Medical authorities must be notified promptly about unique treatments which may be required should acute exposure occur. Fire officials need information about the best available technology for dealing with any subsequent emergency likely to occur at the site. This should include data about chemicals possessing unusual reactivity. The necessity for evacuation of the public in the event of an emergency and also the question of security of external site boundaries must be discussed with the police.

Emergency facilities to be installed at the site include eyewash fountains and deluge showers and firefighting equipment. Worker training should include emergency procedures for evacuation, training in the use of all emergency equipment and techniques of first aid and cardiopulmonary resuscitation. Emergency telephone numbers should be prominently displayed at the command post. Additional emergency equipment can include antidotes or neutralizing solutions (Sproul ., 1980).

The consequences of an incident, such as the sudden release of a chemical can be predicted in terms of the area affected, the distance from the release point at which the concentration decreases to the lower toxic limit and the duration of elevated concentration These predictions are extremely useful in planning evacuation procedures with local police forces. In addition, this, as a worst case situation, draws attention to the adequacy of personnel protection chosen for use on-site.

The hurried evacuation of an injured, contaminated worker must also be addressed by local hospital authorities and site planners. The nature of the injury may be so severe as to require immediate evacuation to the nearest hospital without the usual decontamination and removal of protective equipment. This situation gains in consequence if the contaminants are highly toxic and require specialized agents for their removal or neutralization. In either event the hospital authorities should be informed of these concerns during planning activity.

6.1 Site A: Chlorinated Hydrocarbons

D'Appolonia (1982) described the rehabilitation of chlorinated wastes wit an existing plant facility. The plant formerly man factured hexachlorocyclopentadiene. Waste was stored within the site, 880 acres of which were demarcated into clean and contaminated areas. Earthmoving equipment was used to transport 880,000 cubic yards of wast to a clay-lined vault. Isolation of highly contaminated soil and drumm waste took place only when ambient temperatures were less than 10 °C, i order to take advantage of reduced vapour pressure. Chemical concentra varied significantly between sample locations, thus making increasingly difficult, any prediction of airborne concentration once the repositori were disturbed.

Toxicological data were obtained for chemicals known or suspected present in the work area. These data were employed to specify the med: and industrial hygiene program. Medical screening was performed to obt a baseline for those to be employed within the site and to exclude thos at high risk. Annual screening was carried out on individuals likely t sustain high exposure. Immediate response could be undertaken if deem necessary.

Facilities to carry out an industrial hygiene program included an on-site laboratory, decontamination facility for both personnel and la equipment and a laundry to clean contaminated clothing.

The site was isolated from unauthorized access by fences. Separa roadways were constructed to limit the spread of contamination by vehi movement. Misuse of the road network was strictly forbidden.

tamination.

Self-contained breathing apparatus or full-facepiece respirators were used by all personnel during earthmoving. Operators of heavy earthmoving equipment used self-contained breathing apparatus. During routine work, large volume compressed air cylinders were mounted on this equipment to extend the working time. Each operator also carried a portable compressed air tank for emergency use or routine transportation.

Site entry rules prohibited smoking, eating and drinking. Employees leaving contaminated areas were required to undergo decontamination. A shower and change of clothing were also required prior to leaving the worksite.

The air monitoring program contained three aspects: baseline monitoring to determine background concentrations; site perimeter monitoring before, during and after the operation to determine total suspended particulates and hexachlorocyclopentadiene as a measure of intrusion of contaminants into the community; and personnel monitoring to measure the exposure level of each job type. Area samples were also taken at each worksite. Considerable heterogeneity was observed in soil and water samples taken in contaminated areas. This made prediction of air sampling results essentially impossible. The monitoring results obtained during a week in February were mentioned. Total suspended particulates ranged from 5.00 to 33.60 $\mu g/m^3$ (mean 16.88 $\pm$ 9.03 $\mu g/m^3$). Personnel samples analyzed for hexachlorocyclopentadiene taken as a typical contaminant ranged from 1.90 to 18.63 ppb (mean 5.84 $\pm$ 4.75 ppb).

