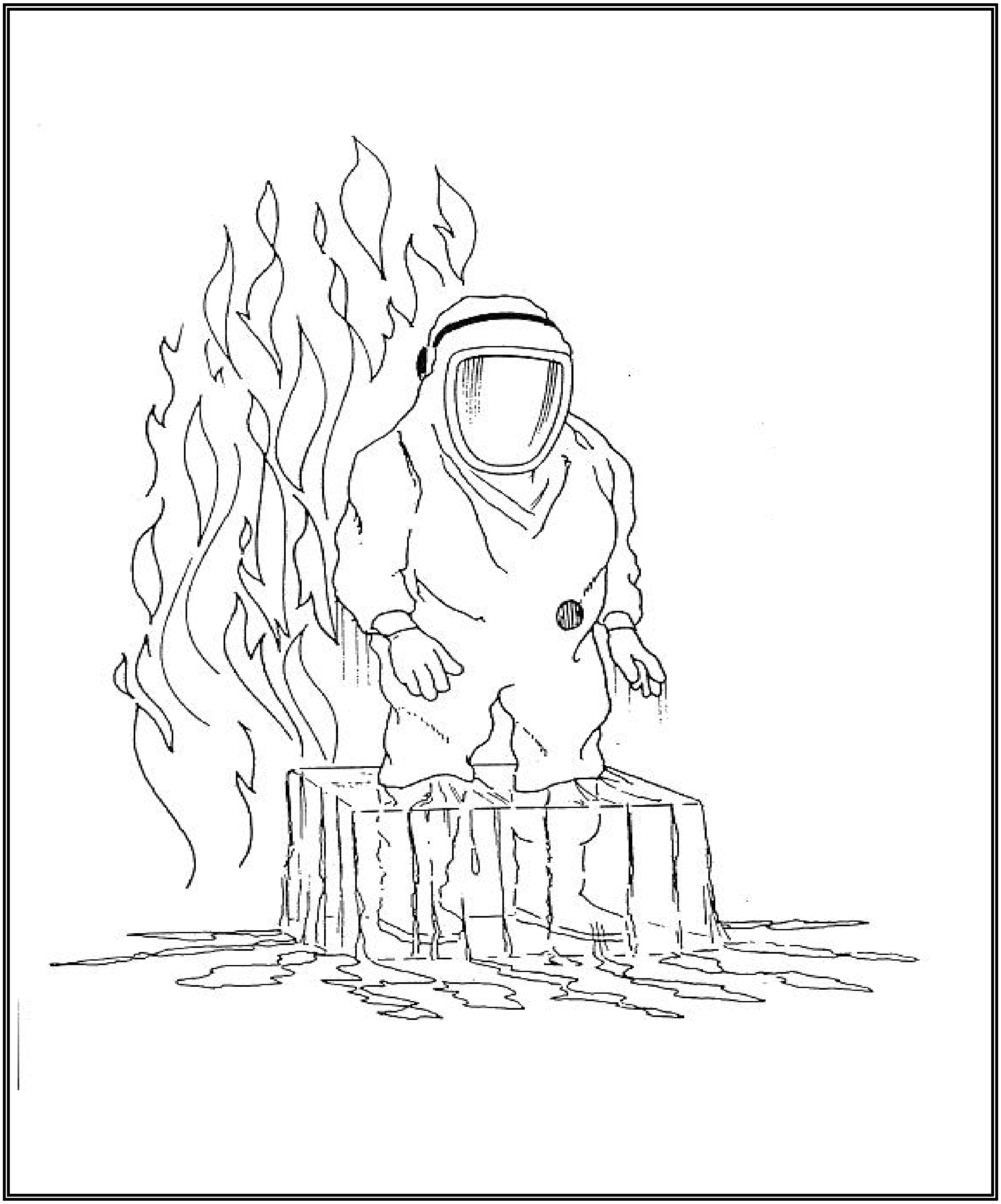
CHAPTER 8 HEAT STRESS AND COLD EXPOSURE

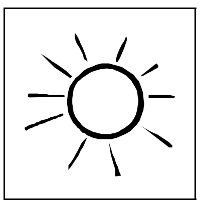


CHAPTER 8 HEAT STRESS AND COLD EXPOSURE

8.0 INTRODUCTION

Temperature extremes pose a hazard of particular concern to the health, safety, and comfort of personnel involved in hazardous waste site activities. Site health and safety personnel must consider the two most common dangers, heat stress and cold exposure, when making decisions regarding PPE selection and work mission duration, when establishing standard operating procedures for site activities, and when conducting medical monitoring.

8.1 HEAT STRESS



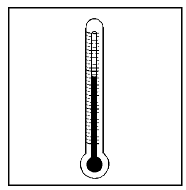
Heat stress is one of the most common and potentially serious illnesses at hazardous waste sites and, therefore, warrants regular monitoring and other preventive measures. Heat stress is caused by a number of interacting factors, including environmental conditions, clothing, workload, and the individual characteristics of the worker. Depending on the ambient conditions and the work being performed, heat stress can occur very rapidly -- within as little as 15 minutes -- and can pose as great a danger to worker health as chem-ical exposure. In its early stages, heat stress can cause rashes, cramps, and drowsiness. This can result in impaired functional ability that threatens the safety of both the individual and co-workers. Continued heat stress can lead to heat stroke and death.

8.1.1 Heat Stress and PPE

Heat stress is a major health hazard for workers wearing PPE because the same protective materials that shield the body from chemical exposure also limit the dissipation of body heat and moisture. Thus, personal protective clothing can create a hazardous condition.

Reduced work tolerance and the increased risk of excessive heat stress is directly influenced by the amount and type of PPE worn. The added weight and bulk of PPE severely reduces the body's access to normal heat exchange mechanisms and increases energy expenditure. When selecting PPE, therefore, each item's benefit should be carefully evaluated in relation to its potential for increasing the risk of heat stress. After PPE has been selected, the safe duration of work/rest periods should be determined based on the anticipated work rate, the ambient temperature and other environmental factors, the type of protective ensemble, and the individual worker characteristics and fitness.

8.1.2 Monitoring for Heat Stress



All workers, even those not wearing protective equipment, should be monitored, because the incidence of heat stress depends on a variety of factors and can affect any worker. Monitoring should be initiated before initial entry and should be continued during each break cycle. Some general guidelines include:

- For
  monitor for signs of heat stress and follow

- For workers wearing semipermeable or
  encapsulating ensembles,
  work
  the temperature in the work area is above
  °F °C). °F, monitoring
  considered on a case-by-case basis.

To
measure the heart rate and body temperature, as

Heart Rate Count the radial pulse during a
period. If the heart rate exceeds 110 beats per
at the beginning of the rest period, shorten the

EXHIBIT 8-1
Suggested Frequency of Physiological Monitoring for Fit and Acclimatized Workers[a]

ADJUSTED TEMPERATURE[b]	NORMAL WORK ENSEMBLE[c]	IMPERMEABLE ENSEMBLE
90°F (32.2°) or above	After each 45 minutes of work	After each 15 minutes of work
87.5°- 90°F (30.8°- 32.2°C)	After each 60 minutes of work	After each 30 minutes of work
82.5°- 87.5°F (28.1°- 30.8°C)	After each 90 minutes of work	After each 60 minutes of work
77.5°- 82.5°F (25.3°- 28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5°-77.5°F (22.5°-25.3°C)	After each 150 minutes of work	After each 120 minutes of work

[a] For work levels of 250 kilocalories/hour.
[b] Calculate the adjusted air temperature (ta adj) by using this equation: ta adj °F = ta °F + (13 X % sunshine). Measure air temperature (ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow. (100 percent sunshine = no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows.)
[c] A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and pants.

Source: *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities* (NIOSH/OSHA/USCG/EPA, 1985).

period the same. If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third.

Oral Temperature. Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking). If oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one-third without changing the rest period. If oral temperatu re still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one-third. Do not permit a worker to wear a semipermeable or impermeable garment when his/her oral temperature exceeds 100.6°F (38.1°C).

Initially, the length of the work cycle should be governed by the frequency of the required physiological monitoring. The frequency of physiological monitoring depends on the air temperature adjusted for solar radiation and the level of physical work (see **Exhibit 8-1**, above).

8.1.3 Preventing Heat Stress

To protect against heat stress, it is important to choose the appropriate level of protection, to provide careful training for workers and site personnel, and to monitor frequently personnel who wear protective clothing. It is also important to ensure that work and rest periods are scheduled regularly, and that workers frequently replace lost fluids (it is not uncommon for workers to lose as many as 6 to 8 quarts of water in a hot shift).

Proper training and preventive measures will help avert serious illness and loss of work productivity caused by heat stress. Preventing heat stress is particularly important because one incident of heat stress will increase the likelihood of future incidences. The site health and safety officer should take the following steps to prevent heat stress:

- Adjust work and rest schedules as needed;

- Provide shelter or shaded areas to protect personnel during rest periods;

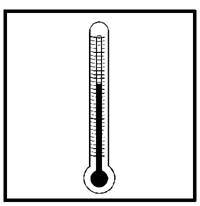
- Maintain workers' body fluids at normal levels to ensure that the cardiovascular system functions adequately. Daily fluid intake must equal the approximate amount of water lost in sweat;

- Encourage workers to maintain an optimal level of physical fitness. Fit individuals
acclimatize more readily to temperatures;

- Provide cooling devices to aid natural body heat exchange during prolonged work or severe heat exposure. Effective devices include field showers or hose-down areas, as well as cooling jackets, vests, or suits;

- Train workers to recognize and treat heat stress, and to identify the signs and symptoms of heat stress (e.g., muscle spasms, dizziness, lack of perspiration). Refer to **Exhibit 8-2** for more detail on the signs and symptoms of heat stress.

8.2 COLD EXPOSURE



Exposure to cold temperatures can cause frostbite and hypothermia as well as impair the ability to work. Extremely low temperatures are not necessary to suffer cold exposure -- a strong wind combined with a cold temperature can chill the body to the point where frostbite and hypothermia are a risk. Maintaining body temperature and recognizing the early signs and symptoms can help prevent illness and injury due to cold exposure.

Cold injury is generally classified as local (e.g., frostbite or frostnip) or general (e.g., hypothermia). The main factors contributing to cold injury are exposure to humidity and high winds, contact with wetness or metal, inadequate clothing, age, and general health. Physical conditions that worsen the effects of cold include allergies, vascular disease, excessive smoking and drinking, and use of specific drugs and medicines.

8.2.1 PPE And Cold Exposure

The correct PPE depends on the specific cold stress situation. It is important to preserve the air space between the body and the outer layer of clothing in order to retain body heat. The more air pockets each layer of clothing has, the better the insulation. However, the insulating effect is negated if the clothing interferes with the evaporation of sweat, or if the skin or clothing is wet.

The most important parts of the body to protect are the feet, hands, head, and face. Hands and feet are the farthest from the heart, and become cooled most easily. Keeping the head covered is important, because as much as 40 percent of body heat can be lost when the head is exposed.

Workers should wear several layers of clothing instead of a single heavy outer garment. In addition to offering better insulation, layers of clothing can be removed as needed to keep the worker from overheating. The outer layer should be windproof as well as waterproof, because body heat is lost quickly in even light winds.

8.2.2 Monitoring for Cold Exposure

Recognizing the early signs and symptoms of cold stress can help prevent serious injury. Described below are the most common types of cold injury and their monitoring signals.

Hypothermia. The first symptoms of hypothermia are uncontrollable shivering and the sensation of cold; the heartbeat slows and sometimes becomes irregular, the pulse weakens, and the blood pressure changes. Severe shaking or rigid muscles may be caused by bursts of body energy and changes in the body's chemistry. Uncontrollable fits of shivering, vague or slow slurred speech, memory lapses, incoherence and drowsiness are some of the symptoms that can occur. Other symptoms that can be seen before complete collapse are cool skin, slow and irregular breathing, low blood pressure, apparent

EXHIBIT 8-2
Classification, Medical Aspects, and Prevention of Heat Illness

Category and Clinical Features	Predisposing Factors	Underlying Physiological Disturbance	Treatment	Prevention
Temperature Regulation Heatstroke				
Heatstroke: (1) Hot dry skin usually red, mottled or cyanotic; (2) rectal temperature 40.5°C (104°F) and over; (3) confusion, loss of consciousness, convulsions, rectal temperature continues to rise; fatal if treatment delays	(1) Sustained exertion in heat by unacclimatized workers; (2) lack of physical fitness and obesity; (3) recent alcohol intake; (4) dehydration; (5) individual susceptibility; and (6) chronic cardiovascular disease	Failure of the central drive for sweating (cause unknown) leading to loss of evaporative cooling and an uncontrolled accelerating rise in t_{re}, there may be partial rather than complete failure of sweating	Immediate and rapid cooling by immersion in chilled water with massage or by wrapping in wet sheet with vigorous fanning with cool dry air, avoid overcooling, treat shock if present	Medical screening of workers, selection based on health and physical fitness, acclimatization for 5-7 days by graded work and heat exposure, monitoring workers during sustained work in severe heat
Circulatory Hypostasis Heat Syncope				
Fainting while standing erect and immobile in heat	Lack of acclimatization	Pooling of blood in dilated vessels of skin and lower parts of body	Remove to cooler area, rest recumbent position, recovery prompt and complete	Acclimatization, intermittent activity to assist venous return to heart
Water and/or Salt Depletion				
(a) <u>Heat Exhaustion</u> (1) Fatigue, nausea, headache, giddiness; (2) skin clammy and moist; complexion pale, muddy, or hectic flush; (3) may faint on standing with rapid thready pulse and low blood pressure; (4) oral temperature normal or low but rectal temperature, usually elevated (37.5-38.5°C) (99.5-101.3°F); water restriction type: urine volume small, highly concentrated; salt restriction type: urine less concentrated chlorides less than 3 g/L	(1) Sustained exertion in heat; (2) lack of acclimatization; and (3) failure to replace water lost in sweat	(1) Dehydration from deficiency of water; (2) depletion of circulating blood volume; (3) circulatory strain from competing demands for blood flow to skin and to active muscles	Remove to cooler environment, rest recumbent position, administer fluids by mouth, keept at rest until urine volume indicates that water balances have been restored	Acclimatize workers using a breaking-in schedule for 5-7 days, supplement dietary salt only during acclimatization, ample drinking water to be available at all times and to be taken frequently during work day

