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Research and Development

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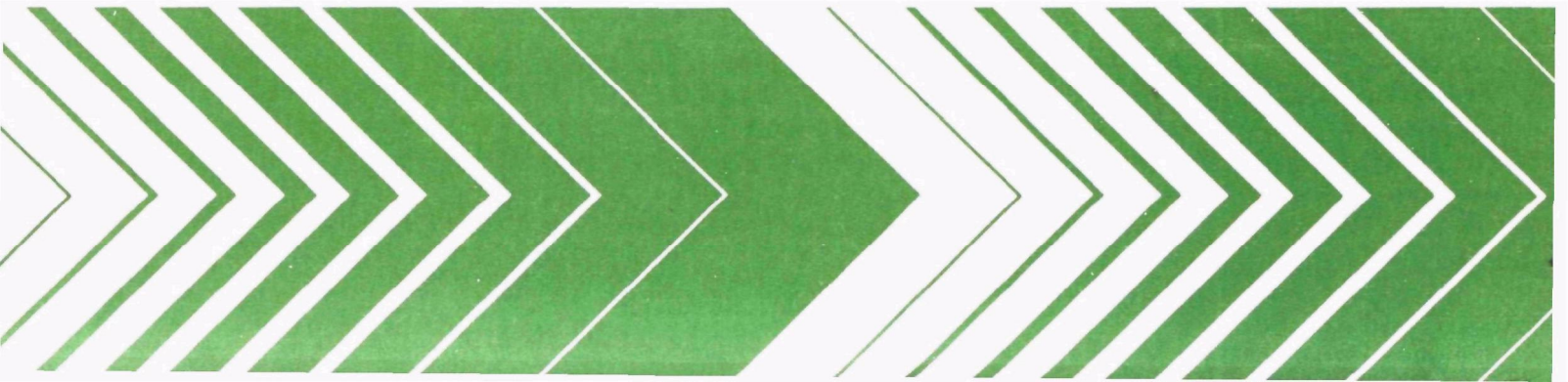
Environmental Monitoring Series

Hazardous Materials Spill Monitoring

Safety Handbook and Chemical Hazard Guide

Part A



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HAZARDOUS MATERIALS SPILL MONITORING

Safety Handbook and Chemical Hazard Guide
Part A

by

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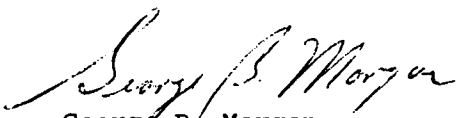
FOREWORD

Protection of the environment requires effective regulatory actions which are based on sound technical and scientific information. This information must include the quantitative description and linking of pollutant sources, transport mechanisms, interactions, and resulting effects on man and his environment. Because of the complexities involved, assessment of specific pollutants in the environment requires a total systems approach which transcends the media of air, water, and land. The Environmental Monitoring and Support Laboratory-Las Vegas contributes to the formation and enhancement of a sound monitoring data base for exposure assessment through programs designed to:

- develop and optimize systems and strategies for monitoring pollutants and their impact on the environment
- demonstrate new monitoring systems and technologies by applying them to fulfill special monitoring needs of the Agency's operating programs

This report presents information on the hazards which may be encountered in spills of specific chemical compounds and appropriate exposure prevention, protection and first-aid measures to be followed by hazardous material spill response personnel to minimize personal and public risk. The information contained is useful to spill monitors and clean-up personnel, to the public for their personal protection, and to on-site coordinators to provide some basis for action decisions with respect to public safety. For further information contact the Water and Land Quality Branch, Monitoring Operations Division.



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SECTION 1. INTRODUCTION

This manual is physically separated into two parts (Parts A and B) designed to be used in concert. Part A is a safety and first aid reference for personnel responding to spills of hazardous materials, particularly those materials which may enter surface waters. The suggested procedures are not intended to replace professional medical attention, but only to provide for immediate first aid in the event of an injury or acute exposure of field personnel to a hazardous substance. Part B (under separate cover) is composed of a listing of the chemicals addressed and individual chemical data sheets containing information on the nature, hazard, exposure and safety precautions for 655 specific chemical compounds. This manual is not intended to provide information on proper clean-up, retention or neutralization procedures, or on long-term, cumulative effects.

It is strongly recommended that personnel be familiar with the contents of this manual and have read the introductory chapters prior to responding to spills of any type.

All personnel responding to a spill of known materials should refer to this manual for pertinent safety procedures, protective equipment, and appropriate first-aid measures before approaching the spill area. If the nature of the chemical(s) spilled is not known, the spill should be approached as that of a highly toxic substance and full-protection gear employed.

In those cases in which the nature or potential hazard of a spill is unknown, but no imminent hazard to a populace is suspected, every effort should be made to determine the spill nature and extent prior to exposure of clean-up personnel. In the long run, time spent in making such a determination may be more than compensated for by making swift, concerted, and appropriate action possible when the problem is properly defined.

Although many spilled materials will be in a solid or liquid form, the greatest danger to personnel is from inhalation or exposure to airborne gases, dusts, vapors, or fumes. The dangers from vaporization, sublimation, or secondary reactions which produce toxic airborne materials cannot be overemphasized.

Each chemical discussed in this manual exhibits some degree of toxicity. Those chemicals for which little information is provided should be considered highly toxic and be treated as such until information to the contrary becomes available. Response personnel must be cautioned as to the possible presence of physical hazards due to damage at the spill site. Jagged debris, slippery footing, disturbed wildlife, open flames, etc., are often present. Downed power lines present a particular hazard, especially in the presence of strong

electrolytes. Identification of potential hazards due to explosive substances, violent secondary reactions, sputtering, high heat output, etc., has been attempted and is noted, if known. Common sense and alertness will prevent most accidents; conversely, overconfidence and ignorance are the leading causes of injury.

Part A of this manual is divided into seven sections. Sections 2-5 present general safety considerations, first-aid procedures, and descriptions of protective equipment. The sixth section contains a description of the hazard rating system used in Part B (Chemical Data). The final section includes a priority listing of hazardous materials based upon their hazard ratings and reported spill frequency.

Part B contains an index of the 655 chemical compounds addressed by this manual, followed immediately by alphabetized chemical "data sheets" with specific precautionary information and first-aid procedures. The data sheets cross-reference the known common synonyms of the various chemicals as well as available trade names. Part B is provided in a form for loose-leaf binding to facilitate addition, revision, and update as new data become available. It is recommended that Part A be inserted and maintained in the same loose-leaf binder.