5.2 Site B. Abandoned Hazardous Wastes

Costello and King (1982) described worker protection at the abandoned site of a former commercial hazardous waste disposal enterprise. The site contained 40,000 drums of unlabelled chemical wastes which had sustained an explosion and subsequent fire damage This report described only air sampling data.

The project involved restaging, identifying, pretreating and transporting the hazardous wastes remaining after the fire for safe disposal. addition, site cleanup which entailed demolition of unsafe structures and clearing navigable waterways was also undertaken.

The workforce was divided arbitrarily into separate groups accord
to job function. These included manual drum handlers who restacked
drums and manoeuvred them into the bucket of a front-end loader. Opera
of heavy equipment such as bulldozers, loaders, backhoes, cranes and
mechanical drum handling equipment transported drums, as well as openin
them by means of a barrel claw and manipulating the contents, demolishe
structures and moved rubble. Operators of other equipment crushed drum
and loaded them into disposal trucks, siphoned liquids into vacuum truc
and transferred the contents to holding tanks. Personnel protective
equipment technicians maintained and supplied personnel protective equi
ment.

Manual drum handlers and operators of heavy equipment worked close
to the original piles of drums and unconfined materials. They were equ
ped with airline respirators or self-contained breathing apparatus and
splash suits, as well as neoprene or butyl rubber gloves, boots and hea
gear. Operators of other equipment and personnel protective equipment
technicians did not work as close to the potential hazards as did the
group. These individuals were equipped with air purifying respirators
suits, or disposable coveralls, gloves and boots.

Personal and area monitoring samples were evaluated for an extens
array of potentially hazardous airborne vapours and particulate-borne
contaminants. D
was typically 7 to 8 hours. The workday, by comparison extended fr
up to sundown, seven days a week.

Based on normal shift length sampling times (8-hours) the inhalat
exposure of unprotected individuals would have been well below the rec
occupational health standards. The reasons may relate to the well ven
lated conditions present at the site, the relatively small size of ind
sources of exposure and the potential consumption of volatile substanc
by the fire.

The lack of collected data on life-threatening situations and potential acute exposures arises from the sampling strategy. Such occurrences were distinctly possible due to the instability of the drums (rupture of one third during initial movement) and the unknown identity of the contents. Since the potential for explosion, leaking drums and spontaneous ignition could not be ruled out, the utilization of high levels of personnel protective equipment was viewed as justifiable and negated any argument for minimum respiratory and skin protection.

5.3 Site C. 'Illicit Chemical Waste'

Muller et al (1983) have recently reported on the rehabilitation of an illicit chemical waste site located on a farm.
This report revealed some of the problems which should be addressed during the planning stage of the project. The survey techniques employed grossly underestimated the number of drums present. Drums had been crushed by the weight of overburden and overstacked drums which had expelled their contents into the soil.

Based on contents, drums were excavated, examined, sampled and transported to a storage area. Contents of leaking drums were transferred to empty drums.

Area and personal sampling was undertaken for a variety of volatile organic contaminants. Area sampling was carried out at the perimeter of the site to establish whether the chemical transfer operations were likely to cause a community odour problem. The time-weighted average concentrations determined during long term sampling were very small compared to the respective Threshold Limit Value. These samples did not address the possibility of acute hazard arising from loss of containment, fire or explosion.

Explosivity and oxygen deficiency were monitored continuously in areas in which excavation and removal of drums was occurring, owing to the volatility of many of the identified compounds, and the presence of soil contaminated by previously ruptured containers.

Remote handling of drums in the excavation area was employed to increase the distance of workers from the potential sources of exposure.

All persons in the work area were issued chemical resistant coveralls, rubber gloves and boots, and hand and eye protection.

All personnel involved in the excavation and materials handling were equipped with self-contained breathing apparatus. Other people in th work areas were equipped with cartridge- or canister- type, air-purifying respirators.

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APPENDIX A

SITE ENTRY - LEVELS OF PROTECTION

EPA 1982

I. INTRODUCTION

Personnel must wear protective equipment when response activities involve known or suspected atmospheric contamination, when vapors, gases, or particulates may be generated, or when direct contact with skin-affecting substances may occur. Respirators can protect lungs, gastrointestinal tract, and eyes against air toxicants. Chemical-resistant clothing can protect the skin from contact with skin-destructive and -absorbable chemicals. Good personal hygiene limits or prevents ingestion of material.