Category and Clinical Features	Predisposing Factors	Underlying Physiological Disturbance	Treatment	Prevention
Water and/or Salt Depletion (cont)				
(b) Heat Cramps				
Painful spasms of muscles used during work (arms, legs, or abdominal); onset during or after work hours	(1) Heavy sweating during hot work; (2) drinking large volumes of water without replacing salt loss	Loss of body salt in sweat, water intake dilutes electrolytes, water enters muscles, causing spasm	Salted liquids by mouth, or more prompt relief by I-V infusion	Adequate salt intake with meals; in unacclimatized workers supplement salt intake at meals.
Skin Eruptions				
(a) Heat Rash (miliaria rubra; "prickly heat")				
Profuse tiny raised red vesicles (blister-like) on affected areas pricking sensations during heat exposure	Unrelieved exposure to humid heat with skin continuously wet with unevaporated sweat	Plugging of sweat gland ducts with retention of sweat and inflammatory reaction	Mild drying lotions, skin cleanliness to prevent infection	Cool sleeping quarters to allow skin to dry between heat exposures
(b) Anhidrotic Heat Exhaustion (miliaria profunda)				
Extensive areas of skin which do not sweat on heat exposure, but present gooseflesh appearance, which subsides with cool environments; associated with incapacitation in heat	Weeks or months of constant exposure to climatic heat with previous history of extensive heat rash and sunburn	Skin trauma (heat rash; sunburn) causes sweat retention deep in skin, reduced evaporative cooling causes heat intolerance	No effective treatment available for anhidrotic areas of skin, recovery of sweating occurs gradually on return to cooler climate	Treat heat rash and avoid further skin trauma by sunburn, periodic relief from sustained heat
Behavioral Disorders				
(a) Heat Fatigue - Transient				
Impaired performance of skilled sensorimotor, mental, or vigilance tasks, in heat	Performance decrement greater in unacclimatized and unskilled worker	Discomfort and physiologic strain	Not indicated unless accompanied by other heat illness	Acclimatization and training for work in the heat
(b) Heat Fatigue - Chronic				
Reduced performance capacity, lowering of self-imposed standards of social behavior (e.g., alcoholic over-indulgence), inability to concentrate, etc.	Workers at risk come from temperate climates for long residence in tropical latitudes	Psychosocial stresses probably as important as heat stress, may involve hormonal imbalance but no positive evidence	Medical treatment for serious causes, speedy relief of symptoms on returning home	Orientation on life in hot regions (customs, climate, living conditions, etc.)

exhaustion, and fatigue after rest. As the core body temperature drops, the victim may become listless, confused, and make little or no attempt to keep warm. Pain in the extremities can be the first warning of dangerous exposure to cold. Severe shivering must be taken as a sign of danger. If the body core temperature reaches about 85°F, significant and dangerous drops in blood pressure, pulse rate, and respiration can occur. In some cases, the victim may die.

Frostbite. Frostbite can occur without hypothermia when the extremities do not receive sufficient heat from central body stores. This can occur because of inadequate circulation and/or insulation. Frostbite occurs when there is freezing of the fluids around the cells of the body tissues due to extremely low temperatures. Frostbite may result in damage to and loss of tissue, and usually affects the nose, cheeks, ears, fingers, and toes. Damage from frostbite can be serious (e.g., scarring, tissue death resulting in amputation, and permanent loss of movement in the affected parts).

The freezing point of the skin is about 30°F (-1°C). As wind velocity increases, heat loss is greater and frostbite will occur more rapidly. If skin comes into contact with objects colder than freezing (e.g., tools or machinery), frostbite may develop at the point of contact, even in warmer environments.

There are three degrees of frostbite: first degree, which is freezing without blistering or peeling; second degree, which is freezing with blistering or peeling; and third degree, which is freezing with tissue death. **Exhibit 8-3** lists the symptoms of frostbite. It is important to remember that the victim is often unaware of the frostbite until someone else observes the symptoms.

8.2.3 Preventing Cold Exposure

In preventing cold stress, health and safety professionals must consider factors relating both to the individual and to the environment. Acclimatization, water and salt replacement, medical screening, continuing medical supervision, proper work clothing, and training and education will contribute to the prevention of cold stress and injury related to working in a cold environment. Control of the environment involves engineering controls, work practices, work-rest schedules, environmental monitoring , and considerations of windchill temperatures.

EXHIBIT 8-3
Symptoms of Frostbite

- The first symptom of frostbite is an uncomfortable sensation of coldness, followed by numbness. There may be tingling, stinging, aching, or cramping.
- The skin changes color to white or grayish-yellow, then to reddish-violet, and finally turns black as the tissue dies.
- Pain may be felt at first, but subsides.
- Blisters may appear.
- The affected part is cold and numb.
- When frostbite of the outer layer of skin occurs, the skin has a waxy or whitish look and is firm to the touch.
- In cases of deep frostbite, the tissues are cold, pale, and solid. Injury is severe.

Acclimatization. Some degree of acclimatization may be achieved in cold environments. With sufficient exposure to cold, the body undergoes some changes that increase comfort and reduce the risk of cold injury. However, these physiological changes are usually minor and require repeated uncomfortably cold exposures to induce them. People who are physically unfit, older, obese, taking medication, or using alcohol or drugs may not acclimatize too readily.

Dehydration. Working in cold areas causes significant water losses through the skin and lungs as a result of the dryness of the air. Increased fluid intake is essential to prevent dehydration, which affects the flow of blood to the extremities and increased the risk of cold injury. Warm, sweet, caffeine-free, non-alcoholic drinks and soup should be available at the work-site for fluid replacement and caloric energy.

Salt. The body needs a certain amount of salt and other electrolytes to function properly. However, using salt tablets is not recommended. Salt tablets cause stomach irritation, which may include nausea and vomiting. A normal, balanced diet should take care of salt needs. Anyone with high blood pressure or who is on a restricted sodium diet should consult a physician for advice on salt intake.

Windchill. Air temperature alone is not sufficient to judge the cold hazard of a particular environment, because even a light wind can blow away the thin layer of air that insulates the body against the cold air temperature. The "windchill factor" is the cooling effect of any combination of temperature and air movement. The windchill index (**Exhibit 8-4**) should be consulted to estimate the equivalent temperature felt by personnel working in cold and windy environments. Remember, however, that the windchill index does not take into account: (1) the body part exposed to the cold: (2) the level of activity and the resulting heat produced; or (3) the amount of clothing worn.

Continuous exposure of skin should not be permitted when the windchill factor results in an equivalent temperature of -32°C (-26°F). Workers exposed to air temperatures of 2°C (35.6°) or lower who become immersed in water or whose clothing gets wet should be given dry clothing and be treated for hypothermia.

Special Considerations. Older workers and workers with circulatory problems need to be extra careful in the cold. Additional insulating clothing and reduced exposure time should be considered for these workers. Obese and chronically ill people need to make a special effort to follow preventive measures. Sufficient sleep and good nutrition are important for maintaining a high level of tolerance to cold. If possible, the most stressful tasks should be performed during the warmer parts of the day. Double shifts and overtime should be avoided. Rest periods should be extended to cope with increases in cold stress.

Workers should immediately go to warm shelter if any of the following symptoms are spotted: the onset of heavy shivering, frostnip, the feeling of excessive fatigue, drowsiness, and/or euphoria. The outer layer of clothing should be removed when entering a heated shelter. If possible, a change of dry work clothing should be provided to prevent workers from returning to work with wet clothing. If this is not feasible, the remaining clothing should be loosened to permit sweat to evaporate.

Alcohol should not be consumed while in the warmer environment. Anyone on medication such as blood pressure control or water pills should consult a physician about possible side effects from cold stress. It is strongly recommended that workers suffering from diseases or taking medication that interferes with normal body temperature regulation, or that reduces tolerance of cold, not be permitted to work in temperatures of -1°C (30°F) or below.

To guard against cold exposure, provide workers with appropriate clothing, have warm shelter available at all times, carefully schedule work and rest periods, and monitor workers" physical conditions. Under no circumstances should a person be given an alcoholic beverage "to keep warm." Alcohol causes the body to release heat more quickly and will therefore increase the risk of cold exposure. Fruits can help warm the body by creating increased energy and metabolism.

EXHIBIT 8-4
Windchill Index[1]

Wind speed in mph	ACTUAL THERMOMETER READING (F)									
	50	40	30	20	10	0	-10	-20	-30	-40
	EQUIVALENT TEMPERATURE (F)									
calm	50	40	30	20	10	0	-10	-20	-30	-40
5	48	37	27	16	6	-5	-15	-26	-36	-47
10	40	28	16	4	-9	-21	-33	-46	-58	-70
15	36	22	9	-5	-18	-36	-45	-58	-72	-85
20	32	18	4	-10	-25	-39	-53	-67	-82	-96
25	30	16	0	-15	-29	-44	-59	-74	-88	-104
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109
35	27	11	-4	-20	-35	-49	-67	-82	-98	-113
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116
Over 40 mph (little added effect)	Little Danger (for properly clothed person)				Increasing Danger			Great Danger		
					(Danger from freezing of exposed flesh)					

[1]Source: *Fundamentals of Industrial Hygiene, Third Edition*. Plog, B.A., Benjamin, G.S., Kerwin, M.A., National Safety Council, 1988.

8.2.4 A Control Program for Cold Stress

A control program for preventing cold stress at hazardous waste sites should include the following elements:

! **Medical supervision of workers** including pre-placement physicals that evaluate fitness, weight, the cardiovascular system, and other conditions that might make workers susceptible to cold stress. Medical evaluation during and after cold illnesses and a medical release for returning to work should be required.

! **Employee orientation and training** on cold stress, cold-induced illnesses and their symptoms, water and alt replacement, proper clothing, work practices, and emergency first aid procedures.

! **Work-rest regimens**, with heated rest areas and enforced rest breaks.

! **Scheduled drink breaks** for recommended fluids.

! **Environmental monitoring**, using the air temperature and wind speed indices to determine wind chill and adjust work/rest schedules accordingly.

! **Reduction of cold stress** through engineering and administrative controls, and the used of personal protective equipment.

FURTHER GUIDANCE: For additional information on recognizing, preventing, and controlling heat and cold stress, see:

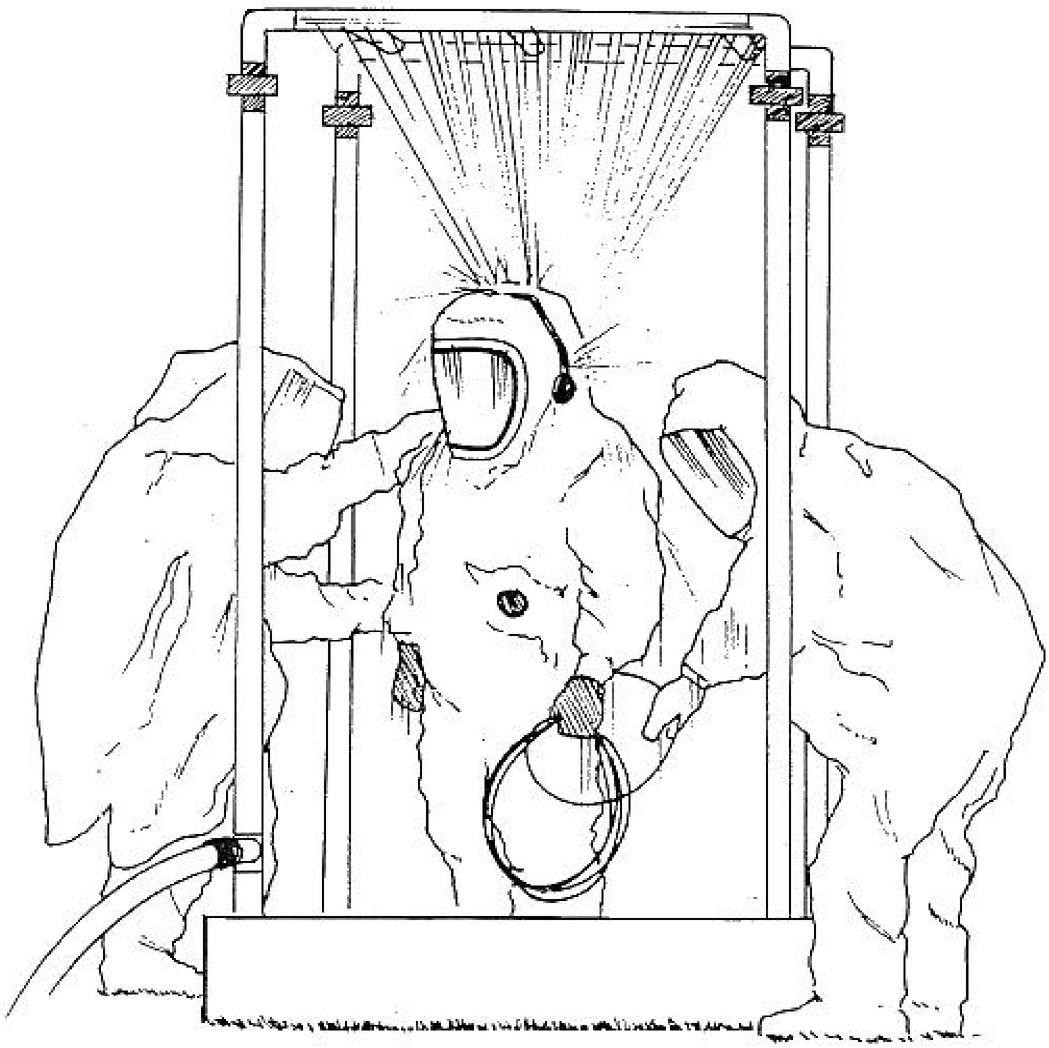
1. Plog, Barbara A., Benjamin, G.S., and M.A. Kerwin. *Fundamentals of Industrial Hygiene, Third Edition.* National Safety Council, 1988.