The hazardous materials addressed in this manual include all chemicals tentatively designated "hazardous" by the U.S. Environmental Protection Agency (1972); all chemicals in the "CHRIS" Manual (U.S. Coast Guard, 1974); and those hazardous materials reported as spilled during the period of 1970 through 1974.

Information on hazards, toxicity, and safety requirements of the chemicals was compiled from information found in the "CHRIS" Manual, the National Fire Codes (NFPA, 1972), the Fire Protection Guide on Hazardous Materials (NFPA, 1975), Sax (1963), Hawley (1971), and U.S. Environmental Protection Agency (1972). First-aid information is condensed from American Red Cross Standard First Aid and Personal Safety (1973) through the courtesy of the American National Red Cross.

SECTION 2. TOXICITY

TYPES OF TOXICITY

The toxicity of a chemical refers to its ability to produce injury once it reaches a susceptible site in or on the body. This includes damage by irritants, corrosives, or poisons.

Toxicity may be subdivided on the basis of duration of exposure:

1. Acute exposure refers to short-term exposure of seconds, minutes, or hours.

2. Subacute exposure refers to exposure intermediate between acute and chronic; the duration is up to about 90 days.

3. Chronic exposure is of long duration. It refers to prolonged or repeated exposure to materials which are inhaled or absorbed into the body.

It is important to differentiate between acute or chronic exposure and acute or chronic effects. Some compounds may produce chronic illness although the exposure was acute.

Toxic effects

Effects of toxic substances may be subdivided on the basis of the site of action:

1. Local effect means that the point of action takes place at the point of contact, whether skin, mucous membrane, or respiratory or gastrointestinal linings. It does not necessarily imply absorption.

2. Systemic effect refers to a site of action other than the point of contact and implies that absorption has taken place.

Toxicity ratings

In this manual, the following terms and definitions are used to indicate relative hazards:

1. Unknown - This rating has been used when sufficient data for valid assessment of a chemical could not be obtained.

2. Non-toxic - This designation was assigned to materials which cause no harm under conditions of normal use or exposure. These may produce toxic effects under unusual conditions or upon overwhelming dosage.

3. Slightly toxic - Materials designated as slightly toxic produce changes in the human body which are readily reversible and which will disappear after termination of exposure, with or without medical treatment.

4. Moderately toxic - Moderately toxic substances may produce irreversible as well as reversible changes to the human body. These changes are not of such severity as to threaten life or to produce serious permanent physical impairment.

5. Highly toxic - Highly toxic materials are those which can cause physiological damage of such severity as to threaten life or cause permanent physical impairment and/or disfigurement.

6. Toxic - Chemicals designated as toxic had insufficient data to provide qualifying adjectives. They should be considered as "highly toxic" until additional data are obtained.

Each of these categories may be divided into acute, subacute, or chronic, and local or systemic as earlier defined. All toxicity ratings provided are based upon acute exposure. The ratings are based on the effect of the material on an individual in normal good health. Susceptibility varies widely, and sensitive individuals may react violently to even small amounts of a given low-toxicity substance.

It should also be noted that some materials designated as nontoxic or slightly toxic may cause an allergic reaction in susceptible individuals. These reactions may range from the discomfort of an itch or runny nose to violent attacks of asthma or swelling of membranes, thereby closing off breathing passages.

FACTORS DETERMINING TOXIC EFFECTS

The key factors which must be considered in evaluating the specific hazard to an individual by exposure to a toxic material spill situation are summarized below:

1. Dosage

   a. Threshold limit value (TLV)

   b. Subject's physical condition, individual susceptibility

   c. Cumulative effects

2. Route of exposure

   a. Physical state of toxic substance

   b. Inhalation

   c. Skin contact (see Section 3)

   d. Ingestion (see Section 3)

   e. Radiation (see Section 3)

3. Complicating conditions at spill site (see Section 4)

Dosage

Threshold limit value

A threshold limit value (TLV) has been assigned to many of the chemicals discussed in this manual. These values have been established by the American Conference of Governmental Industrial Hygienists and the U.S. Food and Drug Administration based upon known experiments and best available data. The TLV represents the maximum concentration to which, it is believed, nearly all workers could be repeatedly exposed during a 40-hour work week without adverse affect. As shown, the values are applicable to industrial conditions, i.e., low concentrations over a prolonged period of exposure. The values have little application to the brief exposure, high dosage situations often faced in spill monitoring or clean-up operations, but are included in this manual to provide some indication of relative toxicities of the compounds noted.

It should be stressed that the omission of a TLV in this manual does not imply that the chemical is non-toxic, but rather that information on its toxicity was not available. When in doubt, it is best to assume a chemical to be highly toxic and accordingly take all available precautionary measures such as use of self-contained breathing apparatus (SCBA), protective clothing, etc.

Individual susceptibility

Under conditions of like exposure to potentially harmful substances, there is often marked variability in the manner in which individuals respond. Some may show no evidence of intoxication by a chemical exposure which would evoke mild, severe, or even fatal responses in other individuals.

Although much of individual response variability is as yet unexplained, there are certain known predisposing factors likely to modify "expected" response. These include previous injury to such sites of detoxification as the liver and kidney, or previous damage to the heart or lung. The liver and kidney, respectively, function to screen and scavenge many toxic substances from general circulation and to excrete them from the body. Impairment of these functions therefore allows potentially dangerous buildups to occur and may lead to further impairment of these vital organs or other symptoms of

general systemic poisoning. Similarly, previous lung damage enhances the likelihood of further damage from inhaled toxic substances and may reduce the effectiveness of the lungs as a route of excretion.

In determining therapeutic drug dosages, age, sex, weight, general physical condition, and the intake of other medication are considered. Such factors should likewise be weighed when evaluating the hazards of spill-site exposure on an individual basis. Obesity can predispose a worker to inordinate accumulations of organic solvents and other fat-soluble compounds within the fatty tissues. Care must be taken to avoid dangerous interactions between medication in use by any spill personnel and active materials at the spill site. Combined effects can result in altered response of the body to the medication and/or altered tolerance to the toxic spill material. Often, such combined effects are not merely additive and the consequences of a particular mixture may be very serious.

Cumulative effects

Some toxic substances are retained in the body for long periods of time and are excreted very slowly, if at all. The levels of the chemical in the body are increased as a function of duration of exposure. Examples include such heavy metals as mercury and lead. Upon repeated or continuous exposure, these substances can reach levels resulting in illness or even death. Physiological changes associated with long-term subacute exposure are often irreparable.