Equipment to protect the body against contact with known or anticipated chemical hazards has been divided into four categories according to the degree of protection afforded:

- Level A: Should be worn when the highest level of respiratory, skin, and eye protection is needed.

- Level B: Should be selected when the highest level of respiratory protection is needed, but a lesser level of skin protection. Level B protection is the minimum level recommended on initial site entries until the hazards have been further defined by on-site studies and appropriate personnel protection utilized.

- Level C: Should be selected when the type(s) of airborne subtance(s) is known, the concentration(s) is measured, and the criteria for using air-purifying respirators are met.

- Level D: Should not be worn on any site with respiratory or skin hazards. Is primarily a work uniform providing minimal protection.

The Level of Protection selected should be based primarily on:

- Type(s) and measured concentration(s) of the chemical substance(s) in the ambient atmosphere and its toxicity.

- Potential or measured exposure to substances in air, splashes of liquids, or other direct contact with material due to work being performed.

In situations where the type(s) of chemical(s), concentration(s), and possibilities of contact are not known, the appropriate Level of Protection must be selected based on professional experience and judgment until the hazards can be better characterized.

While personnel protective equipment reduces the potential for contact with harmful substances, ensuring the health and safety of response personnel requires, in addition, safe work practices, decontamination, site entry protocols, and other safety considerations. Together, these protocols establish a combined approach for reducing potential harm to workers.

II. LEVELS OF PROTECTION

A. Level A Protection

1. Personnel protective equipment

- Pressure-demand, self-contained breathing apparatus, approved by the Mine Safety and Health Administration (MSHA) and National Institute of Occupational Safety and Health (NIOSH).
- Fully encapsulating chemical-resistant suit
- Coveralls*
- Long cotton underwear*
- Gloves (outer), chemical-resistant
- Gloves (inner), chemical-resistant
- Boots, chemical-resistant, steel toe and shank. (Depending on suit construction, worn over or under suit boot)
- Hard hat* (under suit)
- Disposable protective suit, gloves, and boots* (Worn over full encapsulating suit)
- 2-Way radio communications (intrinsically safe)

2. Criteria for selection

Meeting any of these criteria warrants use of Level A Protectic

- The chemical substance(s) has been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on:

  -- measured (or potential for) high concentration(s) of atmospheric vapors, gases, or particualtes

  or

  -- site operations and work functions involving high potential splash, immersion, or exposure to unexpected vapors, gases, particulates.

*Optional

- Extremely hazardous substances (for example: dioxin, cyanide compounds, concentrated pesticides, Department of Transportation Poison "A" materials, suspected carcinogens, and infectious substances) are known or suspected to be present, and skin contact is possible.

- The potential exists for contact with substances that destroy skin.

- Operations must be conducted in confined, poorly ventilated areas until the absence of hazards requiring Level A protection is demonstrated.

- Total atmospheric readings on the Century OVA System, HNU Photoionizer, and similar instruments indicate 500-1,000 ppm of unidentified substances. (See Appendixes I and II.)

3. Guidance on selection criteria

The fully encapsulating suit provides the highest degree of protection to skin, eyes, and respiratory system if the suit material is resistant to the chemical(s) of concern during the time the suit is worn and/or at the measured or anticipated concentrations. While Level A provides maximum protection, the suit material may be rapidly permeated and penetrated by certain chemicals from extremely high air concentrations, splashes, or immersion of boots or gloves in concentrated liquids or sludges. These limitations should be recognized when specifying the type of chemical-resistant garment. Whenever possible, the suit material should be matched with the substance it is used to protect against.

The use of Level A protection and other chemical-resistant clothing requires evaluating the problems of physical stress, in particular heat stress associated with the wearing of impermeable protective clothing. Response personnel must be carefully monitored for physical tolerance and recovery.

Protective equipment being heavy and cumbersome, decreases dexterity, agility, visual acuity, etc., and so increases the probability of accidents. This probability decreases as less protective equipment is required. Thus, increased probability of accidents should be considered when selecting a Level of Protection.