2. *Pocket Guide to Cold Stress.* National Safety Council, 1985.

3. *Pocket Guide to Heat Stress.* National Safety Council, 1985.

4. *1991-1992 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices.* American Conference of Governmental Industrial Hygienists, 1991.

CHAPTER 9   DECONTAMINATION



CHAPTER 9 DECONTAMINATION

9.0 INTRODUCTION

Decontamination, the process of removing or neutralizing contaminants, is critical to health and safety at hazardous waste sites. Decontamination protects workers from hazardous substances that can eventually permeate protective clothing, respiratory equipment, tools, and vehicles. It protects site personnel by minimizing the spread of hazardous substances into clean areas on-site, prevents the mixing of incompatible wastes, and protects the community by preventing the migration of contaminants from the site. Personnel engaged in hazardous waste operations may become contaminated in a number of ways, including:

- Contacting vapors, gases, mists, or particulates in the air;
- Being splashed by materials while sampling or opening containers;
- Walking through puddles of liquids or sitting in contaminated soil; and
- Using contaminated instruments or equipment.

Protective clothing and respirators help prevent the wearer from becoming contaminated or inhaling hazardous substances, and good work practices help minimize contamination on PPE, instruments, and equipment. But even with these safeguards, contamination may occur. To prevent and minimize the severity of such incidences, the HAZWOPER regulations at 29 CFR §1910.120(k) require the development of a decontamination plan prior to site entry; the development of standard operating procedures (SOPs) to minimize contam-ination; full decontamination of employees and equipment; and the monitoring of decontamination procedures by the Site Health and Safety Officer.

Cross contamination from protective clothing to the wearer, from equipment to personnel, and from one area to another can be minimized by combining decontamination, the correct methods for removing contaminated PPE, and the use of site work zones. This chapter provides an overview of decontamination, provides general guidelines for designing and selecting decontamination procedures at a site, explains equipment for decontamination procedures, and discusses how decontamination and PPE are related.

9.1 THE DECONTAMINATION PLAN

Any site where hazardous waste cleanup operations occur must have a plan that outlines decontamination procedures (29 CFR §1910.120(k)). These procedures must be made available to employees and must be implemented before anyone enters areas on-site where there is suspected contamination. The plan must ensure that chosen decontamination methods are effective for the specific hazardous substances present, and that the methods themselves do not pose any health or safety hazards. The decontamination plan also should address:

- The number and placement of decontamination stations;
- The necessary decontamination equipment and methods;
- SOPs to prevent contamination of clean areas and to minimize worker contact with contaminants during removal of PPE; and
- Methods for disposing of clothing and equipment that may not be completely decontaminated.

9.2 DEVELOPING THE PLAN

The initial decontamination plan should be based on the assumption that all personnel and equipment leaving the Exclusion Zone ("hot zone") will be grossly contaminated. A personnel decontamination system should then be established to wash and rinse (at least once) all protective equipment used in contaminated areas. This should be done in combination with a sequential doffing of protective equipment, starting at the first decontamination station with the most heavily contaminated item and progressing to the last decontamination station with the least contaminated article (see Section 9.3).

An essential part of the plan should address SOPs for site operations, that is, methods to **prevent** the contamination of people and equipment. For example, using remote sampling techniques, not opening containers by hand, bagging monitoring instruments, using drum grapplers, watering down dusty areas, and not walking through areas of obvious contamination would reduce the probability of becoming contaminated and, therefore, would reduce decontamination time.

The initial decontamination plan should be based on a worst-case situation and should assume no information is available about on-site contaminants. The initial decontamination plan can be modified later, eliminating unnecessary stations or otherwise adapting it to site conditions, by considering the following factors:

Type of Contaminant. The extent to which personnel decontamination is required varies depending on the effects the contaminants have on the body. All contaminants do not exhibit the same degree of toxicity (or other hazard). Whenever it is known or suspected that personnel can become contaminated with highly toxic or skin-destructive substances, a full decontamination procedure should be followed. The procedure can be downgraded only if less hazardous materials are present at the site.

Amount of Contamination. The amount of contamination on protective clothing (and other objects or equipment) usually can be determined by visual inspection. If, after a visual inspection, the PPE appears grossly contaminated, a thorough decontamination is highly recommended. Gross material remaining on the protective clothing for any extended period of time may degrade or permeate it. This likelihood increases with higher air concentrations and greater amounts of liquid contamination. Gross contamination also increases the probability of personnel contact. Swipe tests may help determine the type and quantity of surface contaminants.

Type and Level of PPE. The level of protection and specific pieces of clothing worn can be used to determine the preliminary layout and decontamination stations needed for the decontamination line. Each level of protection presents different problems in decontamination and doffing of equipment. For example: decontamination of SCBA harness straps and backpack assembly often is difficult; however, a butyl rubber apron worn over the harness may make decontamination easier. Clothing variations and different levels of protection may require adding or deleting stations to the preliminary decontamination line.

Work Function. The work each person performs determines the potential for contact with hazardous materials. In turn, this should dictate the layout of the decontamination line. For example, observers, photographers, operators of air samplers, or others in the Exclusion Zone who are performing tasks that will not bring them in direct contact with contaminants may not need to have their garments washed and rinsed. Others in the Exclusion Zone with a potential for direct contact with the hazardous material will require more thorough decontamination. Different decontamination lines could be set up for different job functions, or certain stations in a line could be omitted for personnel performing certain tasks.

Location of Contamination. Contamination on the upper areas of protective clothing poses a greater risk to the worker because volatile compounds may generate a hazardous breathing concentration both for the worker and for decontamination personnel. There is also an increased probability of contact with skin when doffing the upper part of clothing.

Establishment of Procedures. Once decontamination procedures have been established, all personnel requiring decontamination must be given precise instructions (and practice, if necessary). Compliance must be checked frequently. The time it takes for decontamination also must be ascertained. Personnel wearing SCBA must leave their work area with sufficient air to walk to the Contamination Reduction Corridor and undergo decontamination.

9.3 THE CONTAMINATION REDUCTION CORRIDOR

Decontamination activities should be confined to a designated area within the Contamination Reduction Zone, known as the

Contamination Reduction Corridor. The Corridor controls access into and out of the Exclusion Zone and confines decontamination activities to a limited area. The size of the Corridor varies depending on the number of stations in the decontamination procedure, overall dimensions of work control zones, and amount of space available at the site. A Corridor of 75 feet by 15 feet is the minimum area for full decontamination. Stations should be separated physically to prevent cross contamination and should be arranged in order of decreasing contamination, preferably in a straight line. For example, outer, more heavily contaminated items (e.g., outer boots and gloves) should be decontaminated and removed first, followed by decontamination and removal of inner, less contaminated items (e.g., jackets and pants). Individual routes through the decontamination line should be developed for workers exposed to different contamination zones containing incompatible wastes. Entry and exit points should be marked clearly, and the entry and exit points into and out of the Exclusion Zone should be separate points. Dressing and redressing stations for entry and exit to the CRZ should also be separate. Personnel who wish to enter clean areas of the decontamination facility, such as locker rooms, should be completely decontaminated.

The decontamination Corridor boundaries should be conspicuously marked, with entry and exit restricted. The far end of the Corridor would be the Hotline, the boundary between the Exclusion Zone and the CRZ. Personnel exiting the Exclusion Zone must go through decontamination in the Corridor, and anyone in the Corridor should be wearing the level of protection designated for the decontamination crew. Another Corridor may be required for heavy equipment needing decontamination.

Within the Corridor, distinct areas should be set aside for decontamination of personnel, portable field equipment, removed clothing, etc. These areas should be marked and access should be restricted to personnel wearing the appropriate level of protection. All activities within the Corridor should be confined to decontamination. Personnel protective clothing, respirators, monitoring equipment, and sampling supplies should be stored and maintenanced outside of the Corridor. Personnel should not don their protective equipment in the Corridor.

9.4 DECONTAMINATION PROCEDURES AND EQUIPMENT

All personnel, clothing, equipment, and samples leaving the contaminated area of a site (the Exclusion Zone) must be decontaminated to remove any harmful chemicals or infectious organisms that may have adhered to them. Step-by-step procedures for decontamination of personnel wearing PPE Levels A through C are found in **Appendix E.**

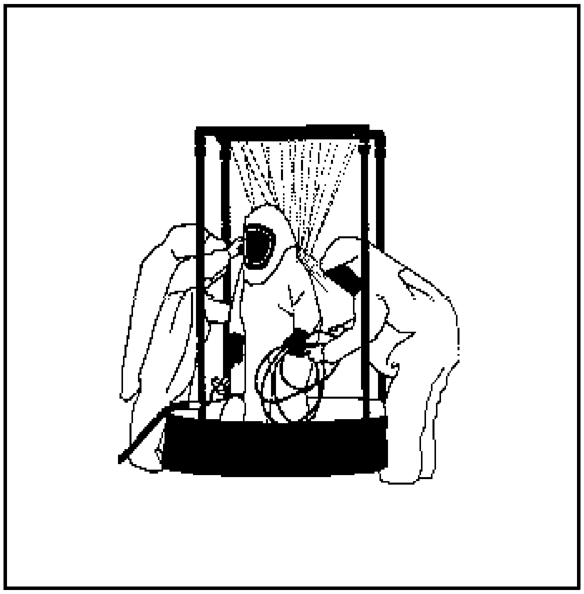
Three general types of decontamination methods are commonly used: (1) physical removal of contaminants; (2) inactivation of contaminants by chemical detoxification or disinfection/ sterilization; or (3) a combination of both physical and chemical means.

9.4.1 Physical Removal of Contaminants

In many cases, contaminants may be removed by physical means; however, high pressure and/or heat should be used only as necessary and with caution because they can spread contamination and cause burns. Some contaminants that can be physically removed are described below.

Loose Contaminants. Soils or dusts that cling to equipment and personnel or that become lodged in PPE materials can be removed with water or a liquid rinse. Commercially available anti-static solutions may help to remove electrostatically attached particles.

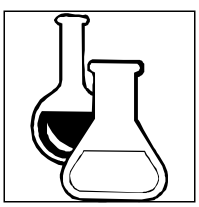
Adhering Contaminants. Some contaminants adhere by forces other than electrostatic attraction. Adhesive qualities vary greatly with the specific contaminants and the temperature. For example, contaminants such as glues, cements, resins, and muds have great adhesive properties and, consequently, are difficult to remove by physical means. Adhesive contaminants can be removed using methods such as solidification, f r e e z i n g



(e.g., using dry ice or ice water), adsorption or absorption (e.g., with powdered lime or kitty litter), or melting.

Volatile Liquids. Volatile liquid contam-inants can be removed from protective clothing or equipment by evaporation (using steam jets) followed by a water rinse. This method should be used with caution because of the potential for employees to inhale the vaporized hazardous chemicals.

9.4.2 Chemical Removal of Contaminants



Physical removal of gross contamination should be followed by washing and rinsing with cleaning solutions. These solutions normally use one or more of the following methods:

Dissolving Contaminants. Chemical removal of surface contaminants can be accomplished by dissolving them in a solvent that must be chemically compatible with the equipment being cleaned. This is particularly important when decontaminating personal protective clothing constructed of organic materials that could be damaged or dissolved by organic solvents. In addition, any flammable or toxic organic solvents must be used and disposed of cautiously. Organic solvents include alcohols, ethers, ketones, aromatics, straight-chain alkanes, and common petroleum products.

Halogenated solvents are toxic and generally are incompatible with most types of PPE. They should be used only for decontamination in extreme cases where other cleaning agents will not remove the contaminant. Because of the potential hazards, decontamination using chemicals should be done only if recommended by an industrial hygienist or other qualified health professional.

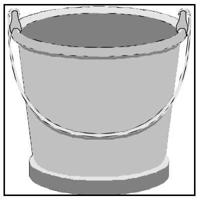
Surfactants. Surfactants supplement physical cleaning methods by minimizing adhesion between contaminants and the surface being cleaned and, therefore, prevent recontamination. Among the most common surfactants are household detergents, some of which can be used with organic solvents to improve the dissolving and dispersal of contaminants into the solvent.

Solidification. Solidifying liquid or gel contaminants can enhance their physical removal. Contaminants may be solidified by: (1) using absorbents such as grounded clay or powdered lime to remove moisture; (2) chemical reactions using polymerization catalysts and chemical reagents; and (3) freezing with ice water.

Rinsing. Rinsing removes contaminants through dilution, physical attraction, and solubilization. Multiple rinses with clean solutions remove more contaminants than a single rinse with the same volume of solution. Continuous rinsing with large volumes is the most effective way to remove contaminants.

Disinfection/Sterilization. Chemical dis-infectants are a practical means of inactivating infectious agents. Unfortunately, standard sterilization techniques are generally impractical for large equipment and PPE. For this reason, disposable PPE is recommended for use with infectious agents.

9.4.3 Decontamination Equipment



Decontamination equipment, materials, and supplies are generally selected based on availability. It is also necessary to consider whether the equipment itself can be decontaminated for reuse or can be easily disposed of. Most equipment and supplies needed for decontamination are easily procured (e.g., soft bristle and long handle brushes for scrubbing; buckets or garden sprayers for rinsing; large galvanized wash tubs or stock tanks for solutions; and large plastic garbage cans or other similar lined containers for storing contaminated clothing and equipment). Other decontamination gear includes paper or cloth towels for drying protective clothing and equipment. **Exhibits 9-1** and **9-2** list recommended equipment for decontaminating personnel and PPE, and heavy equipment and vehicles, respectively.