The potential hazard of cumulative exposure should be considered in addressing repetitive incidents or clean-up operations of long duration involving such substances.

Routes of exposure

There are three routes by which toxic materials can enter the biological system--through inhalation, ingestion, or penetration of the skin or mucous membranes. In general, the nature of exposure to hazardous substances is a function of the physical state of the chemical(s) spilled. Acids and alkalis, at the top of the spill-frequency list, are basically primary contact hazards. However, if these reactive materials are in powder form or produce toxic fumes or vapors as a result of decomposition or reaction with other materials at the spill site, an inhalation hazard is created as well.

Toxic gases, dusts, or aerosols, on the other hand, while basically inhalation hazards, may exert direct effect upon skin surfaces (e.g., chlorine gas) or penetrate to exert systemic toxic effects (e.g., parathion) or both (e.g., bromine).

Inhalation

The most important route in occupational poisoning and a common route of exposure in spill situations is through the respiratory system. Often, personnel underestimate the actual or potential hazards of contaminated air. In

relatively low concentrations many gases, fumes, dusts, and aerosols can be inhaled to toxic dosage in short periods of time. Absorption of gaseous materials within the lungs is generally quite rapid, depending upon partial pressure and the solubility of the gas in tissues and body fluids.

The physiologic response to inhaled toxic materials may be so dramatic in onset as to totally incapacitate a worker, rendering him unable to provide for his own immediate safety needs. Some form of "buddy-system" is strongly recommended to minimize the hazards of human error in dealing with such toxic substances.

Materials which are quite innocuous in liquid or consolidated form may present very serious inhalation hazards as powders. Such materials as powdered animal derivatives may, in a susceptible individual, elicit an anaphylactic reaction with sudden onset and grave consequences (Anaphylaxis is an extreme sensitization to a particular compound, usually a foreign protein, to which the body has been exposed at some time in the past, e.g., bee venom.). Similarly, allergens may evoke a broad range of physiological responses. A good general rule is to treat all powdered materials as potential hazards and take appropriate measures for eye and lung protection. Adequate breathing equipment is mandatory for any spill response team.

SECTION 3. EXPOSURE PROTECTION

BREATHING EQUIPMENT

Inhalation of toxicants is the primary hazard at a spill site. Since numerous chemicals are extremely toxic when inhaled, breathing equipment appropriate for the type or class of chemicals used must be readily available, properly maintained, and precisely fitted, and should be worn as long as an inhalation hazard is suspected.

Respiratory devices are of two types: oxygen or air supply and air-purifying. The former includes:

1. Self-contained breathing apparatus (SCBA).

   SCBA provides a pure air mixture from a source carried by the user and is independent of the surrounding environment. Recirculating respirators using a pure oxygen atmosphere are not recommended at a spill site due to the extreme reactivity of oxygen in high concentrations. Compressed air respirators are recommended whenever they are available.

2. The hose-type respirator.

   This device provides pure air that is pumped from a source outside the contaminated environment.

In air-purifying respirators, gaseous contaminants are removed from otherwise respirable air by absorption, adsorption, and chemical reaction. Particulates are removed by mechanical filtration. Air purifying respirators cannot be used in oxygen deficient atmospheres and must not be used where vapor concentrations are higher than those for which the respirators were designed. Their usefulness is restricted to the gas (or gases) and/or particulates for which they are designed. They are designed for short-term (1/2-hour) use and generally afford no protection from vapor concentrations above 2%. Air purifying respirators are of three types:

1. Chemical respirators.

   Inspired air is drawn over a chemical or through a cartridge containing suitable chemicals to remove gases or vapors. These respirators and interchangeable cartridges are usually specifically designed for a particular type or class of gas or vapor.

2. Mechanical filters.

These are similar to chemical cartridge respirators except that the purifying chemicals in the cartridge are replaced by filters. Filter respirators are designed to remove a single particulate contaminant or class of particulates. Certain substances, such as mercury, have such high vapor pressures that inspired air passing over them may introduce toxic vapors into the air being breathed. Combination chemo-mechanical, air-supplied respirators, or SCBA are required in these cases.

3. Combination respirators for gases and particulates.

These respirators provide simultaneous protection against gases, vapors, and particulates. They consist of gas-mask canister or chemical cartridges with mechanical filters in series.

Maximal protection is obtained by a SCBA with a fitted full-face mask. At any spill site, an unknown chemical should be regarded as highly hazardous and SCBA should be employed. Neither self-contained breathing apparatus nor purifying respirators will provide protection unless they are properly fitted to the individual user and maintained in proper working order. They need to be cleaned after each use and chemical cartridges or mechanical filters should be replaced. In any case, respirators employed should be approved by the National Institute of Occupational Safety and Health.

The type and degree of hazard to be encountered will govern the kind of respiratory device to be used. The following classification of atmospheres may be used to determine the respirator to be used:

- Oxygen Deficient - SCBA
- Gases, Vapors, and Some Fumes - SCBA or Chemical Cartridge
- Particulates - SCBA or mechanical filter
- Combination of Gases and Particulates, Some Fumes - SCBA or combinations of chemical cartridge and mechanical filter.

1. Oxygen deficiency.

Air normally contains 21% oxygen by volume. This may be reduced by dilution, displacement, or removal of oxygen by other gases, chemical reaction, or absorption in certain materials. Atmospheres with 16% or less oxygen may cause serious injury or death, depending on the actual concentration, length of exposure and physical activity. In oxygen-deficient atmospheres, a self-contained breathing apparatus is required.

2. Gases and vapors.

Gases and vapors may be classified as toxic or inert. Inert gases are dangerous when they displace oxygen from the air. This would necessitate the use of self-contained breathing apparatus. Toxic gases require the use of chemical respirators or SCBA.

3. Particulates.

Particulates are dispersions of solids (dust, smoke, or fumes) or liquids (mists or fogs) or combinations of the two. Aerosols are dispersions of very fine solid or liquid particles in air. With rare exceptions, such as in the presence of organic phosphorus pesticides, massive concentrations of highly toxic metals, or rapidly sublimable fumes, mechanical filtration will provide sufficient protection for short exposure periods.

4. Combination of particulates and gases.

Special respiratory devices are available for protection against more than one type of contaminant. These combine chemical canisters and mechanical filters to eliminate both gases and particulates. Special respiratory devices should be selected and their limitations carefully noted to provide protection against the maximum expected concentrations of each contaminant.