Many toxic substances are difficult to detect or measure in the field. When such substances (especially those readily absorbed by or destructive to the skin) are known or suspected to be present and personnel contact is unavoidable, Level A protection should be worn until more accurate information can be obtained.

B. Level B Protection

1. Personal protective equipment

- Pressure-demand, self-contained breathing apparatus (MSHA/NIOSH approved)

- Chemical-resistant clothing (overalls and long-sleeve jacket; coveralls; hooded, one or two-piece chemical-splash suit; disposable chemical-resistant coveralls)

- Coveralls*

- Gloves (outer), chemical-resistant

- Gloves (inner), chemical-resistant

- Boots (outer), chemical-resistant, steel toe and shank

- Boots (outer), chemical-resistant (disposable)*

- Hard hat (face shield*)

- 2-Way radio communications (intrinsically safe)

2. Criteria for selection

Meeting any one of these criteria warrants use of Level B protection:

- The type(s) and atmospheric concentration(s) of toxic substances have been identified and require the highest level of respiratory protection, but a lower level of skin and eye protection. These would be atmospheres:

  -- with concentrations Immediately Dangerous to Life and Health (IDLH)

  or

  -- exceeding limits of protection afforded by a full-face, air-purifying mask

  or

  -- containing substances for which air-purifying canisters do not exist or have low removal efficiency

  or

  -- containing substances requiring air-supplied equipment, but substances and/or concentraions do not respresent a serious skin hazard.

- The atmosphere contains less than 19.5% oxygen.

- Site operations make it highly unlikely that the small, unprotected area of the head or neck will be contacted by splashes of extremely hazardous substances.

*Optional

- Total atmospheric concentrations of unidentified vapors or gases range from 5 ppm to 500 ppm on instruments such as the Century OVA System or HNU Photoionizer, and vapors are not suspected of containing high levels of chemicals toxic to skin. (See Appendixes I and II.)

3. Guidance on selection criteria

Level B equipment provides a high level of protection to the respiratory tract, but a somewhat lower level of protection to skin. The chemical-resistant clothing required in Level B is available in a wide variety of styles, materials, construction detail, permeability, etc. These factors all affect the degree of protection afforded. Therefore, a specialist should select the most effective chemical-resistant clothing (and fully encapsulating suit) based on the known or anticipated hazards and/or job function.

Generally, if a self-contained breathing apparatus is required, Level B clothing rather than a Level A fully encapsulating suit is selected, based on the protection needed against known or anticipated substances affecting the skin. Level B skin protection is selected by:

- Comparing the concentrations of known or identified substances in air with skin toxicity data.

- Determining the presence of substances that are destructive to and/or readily absorbed through the skin by liquid splashes, unexpected high levels of gases or particulates, or other means of direct contact.

- Assessing the effect of the substance (at its measured air concentrations or splash potential) on the small area of the head and neck unprotected by chemical- resistant clothing.

For initial site entry and reconnaissance at an open site, approaching whenever possible from the upwind direction, Level B protection (with good quality, hooded, chemical-resistant clothing) should protect response personnel, providing the conditions described in selecting Level A are known or judged to be absent. For continuous operations, the aforementioned criteria must be evaluated.

At 500 ppm total vapors/gases, upgrading to Level A protection may be advisable. A major factor for re-evaluation is the presence of vapors, gases, or particulates requiring a higher degree of skin protection.

C. Level C Protection

1. Personal protective equipment

- Full-face, air-purifying, canister-equipped respirator (MSHA/NIOSH approved)

- Chemical-resistant clothing (coveralls; hooded, two-piece chemical splash suit; chemical-resistant hood and apron; disposable chemical-resistant coveralls)

- Coveralls*
- Gloves (outer), chemical-resistant
- Gloves (inner), chemical-resistant*
- Boots (outer), chemical-resistant, steel toe and shank
- Boots (outer), chemical-resistant (disposable)*
- Hard hat (face shield*)
- Escape mask*
- 2-Way radio communications (intrinsically safe)

2. Criteria for selection

Meeting all of these criteria permits use of Level C protection:

- Measured air concentrations of identified substances will be reduced b the respirator to at or below the substance's exposure limit, and the concentration is within the service limit of the canister.
- Atmospheric contaminant concentrations do not exceed IDLH levels.
- Atmospheric contaminants, liquid splashes, or other direct contact wil not adversely affect the small area of skin left unprotected by chemic resistant clothing.
- Job functions have been determined not to require self-contained breathing apparatus.
- Total vapor readings register between background and 5 ppm above background on instruments such as the HNU Photoionizer and Century OVA System. (See Appendixes I and II.)
- Air will be monitored periodically.