Currently, there are no available methods for immediately determining the effectiveness of decontamination procedures Discolorations,stains, corrosive effects, and substances adhering to objects may indicate contaminants have not been removed. However, observable effects only indicate surface contamination and not permeation (absorption) into clothing, tools, or equipment. Also, many contaminants are not easily observed.

One method for determining effectiveness of surface decontamination is swipe testing. Cloth or paper patches are wiped over predetermined surfaces of the suspect object and analyzed in a laboratory. Both the inner and outer surfaces of protective clothing should be swipe tested. Positive indications of both sets of swipes would protective clothing (or naturally absorbable materials) may have to be discarded. In this case, all small equipment items (brushes, clothing, tools) should be collected, placed in containers, and labeled. Also, all spent solutions and wash water should be collected and disposed of properly. Clothing that is not completely decontaminated should be placed in plastic bags, pending further decontamination and/or disposal.

9.5 PROTECTION OF DECONTAMINATION PERSONNEL

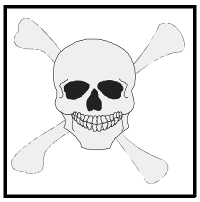
Decontamination workers are vital to the fulfillment of site decontamination procedures. It is their responsibility to monitor and aid the decon-tamination of personnel, PPE, and equipment. Decontamin-ation workers must wear the appropriate level of protection to accomplish this task without exposing themselves to the contamination. This level of protection can be determined by:

- Expected or visible contamination on workers;
- Type of contaminant and associated respiratory and skin hazards; indicate surface contamination has not been removed and substances have penetrated or permeated through the garment. Determining permeation of contaminants into protective garments requires laboratory analysis of a piece of the material. Both swipe and permeation testing provide after-the-fact information. Along with visual observations, results of these tests can help evaluate the effectiveness of decontamination.
- Total vapor/gas concentrations in the contamination reduction corridor;
- Particulates and specific inorganic or organic vapors in the Corridor; and
- Results of swipe tests.

Decontamination workers who initially come in contact with personnel and equipment leaving the Exclusion Zone will require more protection from contaminants than decontamination workers who are assigned to the last station in the decontamination line. In some cases, decontamination personnel should wear the same levels of PPE as workers in the Exclusion Zone. In other cases, decontamination personnel may be sufficiently protected by wearing protection of one level lower (e.g., wearing Level C protection while decontaminating workers who are wearing Level B). Level D is not acceptable in the CRZ for decontamination line personnel. All decontam-ination workers are in a contaminated area and must themselves be decontaminated before entering the clean Support Zone.

All decontamination personnel should be trained in the standard operating procedures for minimizing contact and maximizing worker protection, and these procedures should be enforced throughout site operations. In addition, standard operating procedures should be established that maximize worker protection. For example, proper procedures for dressing prior to entering the Exclusion Zone will minimize the potential for contaminants to bypass the protective clothing and escape decontamination. In general, all fasteners should be used; gloves and boots should be tucked under the sleeves and legs of outer clothing; hoods (if not attached) should be worn outside the collar; all junctures should be taped to prevent contaminants from running inside the gloves, boots, jackets, and suits.

9.6 HEALTH AND SAFETY HAZARDS



While decontamination is performed to protect health and safety, it can pose hazards under certain circumstances. Decontamination methods may:

- Be incompatible with the hazardous substances being removed (i.e., a decontamination method may react with contaminants to produce an explosion, heat, or toxic products).
- Be incompatible with the clothing or equipment being decontaminated (e.g., some organic solvents can permeate PPE).
- Pose a direct health hazard to workers (e.g., vapors from chemical decontamination solutions may be hazardous if inhaled).

The chemical and physical compatibility of the decontamination solutions or other decontamination materials must be determined before they are used. Any decontamination method that permeates, degrades, damages, or otherwise impairs the safe functioning of the PPE should not be used. Measures must be taken to adequately protect all workers and equipment from any decontamination method that does pose a direct health hazard. Hazardous waste facilities should also have in place emergency decontamination procedures, in order to prevent the loss of life or severe injury to site personnel. In the case of threat to life, decontamination should be delayed until the victim is stabilized; however, decontamination should always be performed first, when practical, if it can be done without interfering with essential life-saving techniques or first aid, or if a worker has been contaminated with an extremely toxic or corrosive material that could cause severe injury or loss of life. During an emergency, provisions must also be made for protecting medical personnel and disposing of contaminated clothing and equipment.

EXHIBIT 9-1
Recommended Equipment for Decontaminating Personnel and PPE

- Plastic drop cloths for storing heavily contaminated equipment and outer protective clothing.
- Drums or suitably lined trash cans for storing disposable clothing and heavily contaminated PPE that must be discarded, and for storing contaminated solutions.
- Lined boxes with absorbents for rinsing off solid or liquid contaminants.
- Washing and rinsing solutions selected to reduce contamination and the hazards associated with contaminants.
- Large galvanized tubs, stock tanks, or children's wading pools to hold wash and rinse solutions. These should be at least large enough for a worker to place a booted foot in, and should have either no drain or be connected to a collection tank or appropriate treatment system.
- Plastic sheeting, sealed pads with drains, or other appropriate methods for containing and collecting contaminated wash and rinse solutions spilled during decontamination.
- Long-handled, soft-bristled brushes to help wash and rinse off contaminants.
- Paper or cloth towels for drying protective clothing and equipment.
- Lockers and cabinets for storage of decontaminated clothing and equipment.
- Shower facilities for full body wash or,

FURTHER GUIDANCE: For more information on decontamination procedures and equipment, see:

1. *Standard Operating Guidelines for Decontamination of Response Personnel* (U.S. EPA, draft, Publication 9285.2-02A).

2. *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities* (NIOSH/OSHA/USCG/EPA, 1985, NIOSH Publication 85-115).

CHAPTER 10 DRUM HANDLING

CHAPTER 10 DRUM HANDLING

10.0 INTRODUCTION

Accidents may occur during handling of drums and other hazardous waste containers. Hazards include detonations, fires, explosions, vapor generation, and physical injury. The most significant ways to improve the safety of drum handling activities at a site are to keep the operation as remote from workers as possible, to avoid sudden releases of chemicals if the operation cannot be remote, and to provide adequate safety gear and equipment to protect the worker if spillage or contact with the drums is unavoidable. **Exhibit 10-1** outlines some basic safety precautions in drum handling.

Regulations defining practices and procedures for safe handling of drums and other hazardous waste containers include:

- OSHA regulations (29 CFR Part 1910. 120(j) and Part 1926) -- general requirements and standards for storing, containing, and handling chemicals and containers, and for maintaining equipment used for handling materials;

- EPA regulations (40 CFR Parts 264 and 265) -- requirements for types of hazardous waste containers, maintenance of containers and containment structures, and design and maintenance of storage areas; and

- DOT regulations (49 CFR Parts 171 through 178) -- requirements for containers and procedures for shipment of hazardous wastes.

During hazardous waste operations, containers are handled during inspection, drum opening, sampling, and characterization. This chapter provides guidance for safely performing these procedures when handling drums and other containers.

10.1 INSPECTION

Appropriate procedures for handling drums varies depending on the drum contents. Prior to handling, drums should be inspected visually to identify their contents. Information that may be helpful includes:

- Symbols, words, or other marks on the drum indicating that its contents are hazardous;

- Symbols, words, or other marks indicating that the drum contains discarded laboratory chemicals, reagents, or other potentially dangerous materials in small-volume individual containers;

- Signs of deterioration such as corrosion, rust, and leaks;

- Signs that the drum is under pressure; and

- Configuration of the drumhead. For example, if the whole lid of the drum can be removed, then it was designed to contain solid material; if the lid has a bung, then the drum was intended for liquids. If the drumhead contains a liner, the drum may likely contain highly corrosive or otherwise hazardous materials.

Noting the **type** of drum also may be useful for identifying potential hazards. **Polyethylene** or **PVC-lined** drums often contain strong acids or bases. If the lining is punctured, the substance usually quickly corrodes the steel, and may cause a significant leak or spill. **Exotic metal** drums (e.g., aluminum, nickel, stainless steel) are very strong and expensive, and are often used to store extremely dangerous materials. **Single-walled drums used as a pressure vessel** have fittings for both the storage product and for an inert gas. These drums may contain reactive, flammable, or explosive substances.

Laboratory packs are used for disposal of expired chemicals and process samples from university laboratories, hospitals, and similar institutions. Individual containers within the lab pack often are not packed in absorbent material. They may contain incompatible materials, radioisotopes, or shock-sensitive, highly volatile, highly corrosive, or highly toxic exotic chemicals.

EXHIBIT 10-1
Safety Precautions for Drum Handling

ACTIVITY: LOCATING DRUMS AND CONDUCTING INVENTORY	
POTENTIAL SAFETY HAZARD: Unknown location and contents of drums can lead to unsuspected hazards	
Safety Tips	• Carefully review background data pertaining to the location and types of wastes on-site. • Conduct soil and ground-water sampling only after the geophysical survey is completed to minimize the possibility of puncturing drums. • During the random sampling of drums, which may be required for an inventory, spacing between drums should be adequate to allow for emergency evacuation if needed. • Use remotely operated, nonsparking tools for random sampling whenever possible. • Use direct-reading air monitoring equipment to detect hot spots where contamination may pose a risk to worker safety.

ACTIVITY: DETERMINING DRUM INTEGRITY	
POTENTIAL SAFETY HAZARD: The process of visual inspections requires close contact with drums of unknown content	
Safety Tips	• Approach drums cautiously. Conduct air monitoring to indicate levels of hazards that require withdrawal from the work area or use of additional safety equipment. • Any drum that is critically swollen should not be approached; it should be isolated using a barricade until the pressure can be relieved remotely. • Use of the grappler or other remotely operated equipment can eliminate the need for determining drum integrity prior to excavation, provided that rupture of the drum will not result in fire or unacceptable environmental impact.

ACTIVITY: DRUM EXCAVATION AND HANDLING	
POTENTIAL SAFETY HAZARD: Exposure to toxic/hazardous vapors; rupture of drums	
Safety Tips	• Where buried drums are suspected, conduct a geophysical survey before using any construction equipment in order to minimize the possibility of rupture. • Use a drum grappler where possible and cost-effective to minimize contact with drums. If a grappler is not available, pump or overpack drums of poor integrity before excavation. • Ground equipment prior to transferring wastes to new drums. • Use nonsparking hand tools and nonsparking bucket teeth on excavation equipment, and use plexiglass shields on vehicle cabs. • Where slings, yokes, or other accessories must be used, workers should back away from the work area after attaching the accessory and before the drum is lifted. • Critically swollen drums should not be handled until pressure can be relieved. • Use bars that fit over the teeth of excavation buckets to prevent drum puncture. • Where ionizing levels of radiation are detected, the Site Health and Safety Officer should be contacted; generally, the drum should be overpacked and isolated promptly. • Where explosive or shock-sensitive material is suspected, every effort should be made to handle the drum remotely. Gas cylinders should not be dragged during handling. • Use direct-reading air monitoring equipment when in close proximity to drums to detect any hot spots.

EXHIBIT 10-1
Safety Precautions for Drum Handling

ACTIVITY: DRUM STAGING AND OPENING

POTENTIAL SAFETY HAZARD: Release of toxic, hazardous vapors, rupture of drums

Safety Tips	• Stage gas cylinders in a cool, shaded area. • Stage potentially explosive or shock-sensitive wastes in a diked, fenced area. • Use remote drum opening methods where drums are unsound. • Conduct remote-operated drum opening from behind a barricade or behind a plexiglas shield if backhoe-mounted puncture is being used. • Isolate drum opening from staging and other activities if possible to prevent a chain reaction if an explosion or reaction does occur. • If drum opening cannot be isolated from staging, drums should be staged so as to: (1) minimize the possibility of chain reactions in the event of a fire or explosion; and (2) provide adequate space for emergency evacuation. • Use only nonsparking hand tools if drums are to be opened manually. • Remotely relieve the pressure of critically swollen drums before opening. • Clean up spills promptly to minimize mixing of incompatible materials.

ACTIVITY: CONSOLIDATION AND RECONTAINERIZATION

POTENTIAL SAFETY HAZARD: Mixing of incompatible wastes

Safety Tips	• Perform on-site compatibility testing on all drums. • Segregate wastes according to compatibility class following compatibility testing. • Clean up spills promptly to avoid mixing of incompatible wastes. • Intentional mixing of incompatible wastes such as acids and bases should be performed under controlled conditions in a reaction tank where temperature and vapor release can be monitored. • Monitor for incompatible reactions during consolidation using direct-reading air monitoring equipment.

ACTIVITY: INTERIM STORAGE AND TRANSPORTATION

POTENTIAL SAFETY HAZARD: Mixing of incompatible wastes

Safety Tips	• Segregate incompatible wastes using dikes during interim storage. • Maintain a weekly inspection schedule. • Allow adequate aisle space between drums to allow rapid exit of workers in case of emergency. • Keep explosives and gas cylinders in a cool, shaded, or roofed area. • Prevent contact of water reactive wastes with water. • Clean up spills or leaks promptly. • Have fire fighting equipment readily available within the storage area. • Ensure adherence to DOT regulations regarding transport of incompatible wastes and drum integrity.

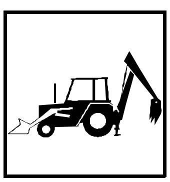
Source: *Drum Handling Practices at Hazardous Waste Sites* (U.S. EPA, 1986, EPA/500/2-86/013).