SKIN CONTACT

The skin and its associated film of lipid and sweat is normally an effective barrier for protection of underlying body tissues. Relatively few substances are absorbed through this barrier in dangerous amounts. Organic solvents can remove the lipid film and gain entrance through the skin, hair follicles, or sebaceous glands. Indeed, such solvents may act as carriers for other chemicals that would not normally penetrate the skin. This mechanism can be an important one if solvents are spilled on skin surfaces or clothing or during the too-frequently routine ritual of washing oily or greasy hands in organic solvent baths. Several of the chlorinated solvents, e.g., trichloroethane, are handled far too casually considering their own toxicity as well as their potential as carriers for other substances.

Keep in mind that the effectiveness of the skin as a barrier depends upon its unit integrity. Breaks in that integrity, in the form of open wounds and bodily orifices greatly reduce the barrier effectiveness. Absorption through and/or attack of mucous membranes is quite rapid for many chemicals. Eye protection therefore serves a two-fold purpose--safeguarding the sensitive tissues of the eye and removing a potential site for systemic absorption.

In addition to absorption through the skin, direct irritation and sensitization of skin layers per se can occur. Caustics and acids represent the most common skin contact irritants. Severe burns can result with associated

disfigurement, disability, and susceptibility to secondary infection. Note that while acids tend to cause conjugation of skin proteins, reinforcing the barrier to further penetration, alkalis do not, and can penetrate to cause deeper tissue destruction. In powdered form, such materials may react with skin moisture to cause localized irritation or more severe burns. Appropriate protective clothing, gloves, and eye covering are indicated when contact with reactive materials is possible.

The reaction of some chemicals with protein in the skin layers causes sensitization. Subsequent exposure is likely to give rise to a contact dermatitis, i.e., skin rash, with associated itching, burning, cracking, and the possibility of secondary infection. Allergic reactions can also result in increased vascular permeability, with development of "water blisters", or edema. Such swellings may cause a severe obstruction to swallowing, breathing, or vision.

There are creams, gels, and greases available which function as a protective barrier and offer limited protection to skin surfaces. The protection is generally rather short-lived in a working environment, but where the necessity for dexterous manipulation precludes the use of protective gloves, such barrier materials may be indicated to provide short-term protection. The silicone greases appear to be among the most effective of these and are even resistant to penetration by a range of organic solvents. The worker should know the limitations of barrier materials including their potential reactivity with spilled chemicals and the likelihood of maintaining barrier integrity in a given work situation.

EYE PROTECTION

Eye protection must not be overlooked while on the spill site. As with inhalation, damage may be irreversible within a matter of seconds. Contact lenses should not be worn on the spill site since they serve to concentrate materials which enter the eye.

A major problem in providing eye protection comes from corrosive fumes or vapor which directly attack eye tissues. Many goggles, although safety-approved, have vents and dust screens to allow for air flow. It is apparent that if corrosive fumes are present, goggles without such ventilation are necessary. Under such conditions, a self-contained breathing apparatus of the type described earlier would normally be necessary and should provide proper protection.

In discharges where the material is not capable of producing corrosive vapors or fumes, dust-type goggles are considered satisfactory providing they are equipped with filters to remove any particles which may enter through the vented regions.

INGESTION

Poisoning by ingestion, i.e., absorption from the gastrointestinal tract, is far less common than inhalation or skin contact in a spill response situation. This is partly the result of a strong human aversion to swallowing foreign substances and the voluntary aspects of ingestion. However, poisoning by this route can occur without the knowledge of the worker through contamination of temporary drinking water supplies or foodstuffs, failure to wash hands before eating, or swallowing inhaled toxic particles entrapped in sputum. Awareness of the potential toxicity of the materials being dealt with and common-sense practice will minimize the chances of intoxication by this route.

RADIATION

This manual includes only a few of the chemicals which represent a radiation hazard when spilled. However, the increasing use of radioisotopes in medicine, nuclear reactors, and diagnostic equipment is greatly increasing the probability of spills involving radioactive materials.

Unlike other hazards, radiation does not require physical contact with the source to result in damage. Mere proximity to strong radiation sources can result in physiological damage. In the event of possible exposure to concentrated radioisotopes, seek immediate medical attention; such attention can allow one to tolerate up to twice the radiation dosage he could tolerate without treatment.

The short-term symptoms of acute whole-body radiation exposure are generally vomiting, nausea, and fatigue beginning shortly after the exposure incident. These last about 1 day and are followed by apparent recovery for a period of 2 or 3 weeks before the onset of additional symptoms. These delayed symptoms may include any or all of the following: depilation (loss of hair), fever, infection, anemia, hemorrhage, severe diarrhea, extreme lethargy, disorientation, and cardiovascular collapse.

In the event of such a spill, the best action would be to wait for qualified personnel to arrive on the scene. If personnel are exposed to radioisotopes, however, the following actions should be taken:

1. Internal decontamination

   Internal contamination may occur through ingestion, inhalation, or by absorption through the skin or open wounds. The aims of corrective procedures are to try to eliminate the internally introduced contaminant as quickly as possible and try to prevent its fixation in the body (increase excretion from the body). Consequently, the promotion of vomiting and/or expectoration should be undertaken immediately. In the case of contaminated cuts or other injuries, the wound should be immediately washed and bleeding encouraged. In all cases, medical assistance should be sought.

2. External decontamination

External contamination on a person presents three hazards:

- o Local exposure of the skin.
- o Absorption through the skin.
- o Transference into the body by inhalation or ingestion.

Of the three, the last is the most critical hazard. Affected areas should be washed immediately. Water to be used should not be hot, rather tepid at best. Soap may be used but it should not be of the abrasive type or strongly alkaline. A soft brush may be used but care must be taken to avoid abrasion. Throughout the washing, care must be exercised to avoid damage to the skin. Use of strong detergents, acids, alkalis, or organic solvents should be avoided. Care should be taken to avoid spreading the contamination to unexposed parts of the body to avoid internal contamination through an open wound. Medical attention should be sought immediately.

In the broad sense, radiation includes light, radiowaves, cosmic rays, x rays, and other forms. At a spill site, the forms of most concern would be those radiations emitted from artificial radioisotopes as discussed previously. In today's technology, however, it is not inconceivable that exposure to laser, radar, x rays, or other high energy radiation sources could occur. In these events, injuries are either of a local nature (generally "burns") or of a more long-term than immediate hazard. If a question exists as to whether exposure occurred, it is best to seek medical attention.

