STEL - Short term exposure limit

TAT - Technical Assistance Team under contract to EPA

TCDD - Tetrachlorodibenzo - p - dioxin

TCE - Trichloroethylene

TLVs - Threshold limit values

TWA - Time weighted average

2, 4, 5-T - 2, 4, 5-Trichlorophenoxyacetic acid

UEL - Upper explosive limit

UL - Underwriters Laboratories

UN - United Nations

USCG - United States Coast Guard

USGS - United States Geological Survey

WEEL - Workplace Environmental Exposure Levels

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DATE DUE	BORROWER'S NAME	ROOM NUMBER

DEMCO