Laboratory packs are a potential ignition source for fires at hazardous waste sites. Conditions in the immediate vicinity of the drums may provide information about drum contents and associated hazards. In addition, air monitoring should be conducted around the drums. If buried drums are suspected, ground-penetrating systems can be used to estimate the location and depth of the drums.

After visual inspection, drums can be classified into preliminary hazard categories. They can be described as radioactive, leaking or deteriorated, bulging, and explosive or shock-sensitive. Until their contents are characterized, unlabelled drums should be handled in the same manner as drums that contain hazardous materials. It is also important to remember that drums are frequently mislabelled -- particularly drums that are reused. Therefore, a drum's label may not accurately describe its contents.

Results of the drum inspection can be used to determine: (1) whether any hazards are present and the appropriate response; and (2) which drums need to be moved before they are opened and sampled. A plan should be developed specifying the extent of handling necessary and the appropriate procedures for handling. Plans should be revised as new information is obtained during drum handling.

10.2 DRUM EXCAVATION AND REMOVAL EQUIPMENT



Drum excavation and removal equipment is used to perform several distinct and important functions, including:

- Excavating to the depth of buried drums and removing surface cover over buried drums.
- Excavating around buried drums to free them for removal.
- Removing (lifting) drums from exposed pits and trenches.
- Loading and transporting drums to onsite storage areas.
- Sampling, segregating, bulking, storing, and recontainerizing (e.g., overpacking) drums.
- Transporting offsite for appropriate storage, treatment, or disposal.

The choice of equipment for drum handling is based on the inherent capabilities and limitations of the equipment, site-specific conditions that affect equipment performance, the necessity to protect worker safety, and costs. Generally, a combination of equipment and accessories is required for a particular job.

10.3 DRUM HANDLING

The purpose of drum handling is to: (1) respond to obvious problems that might impair worker safety; (2) unstack and orient drums for sampling; and (3) if necessary, organize drums into different areas on-site to facilitate characterization and remedial action. Handling may or may not be necessary, depending on how the drums are positioned at a site.

To avoid accidents, drums should only be handled when necessary. Prior to handling, all personnel should be warned about the hazards of handling and instructed to minimize handling as much as possible. In all phases of handling, personnel should be alert for new information about potential hazards and should respond to new hazards before continuing with routine handling operations. Empty overpack drums (larger drums in which smaller leaking or damaged drums are placed for storage or shipment) and an adequate volume of absorbent should be kept near areas where minor spills may occur. Where major spills may occur, a containment berm should be constructed prior to handling. If drum contents spill, personnel trained in spill response should isolate and contain the spill.

The following procedures can be used to maximize worker safety during drum handling and movement:

- Train personnel in proper lifting and moving techniques;
- Select vehicles with sufficient rated load capacity to handle anticipated loads, and ensure that vehicles can operate smoothly on available road surfaces;
- Air condition the cabs of vehicles to increase operator efficiency and protect the operator with heavy splash shields;
- Supply operators with appropriate respiratory protective equipment when needed;

- Prepare overpacks before any attempt is made to move drums;

- Before moving anything, determine the appropriate sequence for moving drums and other containers;

- Exercise extreme caution in handling drums that are not intact and tightly sealed; and

- Ensure that operators have a clear view of the roadway when carrying drums. Where necessary, have ground workers available to direct the operator's motion.

Drums containing **radioactive waste** should not be handled until experts in handling radioactive materials have been consulted. If a drum is suspected to contain **explosive** or **shock-sensitive waste**, specialized assistance should be sought before handling is initiated. If handling is necessary, extreme caution should be used and all non-essential personnel should remain a safe distance from the handling area. In addition, continuous communication with the Site Health and Safety Officer and/or the command post should be maintained until handling operations are complete.

Drums that may be under internal pressure can be identified by **bulging or swelling**. If a pressurized drum must be moved, whenever possible, the drum should be handled with a grappler unit constructed for explosive containment. Either move the bulged drum only as far as necessary to allow seating on firm ground, or carefully overpack the drum. Exercise extreme caution when working with or adjacent to potentially pressurized drums.

Laboratory packs (lab packs) should be considered to hold explosive or shock-sensitive wastes until otherwise characterized. Prior to handling or transporting lab packs, all non-essential personnel should move a safe distance from the handling area. If handling is required, continuous communication with the Site Health and Safety Officer and/or the command post should be maintained until handling operations are complete. Once a lab pack has been opened, it should be inspected and classified according to the hazards of the wastes to ensure safe segregation of the lab packs' contents.

If a **drum containing a liquid** cannot be moved without rupture, its contents should be immediately transferred to a sound drum. **Leaking drums** that contain sludges or semi-solids, open drums that contain liquid or solid waste, and deteriorated drums that can be moved without rupture should be placed in overpack containers.

Prior to initiating **subsurface** excavation, ground-penetrating systems should be used to confirm the location and depth of drums. Soil should be removed with caution to minimize the potential for drum rupture. In addition, a dry chemical fire extinguisher should be available to control small fires.

10.4 DRUM OPENING

Drums are usually opened and sampled in place during site investigations. However, remedial and emergency operations may require a separate drum opening area. Procedures for opening drums are the same, regardless of where the drums are opened. To maximize worker safety during drum opening, the following procedures should be instituted:

- If a supplied-air respiratory protection system is used, place a bank of air cylinders outside the work area and supply air to the operators via airlines and escape SCBAs;

- Keep personnel at a safe distance from the drums being opened; place explosion-resistant plastic shields between personnel and the drums for protection in case of detonation; locate controls for drum opening equipment, monitoring equipment, and fire suppression equipment behind the explosion-resistant plastic shield;

- Conduct air monitoring during drum-opening activities;

- Use non-sparking bronze-beryllium tools when possible;

- Use remote-controlled devices for opening drums, when feasible;
- Hang or balance the drum opening equipment to minimize worker exertion;
- If the drum shows signs of swelling or bulging, perform all steps slowly and relieve excess pressure prior to opening;
- Open exotic metal drums and polyethylene or polyvinyl chloride-lined drums through the bung by removal or drilling;
- Do not open or sample individual containers within laboratory packs;
- Reseal open bungs and drill openings as soon

as possible; and

- Decontaminate equipment after each use to avoid mixing incompatible wastes.

Exhibit 10-2 provides a summary assessment of several drum opening techniques, **Exhibit 10-3** presents a sample drum characterization sheet, and **Exhibit 10-4** illustrates two common examples of drum opening equipment.

10.5 DRUM SAMPLING

Drum sampling can be hazardous to worker health and safety because it can involve direct contact with unidentified wastes. Prior to collecting samples, a sampling plan should be developed, including: (1) research about the waste; (2) identification of drums to be sampled; (3) selection of appropriate sampling device(s) and container(s); (4) determination of the number, volume, and locations of samples to be taken; and (5) development of procedures for opening drums, sampling, and sample packaging and transportation. A trained health and safety professional should determine the appropriate personal protection to be used during sampling, decontamination, and packaging of the sample.

To maximize worker safety during manual sampling from a drum, the following techniques should be used:

- Keep sampling personnel at a safe distance while drums are being opened and sample only after opening operations are complete;
- Do not lean over other drums to reach the drum being sampled, unless absolutely necessary;
- Cover drum tops with plastic sheeting or other suitable uncontaminated materials;
- Never stand on drums -- use mobile steps or another platform to achieve the height necessary to safely sample from the drums; and
- Obtain samples with glass rods or vacuum

10.6 CHARACTERIZATION

The goal of characterization is to obtain data necessary to determine how to safely and efficiently package and transport the wastes for treatment and/or disposal. If wastes are bulked, they must be sufficiently characterized to determine which of them can be safely combined. Standard compatibility tests are simple, rapid, and cost-effective procedures used to segregate wastes into broad categories, including water reactive, oxidative, and radioactive. By identifying broad waste categories, compatible waste types can be safely bulked on-site without the risk of fore or explosion, and disposal options can be determined without exhaustive and costly analysis of each drum. In some cases, however, further analysis may be necessary to identify the waste materials more precisely.

During the compatibility testing process, each drum is scanned for radioactivity as it is opened. If the scan is negative, a sample is taken to perform the compatibility test. (Solid samples should be taken from several different areas within the drum.) In addition, the contents of all drums should be described on the drum data sheet in terms of physical state, viscosity, and number of phases. A sample should be taken for each phase. **Exhibit 10-5** provides a sample HAZCAT checklist for recording screening data.

There are a number of published compatibility testing protocols; however, procedures must be tailored for site-specific conditions. **Exhibit 10-6** presents a thorough protocol developed by the Chemical Manufacturers' Association (CMA). Based on the CMA protocol, wastes can be segregated into the following broad waste categories:

Liquids: Radioactives, Peroxides and oxidizing agents, Reducing agents, and Water-reactive compounds.

Water Insolubles: Low halogen/low PCB, Mixed halogen/high PCB, and High halogen/low PCB.

Acids: Strong (pH<2), Weak (pH 2-7).

Bases: Strong (pH>12) with or without cyanides or sulfides, and Weak (pH 7-12) with or without cyanides or sulfides.

Solids: Radioactive and Non-radioactive.

EXHIBIT 10-2
Summary Assessment of Drum Opening Techniques
Recommended Drum Opening Applications (for Sample Acquisition or Recontainerization)

Technique	# of Drums to be Opened			Physical Condition of Drums		Waste Content of Drum			Restrictions/Disadvantages
	<100	100-500	>500	Damaged or Bulging	Structurally Sound	Unknown	Shock Sensitive/ Explosive	Non-Hazardous	
Bung Wrenches (Nonsparking)	X				X			X	Not recommended for unknown waste contents; full protective gear for worker.
Manual Drum Deheader	X				X			X	Only if bung is impossible to open; used mainly for recontainerization vs. sample acquisition; unsafe if waste contents are unknown.
Self-Propelled Drum Deheader (Electric or Pneumatic)	X				X			X	May require use of a dekinker or readjustment of the deheader if the chime is dented.
Remotely Operated Pneumatic Wrench	X	X		X	X	X	X		Requires direct contact with the drum during attachment of the wrench. Time-consuming setup.
Remote Hydraulic Plunger									Only in controlled area with spill containment.
• Portable	X			X	X	X	X[1]	X	Most time-consuming hydraulic plunger methods. Requires direct contact with the drum to set up the plunger.
• Self-Propelled (Electric or Pneumatic)	X	X			X	X	X	X	Only suitable if the chime is free of dents.
• Backhoe attached			X	X	X	X	X[1]	X	Use long boom-dipper arms (12 meters or 40 feet).
• Conveyor			X	X	X	X	X[1]	X	Has not been used in the field to date.
Backhoe Spike (Nonsparking)	X	X		X		X	X	X	May damage drum; use long backhoe boom (>40 feet).
Tube and Spear device for venting	X	X	X	X			X		Method applicable for venting of pressure, but not for drum sampling.

[1] Plunger may be of nonsparking bronze or of stainless steel, which is more durable.

Source: *Drum Handling Practices at Hazardous Waste Sites* (U.S. EPA, 1986, EPA/500/2-86/013).

EXHIBIT 10-3
Sample Drum Characterization Sheet

SITE: ________________ **DRUM #:** ______________ **SAMPLE #:** ___________

Drum Size:

0 unknown ___
1 55 gal. ___
2 30 gal. ___
3 other ___
specify ___

Drum Opening:

0 unknown ___
1 ring top ___
2 closed top ___
3 open top ___
4 other ___
specify ___

Drum Type:

0 unknown ___
1 metal ___
2 plastic ___
3 fiber ___
4 glass ___
5 other ___
specify ___

Drum Color: PRI SEC

0 unknown __ __
1 cream __ __
2 clear __ __
3 black __ __
4 white __ __
5 red __ __
6 green __ __
7 blue __ __
8 brown __ __
9 pink __ __
10 orange __ __
11 yellow __ __
12 gray __ __
13 purple __ __
14 amber __ __
15 green-blue __ __

Drum Contents Color:

PRI SEC
0 unknown __ __
1 cream __ __
2 clear __ __
3 black __ __
4 white __ __
5 red __ __
6 green __ __
7 blue __ __
8 brown __ __
9 pink __ __
10 orange __ __
11 yellow __ __
12 gray __ __
13 purple __ __
14 amber __ __
15 green-blue __ __

Drum Condition:

0 unknown ___
1 good ___
2 fair ___
3 poor ___

Drum Marking Keywords:

#1 _______________

#2 _______________

#3 _______________

Drum Contents State:

PRI SEC
0 unknown __ __
1 solid __ __
2 liquid __ __
3 sludge __ __
4 gas __ __
5 trash __ __
6 dirt __ __
7 gel __ __

Drum Content Amount:

0 unknown __ __
1 full __ __
2 part __ __
3 empty __ __

Chemical Analysis:

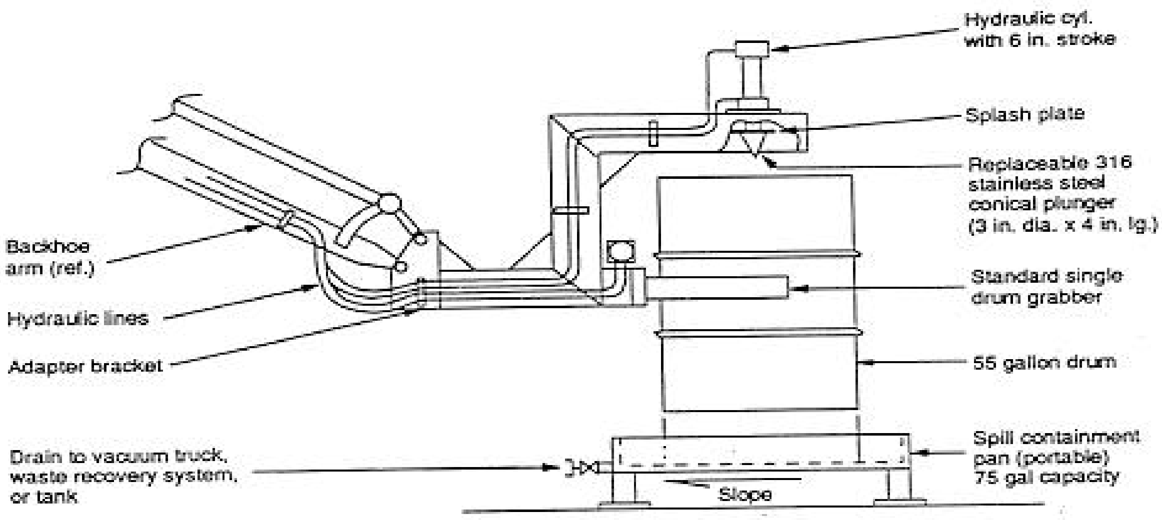
YES NO
radiation __ __
ignitable __ __
water reactive __ __
cyanide __ __
oxidizer __ __
organic vapor __ __ ppm
pH __ __

Real-time Instrument Readings

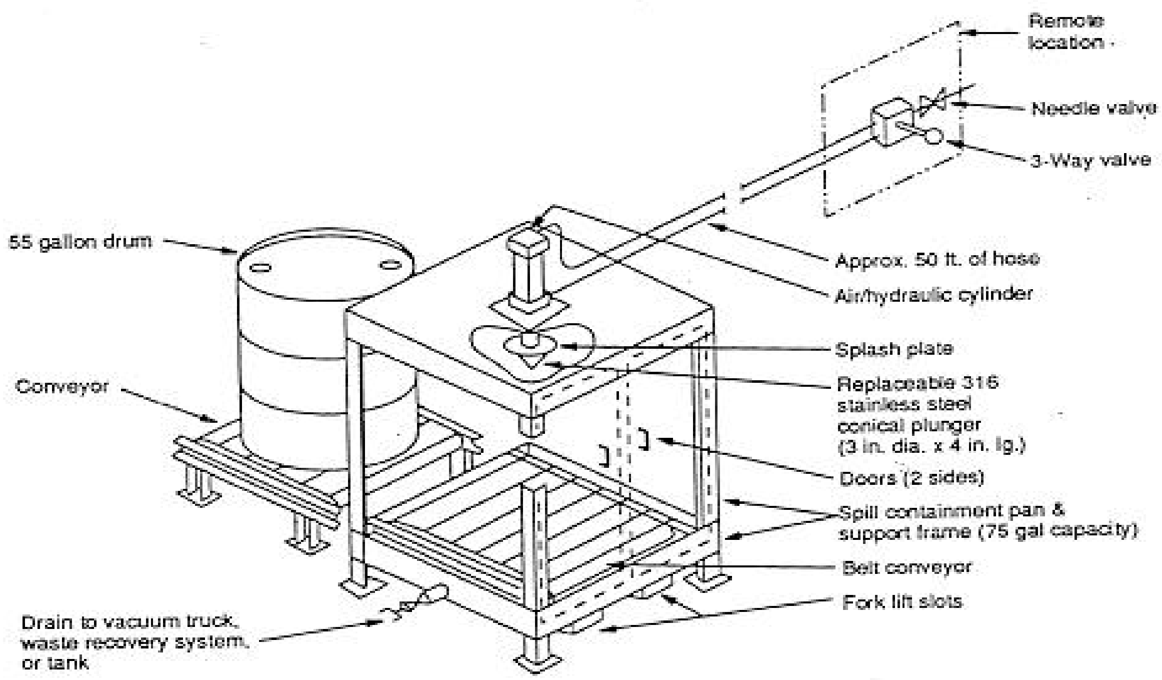
Colorimetric tube _____
Radiation ________
PID ________
FID ________

Source: EPA Region VII Emergency Planning and Response Branch

EXHIBIT 10-4
Examples of Drum Opening Equipment



Hydraulic Backhoe Drum Plunger Arrangement



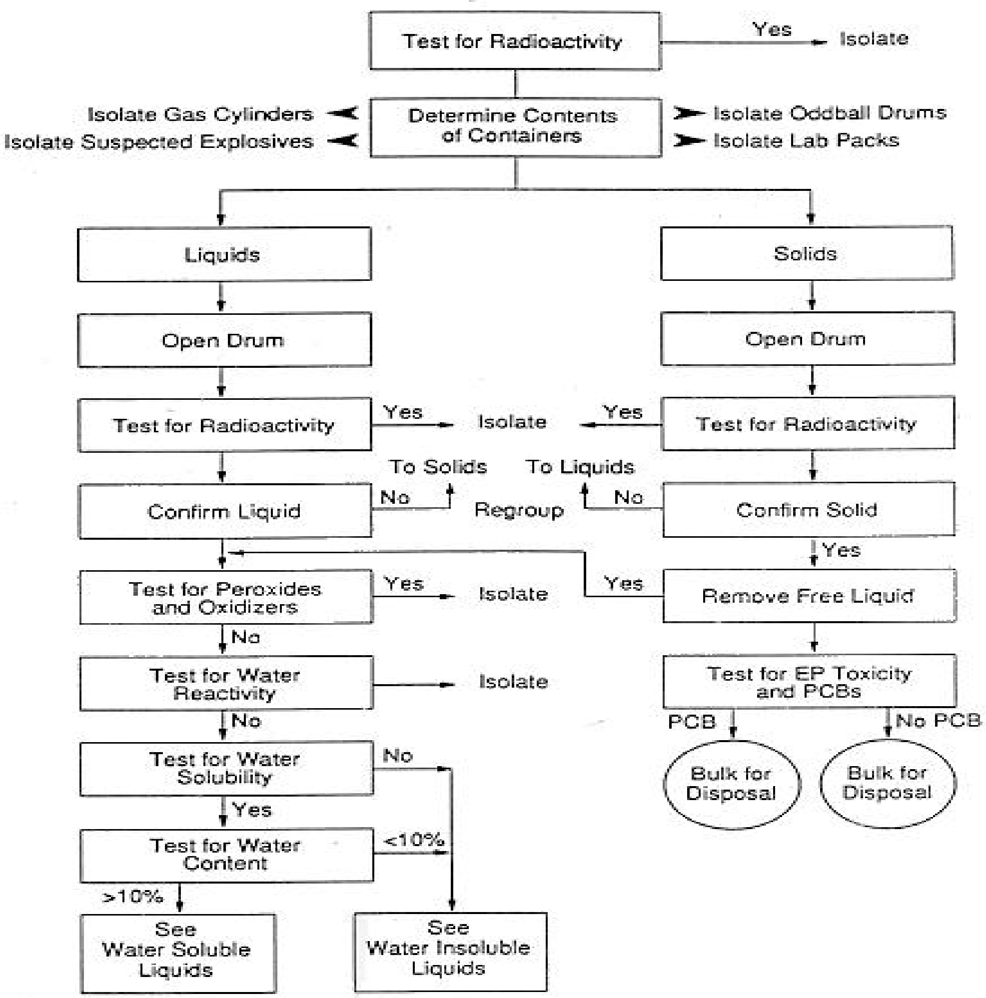
Conveyor Belt System for Remote Hydraulic Puncturing of Large Number of Drums

EXHIBIT 10-5
HAZCAT Checklist: Characterization Screening Data

Screening Data	YES	NO	Criteria
RADIOACTIVE	**G**	**G**	$\geq$1 mR over background
ACIDIC	**G**	**G**	pH $\leq$ 3
CAUSTIC	**G**	**G**	pH $\geq$ 12
AIR REACTIVE	**G**	**G**	Reaction of $\geq$ 10°F temp. change
WATER REACTIVE	**G**	**G**	Reaction of $\geq$ 10°F temp. change
WATER SOLUBLE	**G**	**G**	Dissolves in water
WATER BATH OVA	**G**	**G**	Reading = ____ $\geq$10 ppm = Yes
COMBUSTIBLE	**G**	**G**	Catches fire when torched in water bath
HALIDE	**G**	**G**	Green flame when heated with copper
INORGANIC	**G**	**G**	WATER BATH OVA and COMBUSTIBLE = No
ORGANIC	**G**	**G**	INORGANIC = No
ALCOHOL/ALDEHYDE	**G**	**G**	WATER BATH OVA, WATER SOLUBLE, and COMBUSTIBLE = Yes
CYANIDE	**G**	**G**	Draeger tube over water bath $\geq$ 2 ppm
FLAMMABLE	**G**	**G**	Combustible = Yes, and SETA flashpoint $\leq$ 140°F
OXIDIZER	**G**	**G**	Starch iodine paper shows positive reaction
INERT OR OTHER	**G**	**G**	Everything "No" except INORGANIC or ORGANIC
PCB SCREEN (Chlor-N-Oil)	**G**	**G**	
	G		> 50 ppm
	G		< 50 ppm
	G		100%

Source: EPA Region VII Emergency Planning and Response Branch. This chart is provided only as an example; values may need to be modified as appropriate.

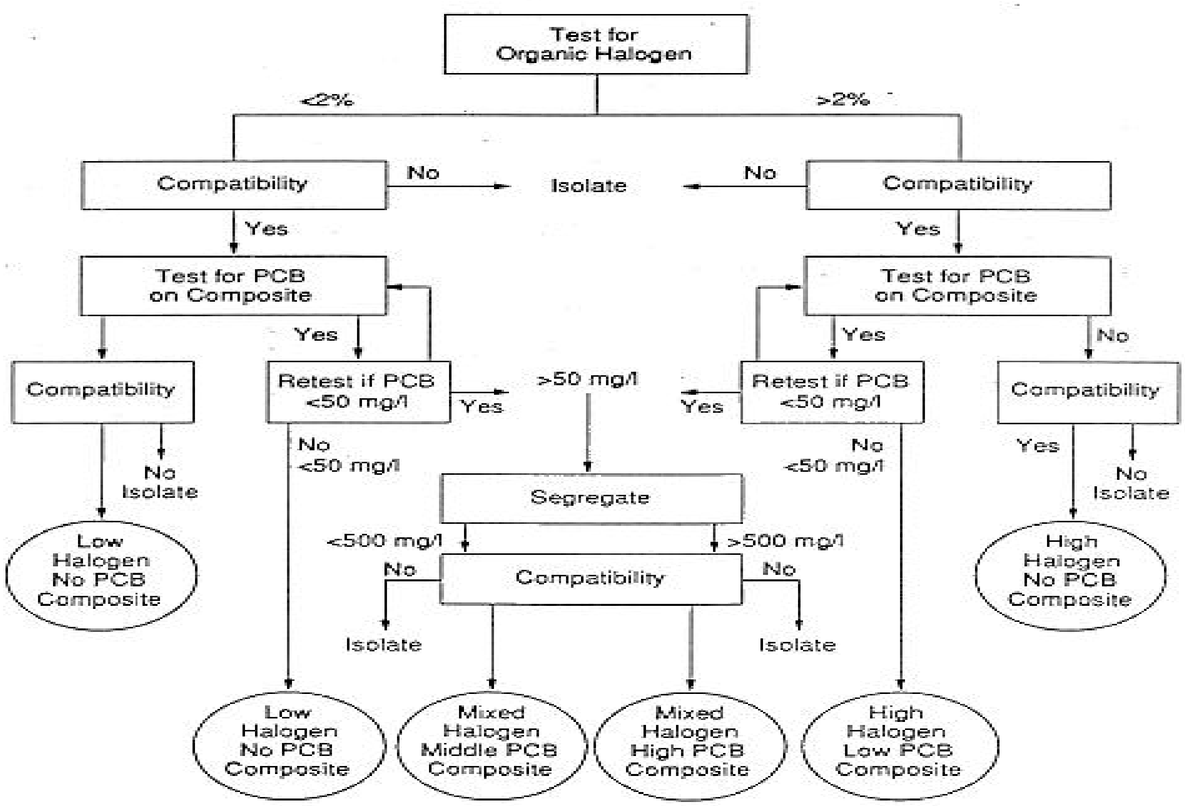
EXHIBIT 10-6
CMA COMPATIBILITY TESTING PROTOCOL



Source: *Drum Handling Practices at Hazardous Waste Sites* (U.S. EPA, 1986, EPA/500/2-86/013).