3. Guidance on selection criteria

Level C protection is distinguished from Level B by the equipment used to protect the respiratory system, assuming the same type of chemical-resistant clothing is used. The main selection criterion for Level C is that conditions permit wearing air-purifying devices.

The air-purifying device must be a full-face mask (MSHA/NIOSH approved) equipped with a canister suspended from the chin or on a harness. Canist

*Optional

must be able to remove the substances encountered. uarter- or half-masks or cheek-cartridge full-face masks should be used only w'th the approval of a qualified individual.

In addition, a full-face, air-purifying mask can be used only if:

- Oxygen content of the atmosphere is at least 19.5% by volume.
- Substance(s) is identified and its concentration(s) measured.
- Substance(s) has adequate warning properties.
- Individual passes a qualitative fit-test for the mask.
- Appropriate cartridge/canister is used, and its service limit concentration is not exceeded.

An air monitoring program is part of all response operations when atmospheric contamination is known or suspected. It is particularly important that the air be monitored throroughly when personnel are wearing air-purifying respirators (Level C). Continual surveillance using direct-reading instruments and air sampling is needed to detect any changes in air quality necessitating a higher level of respiratory protection. See Part 8 for guidance on air monitoring.

Total unidentified vapor/gas concentrations of 5 ppm above background require Level B protection. Only a qualified individual should select Level C (air-purifying respirators) protection for continual use in an unidentified vapor/gas concentration of background to 5 ppm above background.

D. Level D Protection

1. Personal protective equipment

- Coveralls
- Gloves*
- Boots/shoes, leather or chemical-resistant, steel toe and shank
- Boots (outer), chemical-resistant (disposable)*
- Safety glasses or chemical splash goggles*
- Hard hat (face shield)*
- Escape mask*

2. Criteria for selection

Meeting any of these criteria allows use of Level D protection:

No hazardous air pollutants have been measured.

*Optional

Work functions preclude splashes, immersion, or potential for unexpected inhalation of any chemicals.

3. Guidance on selection criteria

Level D protection is primarily a work uniform. It can be worn in areas where: 1) only boots can be contaminated, or 2) there are no inhalable toxic substances.

III. PROTECTION IN UNKNOWN ENVIRONMENTS

In all site operations, selecting the appropriate personnel protection equipment is one of the first steps in reducing the potential for adverse health effects. Until the hazardous conditions presented by an environmental incident can be identified and personnel safety measures commensurate with the hazards - real or potential - instituted, preliminary measures will have to be based on applying experience, judgment, and professional knowledge to the particular incident at hand. Lack of knowledge concerning the hazards that could be encountered precludes selecting protective equipment by comparing environmental concentrations of known toxicants against protection afforded by e[illegible] ty of equipment.

One of the first considerations in evaluating the risk of an unknown environment is to measure immediate atmospheric hazards such as the concentrations (or potential concentrations) of vapors, gases, and particulates; oxygen content of the air; explosive potential; and, to a lesser degree, the possibility of radiation exposure. In addition to a[illegible] measurements, visual observation and/or evaluation of existing data can help determine the degree of risk from other materials that are explosi[illegible] have a high fire potential, are extremely toxic, or exhibit other hazardous characteristics that cannot be monitored by field instruments.

Total vapor/gas concentration as indicated by instruments such as the Century OVA System or the HNU Photoionizer is a useful adjunct to professional judgment in selecting the Level of Protection to be worn i[illegible] an unknown environment. It should not be the sole criterion, but shoul[illegible] be considered with all other available information. Total vapor/gas concentration should be applied only by qualified persons thorough[illegible] familiar with the information contained in Appendixes I and II.