Sunlight cannot be ignored as a radiation hazard. Although it would seem as though common sense would dictate the wearing of shirts at a spill site, severe sunburn is not an uncommon occurrence among clean-up personnel. The effects of ultraviolet radiation upon chemicals in contact with the skin can enhance sensitization and direct reaction. Sunburn, although rarely severe enough to cause serious damage in itself, can increase the susceptibility of a person to exposure to spilled materials and contribute to fatigue, and should be guarded against.

SECTION 4. COMPLICATING CONDITIONS AT SPILL SITE

GENERAL

The hazards presented by spilled materials may be either intensified or ameliorated by local conditions at the spill site. Weather conditions, wreckage, litter, fire (actual or potential) or other conditions may require modification of basic spill monitoring approaches. Such factors may superimpose additional restrictions on monitoring and clean-up operations by affecting the nature and rate of movement of materials within and beyond the immediate spill area, the toxicity and reactivity of spilled substances, and the monitor's mobility within the working area.

WEATHER

Wind increases the dispersal of toxic gases, powders, and aerosols from the spill site. Restriction of public access to affected downwind areas should be considered. If possible, monitors should approach the spill site from upwind to avoid unnecessary exposure to a hazardous substance; this is especially important if there is a potential for ignition. Be aware at all times that winds can shift and that personnel can be subjected to additional hazard under such conditions. Wind action greatly increases the hazards where fire complicates a monitoring or clean-up operation, but can be beneficial as it reduces the possibility of explosive fume buildups. On water, winds increase wave activity and may require windward approach to a spill site, e.g., a damaged barge, to avoid possible collision. The special conditions of such an approach should be carefully evaluated with an eye toward minimizing personnel safety hazards.

Precipitation is often a mixed blessing at a hazardous materials spill site. On the positive side, it can dilute toxic material concentrations, cool potential reactants, and suppress the aerial dispersal of powders and aerosols. On the other hand, rain increases sheet runoff and waterborne dispersal; causes spread of many materials, including combustible liquids; causes slippery working conditions; and may react with alkali metals, anhydrous powders, concentrated acids, some organics, etc., to yield heat, fire, spattering, gases, or toxic fumes.

High ambient temperatures increase volatilization and chemical reaction rates. The likelihood of explosive gas concentrations and toxic reaction products increases with increasing temperature. High temperatures also increase the personnel fatigue factor and therefore the possibilities of potentially dangerous judgement errors. As judgement and common sense are the

worker's primary safeguards, on-site supervisors and working-level personnel should recognize the signs of fatigue and remove themselves to rest areas for recuperation.

FIRE

Fire or high fire potential at a spill site represents a very special working environment for spill monitors. In general, to cope with these hazards, on-site personnel either should have training in appropriate techniques for prevention and control of fires, or should leave the job to specialized units who have the proper training and equipment. Chemical reactivity and the potential for toxic products is greatly enhanced under fire conditions. Monitors should coordinate closely with fire safety personnel to identify and prioritize the potential hazards to spill-site personnel and the public.

The convective air currents formed by fires can carry toxic products far from the spill site. Restricting access to downwind areas should be considered as well as monitoring the nature, concentration, and extent of such transport.

WRECKAGE LITTER

Especially where spills result from wrecks of transport vehicles or explosions at manufacturing, processing, or packaging installations, monitors may find themselves working around torn and twisted structural materials. Care should be exercised to avoid cutting or tearing protective clothing or snagging breathing apparatus on such site debris. When working with toxic substances a laceration or puncture can be a serious route to systemic poisoning. Fume and fire hazard potential should be evaluated prior to any torch cutting.

MISCELLANEOUS

Other hazards may also exist. Downed power lines present a shock danger and add to the probability of fire and explosion. Broken steam lines, in addition to posing a burn hazard, may also reduce visibility and contribute substantial amounts of uncontrolled water at the scene. Disturbed wildlife may be present and, due to the stresses imposed, be atypically aggressive. (If bitten, attempt to kill or capture the animal for rabies tests, identify snake species for anti-toxin selection, etc.) High speed traffic, extreme cold, radioactive materials, deep swift water, etc., will present different, but significant dangers. It is impossible to foresee all possible hazards at a spill site. Again, alertness, the use of common sense and good judgement will help to avoid most of these dangers.

SECTION 5. FIRST AID

GENERAL

First aid is generally defined as the immediate and temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained. Common sense and a few simple rules are the keys to effective first aid.

The first objective is to save life by:

- Ensuring an open airway and maintaining breathing.
- Preventing heavy loss of blood.
- Giving first aid for poisoning.
- Preventing or reducing shock.
- Preventing further injury.
- Sending for medical aid.

The first-aider should also:

- Avoid panic.
- Inspire confidence.
- Do no more than necessary until professional help arrives.

HEAVY BLEEDING

A victim who has profuse bleeding may die within one minute or less, therefore:

- DO NOT WASTE TIME.
- USE PRESSURE DIRECTLY OVER THE WOUND.
- Place a pad, clean handkerchief, clean cloth, etc., directly over the wound and press firmly with one or both of your hands. If a pad or bandage is not available, close the wound with your hand or fingers.

- o Hold the pad firmly in place with a strong bandage, necktie, strips of cloth, etc. Unless bones are broken, raise the bleeding part higher than the rest of the body.

- o Keep the victim lying down.

- o Keep the victim warm to prevent loss of body heat. Cover with blankets, coat, or anything available and put something under him if he is on a cold or damp surface. Do not add heat.

- o Give fluids only if victim does not have head or abdominal injuries, probably will not require surgery, and professional help will be more than one hour arriving. If the victim is conscious and can swallow, give him plenty of liquids to drink. Give him sips and do not give stimulants.

- o Call a physician.

- o Use a tourniquet only if victim is bleeding profusely and other methods have failed and the victim's life is in danger.

- o DO NOT give the victim alcoholic drinks.

- o If the victim is UNCONSCIOUS or if abdominal injury is suspected, DO NOT give him fluids.

BREATHING STOPPED

A person who has stopped breathing will die if breathing is not restored immediately.

If breathing is restored, victims who had stopped breathing need hospitalization.

The following are major factors in breathing stoppage.

Poisonous gases in the air or lack of oxygen

- o Move victim to fresh air.

- o Begin mouth-to-mouth breathing.

- o Control the source of poisonous gases, if possible.

- o Keep others away from area.

- o DO NOT enter an enclosed area to rescue an unconscious victim without first being equipped with a self-contained or air-supplied breathing apparatus.