E XHIBIT 10-6 (cont'd)
CMA COMPATIBILITY TESTING PROTOCOL

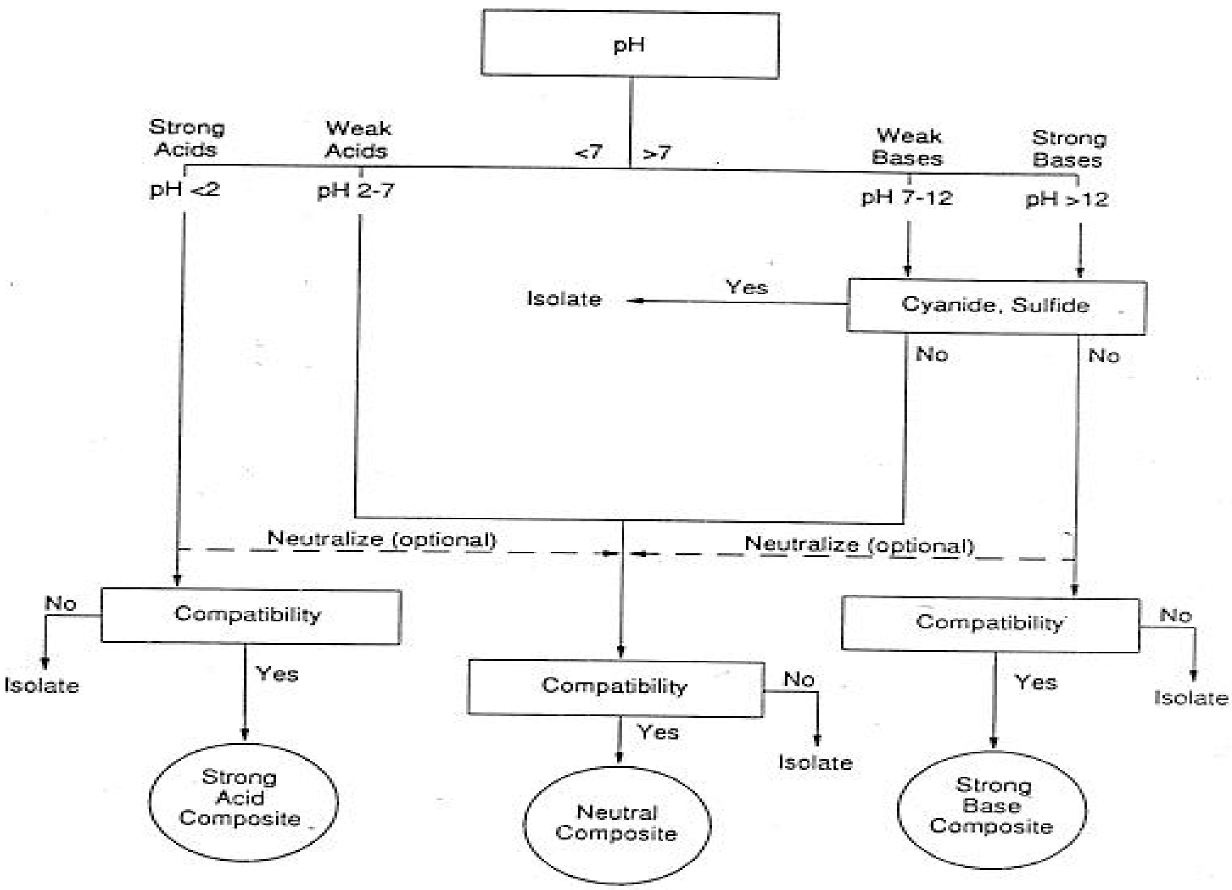
Water Insoluble Liquids Testing



Source: *Drum Handling Practices at Hazardous Waste Sites* (U.S. EPA, 1986, EPA/500/2-86/013).

EXHIBIT 10-6 (cont'd)
CMA COMPATIBILITY TESTING PROTOCOL

Water Soluble Scan



Source: *Drum Handling Practices at Hazardous Waste Sites* (U.S. EPA, 1986, EPA/500/2-86/013).

This protocol also requires that a compatibility test be performed by mixing small samples of wastes that are intended to be bulked, making visual observations for precipitation, temperature changes, or phase separation.

When possible, materials should be characterized using an on-site laboratory to minimize the time before appropriate action can be taken to handle any hazardous materials. If samples must be analyzed off-site, samples should be packaged on-site in accordance with DOT regulations (49 CFR Parts 171-178) and shipped to the laboratory for analysis.

FURTHER GUIDANCE: For more information on drum handling, see:

1. *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*. (NIOSH/OSHA/USCG/EPA, 1985, NIOSH Publication 85-115).

2. *Drum Handling Practices at Hazardous Waste Sites* (U.S. EPA, 1986, EPA 500/2-86/013).

3. *Guidance Document for Cleanup of Surface Tank and Drum Sites* (U.S. EPA, Publication 9380.0-3).

CHAPTER 11 OTHER REQUIREMENTS AND SAFETY CONSIDERATIONS

CHAP
TER 11 OTHER REQUIREMENTS AND SAFETY CONSIDERATIONS

11.0 INTRODUCTION

This chapter provides information on three other important HAZWOPER requirements and on specific hazards that employees may face in hazardous waste operations:

- Emergency response and prevention requirements;
- Confined space entry procedures;
- Information and new technology programs;
- Specific hazards, including chemical contamination, explosion and fire, oxygen deficiency, ionizing radiation, biological hazards, and noise and safety hazards.

11.1 EMERGENCY RESPONSE AND PREVENTION

Site emergencies are characterized by their potential for complexity; uncontrolled toxic chemicals may be numerous and unidentified, and their effects may be synergistic. Rescue personnel attempting to remove injured workers may themselves become victims. This variability means that advance planning, including anticipation of different emergency scenarios and thorough preparation for contingencies, is essential to protect worker and community health and safety.

One of the most important components of the HASP is the written site-specific emergency response plan. The emergency response plan should be designed as a separate section of the HASP, and must be compatible and integrated with the disaster, fire, and/or emergency response plans of local, state, and federal agencies. The 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 listed in **Exhibit 11-1** and are codified at 29 CFR §1910.120(l)(2). Employers must develop emergency response plans to protect workers in emergencies resulting from the release of all kinds of hazardous substances, including Extremely Hazardous Substances (EHSs), CERCLA hazardous substances, RCRA hazardous wastes, and any substance listed by the U.S. Department of Transportation as a hazardous material.

EXHIBIT 11-1
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.
- Site topography, layout, and prevailing weather conditions.
- Procedures for reporting incidents to local, state, and federal governmental agencies.

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. As part of the overall training program for site operations, the emergency response plan also must 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. The plan must be in writing and available for inspection and copying by employees, their representatives, OSHA personnel, and other government agencies with relevant responsibilities.

An employee alarm system must be installed at all sites 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 communications, and to begin emergency procedures. Based on the information available at the time of the emergency, the employer should evaluate the incident and the site response capabilities and proceed with the appropriate steps to implement the site emergency response plan.

In lieu of preparing an emergency response plan, site managers 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 would direct employees to leave the site and maintain a safe distance, and would also 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 regarding 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 should be notified of site operations prior to the commencement of any site activities. As an additional good operating practice, the site manager may choose to provide local officials with a copy of the plan to review and concur upon.

11.1.1 Prevention

On a day-to-day basis, individual personnel should be constantly alert for indicators of potentially hazardous situations and for signs and symptoms in themselves and others that warn of hazardous conditions and exposures. Rapid recognition of dangerous situations can avert an emergency and prevent injuries and loss of life. Regular health and safety meetings with employees should address:

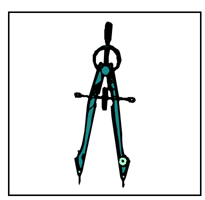
- Tasks to be performed;
- Time constraints (e.g., rest breaks, air tank changes);
- Hazards that may be encountered, including their potential effects, how to recognize symptoms or monitor them, concentration limits, or other danger signals; and
- Emergency procedures.

After daily work assignments, a debriefing session should be held to review work accomplished, problems observed, and suggestions for future improvement.

11.1.2 Communications

In an emergency, crucial messages must be conveyed quickly and accurately. Site staff must be able to communi-cate information, such as the location of injured personnel, orders to evacuate the site, and information on safe evacuation routes to employees, even through noise and confusion. Outside support sources must be reached and measures for public notification must be ensured, if necessary. To accomplish this, a separate set of internal emergency signals should be developed and rehearsed daily. External communication systems and procedures should be clear and accessible to all workers.

11.1.3 Site Mapping



Detailed information about the site is essential for advance planning. For this purpose, a site map is a valuable tool. It serves as a graphic record of the locations and types of hazards, a reference source, and a method of documentation. The map should focus on potential areas where emergencies may develop, and should be sure to highlight:

- Hazard areas, especially potential IDLH conditions;
- Site terrain: topography, buildings, barriers;
- Evacuation routes;
- Site accessibility by land, sea, and air; and
- Off-site populations or environments at risk.

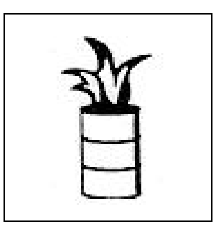
It is recommended that maps be prepared to scale in a professional manner so that the map can be used as a basis for planning and training, as well as for developing potential emergency scenarios and alternative response strategies. When an emergency occurs, the problem areas should be pinpointed on the map. Pertinent information (e.g., weather and wind conditions, temperature, and forecast) should be added. The map can then be used to design the emergency response plan. When using the map for such purposes, the accuracy of the data obtained and the potential for over- or under-estimating a hazard should be considered. Even if the emergency develops so fast that the map cannot be used for on-the-spot planning, prior familiarity with it will aid in making informed decisions.

11.2 HAZARDS

Although the medical program is essential for assessing and monitoring employee health and fitness before the employee begins activities and during the course of employment, employees should be aware of specific hazards in the workplace.

The following sections describe the specific hazards that site personnel face during hazardous waste operations. It is important to remember that no two sites are alike, and that each site may present unique hazards to employees based on the contaminants present, site conditions, site geography and location, and weather.

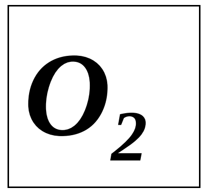
11.2.1 Explosion and Fire



Explosions and fires at a hazardous waste site may occur for a variety of reasons. Accidentally mixing incom-patible chemicals could cause an intense exothermic reaction. A spark or flame could be introduced into an oxygen enriched or flammable atmosphere. The movement or removal of tanks and drums could agitate shock-sensitive compounds or could release materials stored under high pressure.

Explosions and fires may arise spontaneously, although they more commonly result from site activities. In addition to the normal dangers of intense heat, open flame, smoke inhalation, and flying objects, an explosion or fire at a hazardous waste site poses the additional threat of potentially releasing hazardous substances into the atmosphere. Such releases can threaten both personnel on-site and members of the general public living or working nearby. The following precautions should be taken to protect against the hazard: (1) have qualified personnel monitor for explosive atmospheres and flammable vapors; (2) keep all potential ignition sources away from an explosive or flammable environment; (3) use nonsparking, explosion-proof equipment; and (4) follow safe practices when performing any task that might result in the agitation or release of chemicals.

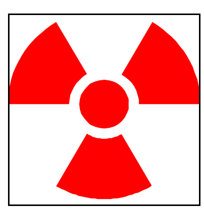
11.2.2 Oxygen Deficiency



The oxygen content of normal air at sea level is approx-imately 21 percent. Physio-logical effects of oxygen deficiency are readily apparent when the oxygen concentration in air decreases to 16 percent. These effects include impaired attention, judgment and coordination, and increased breathing and heart rate. Oxygen concentrations lower than 16 percent can result in nausea and vomiting, brain damage, heart damage, unconsciousness, and death. For individual physiological responses and errors in measurement, precautions should be taken when the ambient oxygen level is 19.5 percent or lower.

Oxygen deficiency may result from the displacement of oxygen by another gas, or the consumption of oxygen by a chemical reaction. Confined spaces or low-lying areas are particularly vulnerable to oxygen deficiency and should always be monitored prior to entry. Qualified field personnel should always monitor oxygen levels and should use atmosphere-supplying respiratory equipment when oxygen concentrations drop below 19.5 percent.

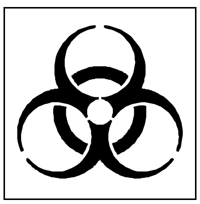
11.2.3 Ionizing Radiation



Radioactive materials emit one or more of three types of harmful radiation: alpha, beta, and gamma. **Exhibit 11-2** presents the characteristics of these three types of radiation. Alpha radiation has limited penetration ability and is usually stopped by clothing and the outer layers of the skin. Alpha radiation poses little threat outside the body. Beta radiation can cause harmful "beta burns" to the skin and damage the subsurface blood system. Both alpha and beta radiation can be hazardous if radioactive materials emitting alpha or beta radiation are introduced into the body. Use of protective clothing combined with scrupulous personal hygiene and decontamination provides good protection against alpha and beta radiation. Gamma radiation passes easily through clothing and human tissue and can also cause serious permanent damage to the body. Chemical-protective clothing affords no protection against gamma radiation itself; however, use of respiratory and other protective equipment can help keep radioactive materials from entering the body.

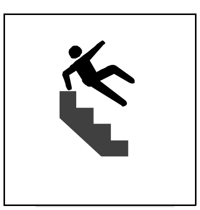
If levels of radiation above natural background levels are discovered, a health physicist should be consulted. At levels greater than 1 millirem per hour, all site activities should cease until the site has been assessed by health physicists.

11.2.4 Biological Hazards



Wastes from hospitals and research facilities may contain disease-causing organisms that could infect site personnel. Like chemical hazards, patho-gens may be dispersed in the environment via water and wind. Other biologic hazards that may be present include poisonous plants, insects, animals, andindigenous pathogens. Protective clothing and respiratory equipment, and identification of toxic plants, animals, and insects in the area can help reduce the chances of exposure. Thoroughly washing any exposed body parts and equipment will also help protect against infection.

11.2.5 Safety Hazards



Hazardous waste sites may contain a variety of safety hazards, including holes, ditches, precariously positioned or sharp objects, slippery surfaces, steep grades, uneven terrain, and unstable surfaces. In addition to those safety hazards that are a function of the site, many safety hazards are a function of the work itself. Heavy equipment creates an additional hazard for workers in the vicinity of the operating equipment. PPE can impair workers' vision, hearing, or agility. Removal of wastes can create physical hazards at the site that were not present prior to the beginning of operations.

Accidents involving physical hazards can directly injure workers and can create additional hazards such as increased exposure to chemicals due to damaged protective equipment. Site personnel should constantly be aware of potential safety hazards, and should immediately inform a supervisor of any new hazards so that mitigative action can be taken.

One potential hazard that results from a variety of sources is electrocution. Overhead power lines, downed electrical wires, and buried cables all pose a danger of shock or electrocution if workers come into contact with or sever them during site operations. Electrical equipment used on-site may also pose a hazard to workers. Low-voltage equipment with ground-fault interrupters and water tight, corrosion-resistant connecting cables should be used on-site to minimize electrical hazards. Lightning is a hazard during outdoor operations, particularly for workers handling metal containers or equipment. To eliminate this hazard, weather conditions should be monitored and work should be suspended during electrical storms. The OSHA standards at 29 CFR §1910.136 describe proper clothing and equipment for protection against electrical hazards.