The initial on-site survey and reconnaissance, which may consist of mor[illegible] than one entry, is to characterize the immediate hazards and, based on these findings, establish preliminary safety requirements. As data are obtained from the initial survey, the Level of Protection and other saf[illegible] procedures are adjusted. Initial data also provide information on whic[illegible] to base further monitoring and sampling. No method can select a Level c[illegible] Protection in all unknown environments. Each situation must be examine[illegible] individually. Some general approaches can be given, however, for judgir[illegible] the situation and determining the Level of Protection required.

A. Level C

Level C protection (full-face, air-purifying respirator) should be worn routinely in an atmosphere only after the type(s) of air contaminant(s) is identified and concentrations measured. To permit flexibility in prescribing a Level of Protection at certain environmental incidents, a specialist could consider air-purifying respirators for use in unidentified vapor/gas concentrations of a few parts per million. The guideline of total vapor/gas concentration of background to 5 ppm above background should not be the sole criterion for selecting Level C. Since the individual contributors may never be completely identified, a decision on continuous wearing of Level C must be made, after assessing all safety considerations, including:

- The presence of (or potential for) organic or inorganic vapors/gases against which a canister is ineffective or has a short service life.

- The known (or suspected) presence in air of substances with low TLV or IDLH levels.

- The presence of particulates in air.

- The errors associated with both the instruments and monitoring procedures used.

- The presence of (or potential for) substances in air which do not elicit a response on the instrument(s) used.

- The potential for higher concentrations in the ambient atmosphere or in the air adjacent to specific site operations.

The continuous use of air-purifying respirators (Level C) should be based on the identification of the substances contributing to the total vapor/gas concentration and the application of published criteria for the routine use of air-purifying devices. Unidentified ambient concentrations of organic/vapors or gases in air approaching or exceeding 5 ppm above background require Level B protection.

Individuals without appropriate training and/or experience should be discouraged from modifying upward the recommended total vapor/gas concentration guideline and associated Levels of Protection.

B. Level A

Level A should be worn when maximum protection is needed against substances that could damage the surface of the skin and/or be absorbed through the skin. Since Level A requires the use of a self-contained breathing apparatus, the eyes and respiratory system are also protected. For initial site entry, skin toxicants would exist primarily as vapors, gases, or particulates in air, with a lesser possibility of splash. Continuous operations at an abandoned waste sit for instance, may require Level A due to working with and around severe skin toxicants.

Until air monitoring data are available to assist in the selection of t appropriate Level of Protection, the use of Level A for initial site entries may have to be based on indirect evidence of the potential for. atmospheric contamination or direct skin contact.

Considerations that may require Level A protection include:

- Confined spaces: Enclosed, confined, or poorly ventilated areas are conducive to buildup in air of toxic vapors, gases, or particulates. (Explosive or oxygen-deficient atmospheres also are more probable in confined spaces.) Low-lying outdoor areas - ravines, ditches, and gulleys - tend to accumulate any heavier-than-air vapors or gases present.

- Suspected/known toxic substances: Various substances may be known c suspected to be involved in an incident, but there are no field instruments available to detect or quantify air concentrations. In these cases, media samples must be analyzed in the laboratory. Unti these substances are identified and levels measured, maximum protection may be necessary.

- Visible emissions: Visible emissions from leaking containers or railroad/vehicular tank cars, as well as smoke from chemical fires, indicate high potential for concentrations of substances that could extreme respiratory or skin hazards.

- Job functions: Initial site entries are generally walk-throughs in which instruments and/or visual observations provide a preliminary characterization of the hazards. Subsequent entries are to conduct the many activities needed to reduce the environmental impact of th hazards. Levels of Protection for later operations are based not o on data obtained from the initial and subsequent environmental monitoring, but also on the probability of contamination. Maximum protection (Level A) should be worn when:

  -- there is a high probability for exposure to high concentrations vapors, gases, or particulates.

  -- substances could splash.

  -- substances are known or suspected of being extremely toxic direc to the skin or by being absorbed.

Examples of situations where Level A has been worn are:

- Excavating of soil suspected of being contaminated with dioxin.