Electric shock

- If electrical hazard persists: Indoors, open main electrical breaker if appropriate individual breaker cannot be immediately identified; outdoors, contact power company to turn current off.
- DO NOT TOUCH the victim until he is separated from the current.
- Begin mouth-to-mouth resuscitation or cardiopulmonary resuscitation, if needed and if trained in this technique, as soon as the victim is free of contact with the current.
- DO NOT try to remove a person from an out-of-doors wire unless you have had special training for this type of rescue work.

Heart attack

Laryngeal obstruction

Accident or drowning

When breathing movements stop or lips, tongue, and fingernails become blue, there is need for help with breathing.

When in doubt, begin artificial respiration. No harm can result from its use. Delay may cost the victim his life.

ARTIFICIAL RESPIRATION

General

- Seconds count. Start immediately.
- Remove any obvious obstruction from mouth and throat.
- Place victim in appropriate position and begin artificial respiration.
- Maintain steady rhythm of 12 breaths per minute.
- Maintain an open airway and periodically check the victim. Be ready to resume artificial respiration if necessary.
- Call a physician.
- DO NOT move the victim unless absolutely necessary to remove from danger.
- DO NOT wait or look for help.
- DO NOT stop to loosen clothing or warm the victim.
- DO NOT GIVE UP.

Mouth-to-mouth breathing for adults

- Place victim in supine position (on back).
- Tilt victim's head back by pressing on his forehead with your other hand.
- Place your cheek and ear over the victim's nose and mouth, looking at his chest. Look, listen and feel for breathing for about 5 seconds.
- Pinch the victim's nose shut with the thumb and forefinger of the hand on victim's forehead. Take a deep breath and place your mouth over the victim's mouth or nose making a leak-proof seal.
- Blow your breath into the victim's mouth or nose until you see the chest rise; repeat these breaths 4 times in rapid succession without allowing the lungs to fully deflate between breaths.
- Maintain the head tilt and again check the victim for breathing for approximately 5 seconds.
- Remove your mouth and let the victim exhale while you take another deep breath. As soon as you hear the victim breathe out, replace your mouth over his mouth or nose and repeat the procedure.
- Repeat this procedure of giving one breath, turning to look, listen and feel for return of air, and blowing again, once every five seconds (12 times per minute).

Manual method of artificial respiration

- Place victim in a face-up position but allow his head to turn to the side to avoid aspiration.
- Place something under the victim's shoulders to raise them to allow the head to drop backward.
- Kneel above victim's head, facing the victim.
- Grasp victim's arm at the wrists, crossing and pressing victim's wrists against the lower chest.
- Immediately, pull arms upward, outward, and backward as far as possible.
- Repeat 15 times per minute.
- If a second person is present, he should hold the victim's head so that it tilts backward and the jaw juts forward.
- This method should be used when mouth-to-mouth resuscitation is advised against.

Cardiopulmonary resuscitation (CPR)

Heart-lung resuscitation is an emergency procedure which requires the ability to recognize a cardiac arrest and special training in its performance. All training programs should adhere to the standards put forth in JAMA "Supplement on Standards for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiac Care (ECC)". 18 February 1974, Volume 227, Number 7. *Information provided here on cardiopulmonary resuscitation is not designed to supplant a complete course of instruction under direction of a qualified instructor. Such instruction is strongly recommended for all personnel who must respond to hazardous materials spill sites.*

Emergency cardiopulmonary resuscitation involves the following steps:

- o Airway opened.
- o Breathing restored.
- o Circulation restored.

External cardiac compression should be started after providing four quick breaths and checking for pulse and breathing. If apnea (breathing stoppage) persists, and there is unconsciousness, death-like appearance and absence of carotid pulse, external cardiac compression should be started.

External cardiac compression consists of the application of rhythmic pressure over the lower half of the sternum. This compresses the heart and produces artificial circulation because the heart lies almost in the middle of the chest between the lower sternum and the spine.

External cardiac compression should always be accompanied by artificial respiration. To be effective it requires sufficient pressure to depress the victim's lower sternum 1-1/2 to 2 inches (3.8 to 5.1 centimeters) in an adult; the rate should be once a second. Considerably less effort will be required to achieve such depression in a child. The victim should be on his back on a firm surface. The rescuer stations himself at the side of the patient and places only the heel of one hand over the lower half of the sternum. He then places his other hand on top of the first one and rocks forward so that his shoulders are almost directly above the patient's chest. Keeping the arms straight and elbows locked, he exerts adequate pressure almost vertically downward. The preferred rate of 60 per minute is usually rapid enough to maintain blood flow and slow enough to allow cardiac refill. The compressions should be regular, smooth, and uninterrupted, with compression and relaxation being of equal duration. Under no circumstances should compression be interrupted for more than 5 seconds.

When there are two rescuers, optimum ventilation and circulation are achieved by quickly interposing one inflation after five chest compressions without any pause in compressions (5:1 ratio). Every interruption in cardiac compression results in a drop of blood pressure to zero. One rescuer performs external cardiac compression while the other one keeps the patient's head tilted back and continues ventilation. When there is only one rescuer he must

perform both artificial respiration and artificial circulation using a 15:2 ratio; two quick lung inflations after every 15 chest compressions. Periodic palpation of the carotid pulse should be employed to check the effectiveness of external cardiac compressions or the return of a spontaneous heartbeat.

Complications occurring from the use of cardiopulmonary resuscitation may include fracture of the ribs and sternum, laceration of the liver, and fat emboli.

Several rules to follow are:

- Never compress over the xiphoid process, the lower tip of the sternum. It extends down over the abdomen and pressure on it may cause a dangerous laceration of the liver.
- Never let the fingers touch the patient's ribs when compressing. Keep just the heel of the hand in the middle of the victim's chest over the lower half of his sternum.
- Never use sudden or jerking movements to compress the chest.
- Never compress the chest and abdomen simultaneously. This traps the liver and may cause it to rupture.

SHOCK

Severe injury or emotional upset is usually followed by shock. It can also follow infection, pain, disturbance of circulation from bleeding, stroke, heart attack, heat exhaustion, food or chemical poisoning, extensive burns, etc. The following information pertains to traumatic, injury-related shock rather than to emotional shock, per se.

The signs of shock include:

- Cold and clammy skin with beads of perspiration on the forehead and palms of hands.
- Pale face, weakness, dilated pupils, and weak, rapid pulse.
- Complaint by the victim of feeling cold, or even shaking chills.
- Frequent nausea or vomiting.
- Shallow breathing.

To prevent shock:

- If possible, correct cause of shock (e.g., control bleeding).
- Keep victim lying down.

- o Keep the airway open. If victim is vomiting, turn his head to the side so that the neck is arched.