11.2.6 Noise Hazards

At many sites, different activities (e.g., drilling operations, heavy equipment operations) may result in appreciable noise levels. 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 the sound levels throughout the work day is required to monitor employee exposure to noise levels. **Exhibit 11-3** provides OSHA's Permissible Noise Exposures. These values represent noise levels over which workers may not be exposed without risking adverse hearing effects. These values should be used as guides and should not be regarded as fine lines between safe and dangerous levels.

EXHIBIT 11-3
Permissible Noise Exposures

Duration per day, hours	**Sound level dBA slow response**
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

NOTE: When daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: $C_1/T_1 + C_2/T_2 ... C_n/T_n$ exceeds unity, then, the mixed exposure should be considered to exceed the limit value. C_n indicates the total time of exposure at a specified noise level, and T_n indicates the total time of exposure permitted at that level.

Continuous and Intermittent Noise. Currently, the OSHA-Permissible Exposure Limit (PEL) for an 8-hour work day, 40-hour work week is 90 decibels, as recorded on a sound level meter on the A weighted scale (dBA). If the 8-hour time weighted average noise exposures equal or exceed 85 dBA, the site manager must implement a hearing conservation program. If feasible administrative and engineering controls do not reduce sound levels to within acceptable limits, employees should use appropriate PPE to reduce personal exposure.

Impulsive or Impact Noise. Exposure to impulsive or impact noise should not exceed the limits given in **Exhibit 11-4**. No exposures in excess of 140 dB peak sound pressure level are permitted. Impulsive or impact noise is considered to be a variation in noise levels that involves maxima at intervals of greater than one per second. Where the intervals are less than one second, exposure should be considered continuous and should be integrated into the time weighted average.

EXHIBIT 11-4
Threshold Limit Values for Impulsive or Impact Noise

Sound Level dB*	Permitted Number of Impulses or Impacts per Day
140	100
130	1000
120	10,000

* Decibels peak sound pressure level

11.2.7 Work Hazards

The nature of the work done at a hazardous waste site can contribute to the health and safety risks at the site. **Trench excavation** can increase the instability of the site and increase the risk of a "cave in" or collapse. Moving chemical **drums** may injure a worker if the drum ruptures, spilling chemicals in higher quantity than the protective clothing was designed to accommodate. Drums also pose the threat of back injury or a hernia if those workers moving them do not take proper precautions.

Confined spaces, discussed in detail below, often present a major health and safety hazard to workers involved in hazardous waste site operations. In accidents involving confined spaces, a potential rescuer frequently becomes a victim because he or she rushes into the space without taking proper precautions such as a self-contained breathing apparatus. Therefore, it is important that rescuers recognize the atmospheric hazards of a confined space and take proper precautions.

11.3 CONFINED SPACE ENTRY

The proposed Confined Space Standards at 29 CFR §1910.146 may provide the basis upon which to develop a program for entry into confined spaces that pose potential health or safety risks. A confined space is defined as any location that, by design, has limited openings for entry and egress, is not intended for continuous employee occupancy, and is so enclosed that natural ventilation may not reduce air contaminants to levels below the threshold limit value (TLV). Entry into confined spaces without the proper precautions could result in injury and/or impairment due to:

- An atmosphere that is flammable or explosive;
- Lack of oxygen to support life;
- Toxic materials that upon contact or inhalation could cause injury, illness, or death; or
- General safety hazards such as steam, high pressure materials, or other work area hazards that could result in injuries.

Examples of confined spaces include: manholes, stacks, pipes, storage tanks, trailers, tank cars, pits, sumps, hoppers, and bins. It is important to note that even some buildings might be considered a confined space (e.g., an abandoned chemical laboratory with no open doors or windows).

The following elements of confined site entry should be addressed at each site:

- Hazards information and control;
- Employee training and information;
- Prevention of unauthorized entry;
- Equipment;
- Emergency rescue;
- Protection from external hazards;
- Training and duties of authorized entrants, attendants, and individuals authorizing or in charge of entry.

Before entry could be made into a confined space, a confined space entry checklist should be completed and signed. **Exhibit 11-5** provides the proposed Confined Space Entry Permit. To insure that all areas of the confined space are safe for work, the following situations should be evaluated by competent personnel:

Flammable or Explosive Potential. Technic-ally competent personnel trained in testing methods using an explosive gas detector should test the atmosphere within the confined space. If combustible gases are present, entry should not be allowed until the source has been isolated and the space flushed or purged so that the test indicates less than 5 percent of the lower explosive limit.

Oxygen Deficiency. Technically competent personnel should use approved oxygen testing equipment to test the atmosphere within the confined space to determine whether the air is respirable and contains sufficient oxygen to support normal consciousness. If the air is found to be oxygen deficient (less than 17 percent by volume), positive ventilation techniques, including fans and blowers, may be used to increase the oxygen content. If, after further testing, the oxygen concentration is still deficient, SCBA or another proven air supply should be provided and used.

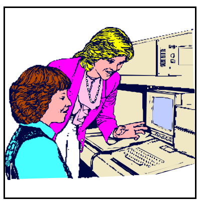
Toxic or Corrosive Materials. When toxic or chemical materials that could result in injury by contact or inhalation by persons entering the confined space are detected or suspected, several actions should be taken by on-site personnel. First, any piping that conveys hazardous materials to the confined space should be isolated. Second, the space should be emptied of the hazardous substance until safe limits are reached. Third, adequate ventilation equipment, as well as all other appropriate protective equipment for protection of the eyes, face, and arms should be provided if the work to be done in the confined space includes welding, burning, or heating, which may generate toxic fumes and gases. Finally, all employees entering a confined space that has contained corrosive materials should wear eye and other appropriate protective equipment to prevent possible contact with any remaining corrosive material.

A hazard evaluation should be conducted before any work in a confined space is started, to identify existing or potential work area hazards that have the potential to cause injuries, illness, or property damage. Examples of work area hazard control items include unguarded openings, high or low temperatures, poor illumination, sharp edges, steam, compressed gases and liquids, flammable or combustible materials, and mechanical or electrical exposures. When dealing with hazards that cannot be eliminated or controlled, adequate PPE should be used.

Prior to entry into a confined space, consideration should be given to how life support systems would function in the event of a power failure. For example, in the event of electrical failure, air supply pumps, lights, warning systems, and other electrically powered devices would be inoperative. Site personnel should have an emergency plan of action that provides alternate life support systems and a means of escape from the confined space. The Site Health and Safety Officer should have communicated this plan to all employees engaged in work in confined spaces.

Each employee entering a confined space should wear a safety belt equipped with a life-line for evacuation purposes in case of an emergency. If the entry is through a top opening, the safety belt should be of the harness type that will suspend a person in an upright position. Emergency equip-ment such as life-lines, safety harnesses, fire extinguishers, breathing equipment, and other devices appropriate to the situation should be ready and immediately available. All persons engaged in the activity should be trained in the use of the life support system, rescue system, and emergency equipment. In keeping with the buddy system, at least one person, trained in first aid and respiration, should be immediately available outside the confined space to provide assistance if needed, utilizing a planned and immediately available communications means.

11.4 INFORMATION AND NEW TECHNOLOGY PROGRAMS



Two additional programs that must be developed, imple-mented, and included as part of the employer's health and safety program are information and new technology programs (29 CFR §1910.120(i) and (o)). The information program must be developed and implemented to inform employees, contractors, and subcontractors engaged in hazardous waste operations of the nature, level, and degree of exposure that may result from 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), which may contain information that would be useful to incorporate into the informational program or emergency response plan for a site. Employees, contractors, and subcontractors working outside of the operational part of a site are not covered by this standard.In addition to developing an informational program, the employer must include as part of the health and safety 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 cleanup 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. This evaluation, which must be completed prior to using the new technology on a large scale at the site, must assess 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.

11.5 CONSTRUCTION REQUIREMENTS

In addition to the worker protection standards at 29 CFR §1910.120, OSHA has a number of regulations at 29 CFR Part 1926 that set forth safety and health standards specifically applicable to the construction industry. These standards establish workplace requirements for the following, among others:

- Subpart C: General Health and Safety Provisions;
- Subpart D: Occupational Health and Environmental Controls, for providing adequate illumination and ventilation;
- Subpart F: Fire Protection and Prevention, for storing flammable and combustible liquids;
- Subpart G: Signs, Signals, and Barricades, for posting adequate accident prevention signs and tags;
- Subpart I: Tools -- Hand and Power; and
- Subpart P: Excavations.

Appendix B provides a detailed description of these and other common applicable OSHA standards.

EXHIBIT 11-5
OSHA's Proposed Confined Space Entry Permit

G CONFINED SPACE ENTRY PERMIT **G** HAZARDOUS AREA ENTRY PERMIT

LOCATION and DESCRIPTION of Confined Space ______________ Date ______

1 PURPOSE of Entry ______________ Time ______ M

DEPARTMENT ______________ Expiration ______ M

PERSON in Charge of Work ______________

SUPERVISOR (S) in Charge of Crews	Type of Crew	Phone

2

3

SPECIAL REQUIREMENTS	Yes	No		Yes	No
Lock Out - De-energize			Escape Harness		
Lines Broken - Capped or Blanked			Tripod emergency escape unit		
Purge - Flush and vent			Lifelines		
Ventilation			Fire Extinguishers		
Secure Area			Lighting		
Breathing Apparatus			Protective Clothing		
Resuscitator - Inhalator			Respirator		

4

TEST(S) TO BE TAKEN (Valid for one 8-hour turn entry)	P.E.L.*	YES	NO	DATE M	DATE M	DATE M	DATE M	DATE M	DATE M	DATE M	DATE M
% of Oxygen	.19.5% +21%										
% of L.E.L.*	Any % over 10										
Carbon Monoxide	50 ppm										
Aromatic Hydrocarbon	10 ppm										
Hydrocyanic Acid	10 ppm										
Hydrogen Sulfide	10 ppm										
Sulfur Dioxide	5 ppm										
Ammonia	25 ppm										

Name

GAS TESTER ______________

Note: Continuous/periodic tests shall be established before beginning job. Any questions pertaining to test requirements contact certified division gas tester, Plant Gas Coordinator or the Industrial Hygienist

5

INSTRUMENTS USED Name	Type	Ident. No.

	SAFETY STANDBY PERSON(S) Name	Ck. No.
Yes **G**		
No **G**		

Supr. authorizing all above conditions satisfied ______________

AMBULANCE * P.E.L. Permissible Entry Level

FIRE * L.E.L. Lower Explosion Level

Orig. to Dept.
Copy to Safety

FURTHER GUIDANCE: For more information on emergency response and safety considerations, see:

1. *HAZMAT Team Planning Guidance* (U.S. EPA, 1990, EPA 540/G-90/003).

2. *NIOSH Pocket Guide to Chemical Hazards* (NIOSH, 1991, Publication 90-117).

3. *Occupational Safety and Health Guidelines for Chemical Hazards/Supplement II-OHG* (NIOSH, 1989, Publication 89-104).

4. *1991-1992 Threshold Limit Values for Chemical Substances and Physical Agents, and Biological Exposure Indices.* American Conference of Governmental Industrial Hygienists, 1991.

5. *Criteria Document -- Working in Confined Spaces* (NIOSH, 1980, Publication 80-106).

6. *NIOSH Alert: Request for Assistance in Preventing Occupational Fatalities in Confined Spaces* (NIOSH, 1986, Publication 86-110).

ACRONYMS

ANSI	American National Standards Institute
CFR	Code of Federal Regulations
CGI	Combustible Gas Indicator
CPC	Chemical Protective Clothing
CPR	Cardiopulmonary Resuscitation
CRZ	Contamination Reduction Zone
DOT	U.S. Department of Transportation
DRI	Direct Reading Instrument
EHS	Extremely Hazardous Substance
EPA	US Environmental Protection Agency
ERT	US EPA Environmental Response Team
FID	Flame Ionization Detector
FR	Federal Register
GC	Gas Chromatography
HASP	Site-Specific Health and Safety Plan
HAZCOM	Hazard Communication Standard (HCS)
HAZMAT	Hazardous Material
HAZWOPER	Hazardous Waste Operations and Emergency Response
HCS	Hazard Communication Standard (HAZCOM)
IDLH	Immediately Dangerous to Life or Health
IR	Infrared
LEL	Lower Explosive Limit
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NPRM	Notice of Proposed Rulemaking
OSHA	U.S. Occupational Safety and Health Administration
OVA	Organic Vapor Analyzer
PA/SI	Preliminary Assessment and Site Investigation
PCB	Polychlorinated Biphenyls
PE	Preliminary Investigation
PEL	Permissible Exposure Limit
PHC	Principal Hazardous Constituent
PID	Photoionization Detector
PPE	Personal Protective Clothing and Equipment
RCRA	Resource Conservation and Recovery Act
REL	Recommended Exposure Limit
RI/FS	Remedial Investigation and Feasibility Study
SAR	Supplied-Air Respirator
SARA	Superfund Amendments and Reauthorization Act of 1986
SCBA	Self-Contained Breathing Apparatus
SOP	Standard Operating Procedure
SOSG	Standard Operating Safety Guides
TLV	Threshold Limit Value
TSD	Treatment, Storage, and Disposal
TWA	Time-Weighted Average
USCG	U.S. Coast Guard

ABBREVIATIONS

cm^3	cubic centimeter
CO_2	carbon dioxide
dBA	decibels on A-weighted scale
ft	foot
g	gram
hr	hour
l	liter
lb	pound
m^3	cubic meter
mg	milligram
ml	milliliter
mrem	milliroentgen equivalent in man
O_2	oxygen
ppb	parts per billion
ppm	parts per million
ta	ambient air temperature
ta adj	adjusted ambient air temperature