- o Keep victim warm if weather is cold or damp.

- o Give fluids only if victim does not have head or abdominal injuries, probably will not require surgery, and professional help will be more than one hour arriving. Give him sips and do not give stimulants. A suggested formula is one pinch baking soda and two pinches salt per glass (10 oz.) of water.

- o Reassure victim.

- o NEVER give alcoholic beverages.

- o DO NOT give fluids to unconscious or semiconscious persons.

- o PREVENTION OF SHOCK SHOULD BE CONSIDERED WITH EVERY INJURY.

POISONING

Before medical aid is available, the following should be done.

SPEED IS ESSENTIAL:

- o Act before the body has time to absorb the poison.

- o When medical aid is available, give physician all possible knowledge available on the poison.

The nature of the poison will determine the first aid measure to use:

Swallowed poisons

- o If victim is conscious, give water or milk immediately.

DO NOT INDUCE VOMITING (except on the advice of doctor or Poison Control Center):

- o If the victim is unconscious,

- o Is in convulsions,

- o Is known to have swallowed a petroleum product (kerosene, gasoline, lighter fluid), toilet bowl cleaner, rust remover, drain cleaner, lye, acids for personal or household use, iodine, styptic pencil, washing soda, ammonia water, or household bleach, or has symptoms of severe pain, or a burning sensation in mouth or throat.

DO NOT INDUCE VOMITING if "do not induce vomiting" is indicated in the first aid segment of the chemical data sheets.

- Information on labels may be incorrect; contact physician or Poison Control Center immediately for proper advice.
- Call for medical aid immediately.
- Begin mouth-to-mouth resuscitation if the victim has difficulty breathing.
- If safe (see above), induce vomiting.
- Induce vomiting by use of 10 grams salt in 200 cc of warm water (2 teaspoonfuls in a glass of warm water) or use 30 cc's or one ounce of syrup of ipecac.
- When vomiting begins, place the victim face down with head lower than hips. This prevents vomitus from entering the airways and causing further damage.

Inhaled poisons

- Assist or carry victim to fresh air immediately.
- Apply artificial respiration if breathing has stopped or is irregular.
- Call physician.
- Treat for shock.
- Keep victim as quiet as possible.
- DO NOT give alcohol in any form.
- DO NOT become a victim by exposure to the same poison.
- Rescuer should employ appropriate protective clothing and breathing apparatus until clear of hazard.

EYES

First aid for chemicals in the eyes is the immediate washing of the eyes with large quantities of water. Hold the eyelids open and roll the eye while irrigating with water. Emphasis should be placed on the amount of water, the speed with which it is applied, amd washing the eye "from the inside outward". Eyes should be washed for at least 10 minutes. A delay of 30 seconds can mean the difference between no injury to the eye and permanent loss of vision.

Chemical burns to the eyes can be aggravated by contact lenses. Chemicals spilled in the eyes tend to accumulate under contact lenses. In addition, for proper irrigation, contact lenses need to be removed. It is advisable not to wear contact lenses at a spill site.

In cases of alkaline or acid chemicals in the eyes, irrigation with neutralizing agents should not be used as first-aid treatment. Acids in contact with the cornea will react with protein to form an insoluble barrier. This barrier prevents penetration of the acid into the eye. An alkaline solution does not form this barrier and is free to soak deep into the eye. If this happens with an alkaline solution and an acid neutralizing agent is used, the alkaline solution will be trapped under the insoluble barrier formed by the acid-protein reaction. This will prevent the leaching out of the alkaline solution by irrigation.

Most serious chemical injuries to eyes can be avoided by quickly and properly washing the eyes with large amounts of water.

BURNS

General

- Burns can result from heat (thermal burns) or from chemicals (chemical burns).
- Shock can complicate every type of burn.
- A person with "burn shock" may die unless he receives immediate first aid.
- In "burn shock" the liquid part of the blood is sent by the body into the burned areas. There may not be enough blood volume left to keep the brain, heart, and other organs functioning normally.
- All burns should be seen by a physician or nurse.

Objectives of first aid care for burns are to:

- Prevent and treat shock.
- Prevent contamination.
- Control pain.

Extensive thermal burns

- Place the cleanest available cloth material over all burned body areas to exclude air. Covering for burns should be a clean, thick, dry dressing. Clean newspaper can be substituted if no clean cloth is available.

- o Have victim lie down.
- o Call physician.
- o Place victim's head and chest a little lower than the rest of the body. Elevate the legs slightly if possible.
- o If the victim is conscious and can swallow, give him plenty of non-alcoholic liquids to drink (water, tea, coffee, dilute salt solution).
- o Move to hospital immediately.

Small thermal burns

- o If SKIN IS NOT BROKEN, immerse burned part in clean, cold water to relieve pain, reduce inflammation. Do not apply ice directly to the skin.
- o Soak a sterile gauze pad or clean cloth in baking soda solution: 2 tablespoonfuls baking soda (sodium bicarbonate) to 1 quart of lukewarm water.
- o Place pad over burn and bandage it loosely.
- o DO NOT disturb or open blisters.

Chemical burns

- o Immediately flush with water; speed in washing is most important in reducing the extent of injury.
- o Flush affected area with plenty of water.
- o Remove all contaminated clothing and shoes.
- o Place the cleanest available material over the burned area.
- o Treat for shock.
- o If the burned area is extensive, have victim lie down.
- o Keep him down until medical aid is available.
- o Place his chest and head a little lower than the rest of the body (raise the legs slightly if possible).
- o Maintain an open airway.
- o If he is conscious and can swallow, give him plenty of non-alcoholic liquids to drink.

- o DO NOT APPLY OINTMENTS, greases, baking soda, or other substances to extensive burns.

ENVIRONMENTAL TEMPERATURE EXTREMES

Heat exhaustion

SYMPTOMS:

- o Pale and clammy skin.
- o Pulse rapid and weak.
- o Victim complains of weakness, headache, or nausea.
- o Victim may have cramps in abdomen or limbs.

FIRST AID:

- o Have victim lie down with his head level with or lower than his body.
- o Move victim to a cool place, but protect him from chilling.
- o Give the victim salt water (1 teaspoonful salt to 1 quart water) to drink if he is conscious.
- o Loosen tight clothing.
- o Call for medical aid.

Heat stroke

SYMPTOMS:

- o Flushed and hot skin.
- o Pulse rapid and strong.
- o Victim often is unconscious.

FIRST AID:

- o Call for medical aid.
- o Cool body by sponging it with cold water or by cold applications.
- o If the victim is fully conscious and can swallow, give him salt water (1 teaspoonful salt to 1 quart water).
- o DO NOT give alcohol in any form.

Frostbite

SYMPTOMS:

- Skin color changes to white or greyish-yellow as frostbite develops.
- Initial pain which quickly subsides.
- Victim feels cold and numb; he usually is not aware of frostbite.

FIRST AID:

- Cover the frostbitten part with a warm hand or woolen material.
- If fingers or hand are frostbitten, have victim hold his hand in his armpit, next to his body.
- Bring victim inside as soon as possible.
- Place frostbitten part in warm water, about 42 C. (108° F.).
- Gently wrap the part in blankets if warm water is not available or is impractical to use.
- Let circulation reestablish itself naturally.
- When the part is warmed, encourage the victim to exercise fingers and toes.
- Give victim a warm, sweet, non-alcoholic drink.
- DO NOT RUB with snow or ice. DO NOT USE HOT WATER, hot water bottles, or heat lamps over the frostbitten area.

MOVING THE INJURED

General

Do not move an injured person until an experienced crew arrives, unless there is real danger of his receiving further injury by remaining at accident site.

Control bleeding if possible, maintain breathing, and immobilize all suspected fracture sites before moving.

Treat for shock.

Pulling the victim to safety

Pull the victim head first or feet first, not sideways.

BE SURE HEAD IS PROTECTED.

Lifting the victim to safety

If he must be lifted before a check for injuries can be made, every part of the body should be supported. The body should be kept in a straight line and should not be bent. Once victim is lifted, the lifter is responsible for the victim's safe return to the ground/floor.

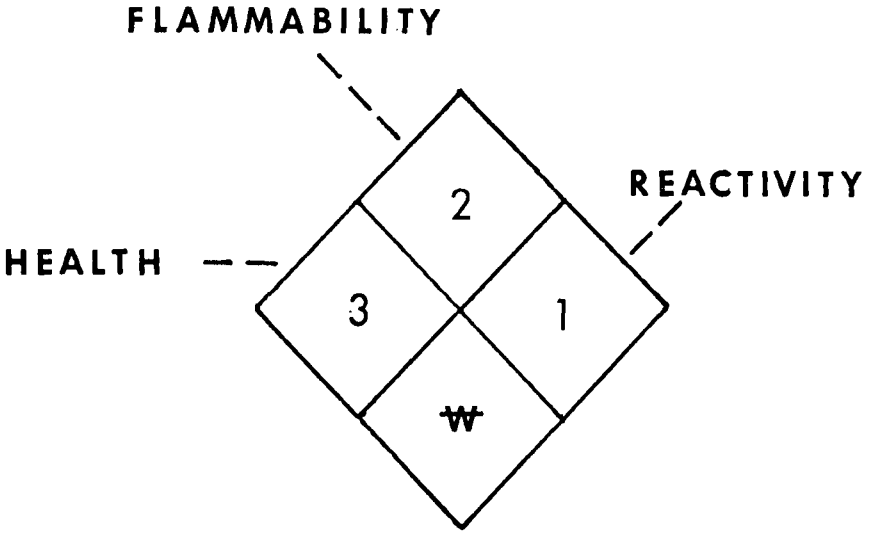
Exercise care in the approach of any "downed" co-worker or bystander victim. Rapid action may be called for, but hasty and careless intervention may lead to additional injury or loss of life, avoidable if a few moments are taken to assess the immediacy and severity of the situation. Once again, the exercise of careful, informed judgement and plain common sense is the most important safeguard of personnel health.

SECTION 6. HAZARDOUS CHEMICAL DATA

Information on the nature, hazard, exposure and safety precautions for 655 alphabetically arranged chemical compounds is presented in Part B of this report (Chemical Data), furnished under separate cover for loose-leaf binding. Chemical synonyms and Chemical Abstracts Service (CAS) Registry Numbers are included to facilitate cross-referencing with other hazardous materials literature and computerized data bases. Chemical Abstracts Service Registry Numbers provide a unique identifier for a chemical substance and serve as the link between the various names by which a single substance is denoted in the Abstracts on Health Effects of Environmental Pollutants (HEEP) (BIS, 1975). It should be noted that the Registry Numbers per se have no chemical significance but are assigned as each new substance enters the CAS Registry System.

In CAS publications and in the HEEP Chemical Index Guide, the Registry Number contains from five to nine digits separated into three groups by hyphens. The last group contains a single digit, the middle group two digits, and the first group all remaining digits, e.g., 504-37-3, 35014-03-8. These numbers appear in a modified form in the HEEP monthly and annual indexes. In the former, the hyphens are deleted; in the latter, the hyphens are deleted and prefix zeros attached where necessary to make up a nine-digit number. Instructions for use of the Registry Numbers for cross-reference are included in the HEEP Chemical Index Guide.

Information on degrees of hazard, where available, is summarized utilizing the National Fire Protection Association (NFPA) Hazard Identification System. The order of severity of each hazard, "health" (toxicity), "flammability" and "reactivity" (instability and water reactivity), is designated on a scale of zero (0), indicating no special hazard, to four (4) indicating severe hazard or extreme danger. In a diamond-shaped diagram (upper right-hand corner on chemical data sheets) the toxicity hazard is identified at the left, flammability at the top and reactivity at the right. The bottom space is used to denote unusual reactivity with water, using a "crossed-W" character, radiation hazard, using the symbol  , or strong oxidizers using OXY. The following example shows how the hazard identification system would apply to the compound benzoyl chloride.



Example: BENZOYL CHLORIDE

A detailed description of the hazard identification system used here is included in "Recommended System for the Identification of the Fire Hazards of Materials" (NFPA No. 704M) (NFPA, 1975).

The diagram identifies benzoyl chloride as having a health (toxicity) hazard rating of 3, a flammability hazard rating of 2, and a reactivity hazard rating of 1. Note, also, the designation of unusual reactivity with water.

Materials with a health hazard rating of 4 can cause death or major residual injury even with prompt medical attention. A health hazard rating of 3 relates to materials which could cause serious temporary or residual injury from short exposure even with prompt medical attention. Materials with a rating of 2 can, upon intense or continuous exposure, cause temporary incapacitation or possible residual injury unless prompt medical attention is received. At a rating of 1, materials can be expected to cause irritation and/or minor injury with no treatment. A hazard rating of 0 is applied to materials which provide, under fire conditions, no hazard beyond that of other ordinary combustible materials.

Those materials which rapidly or completely vaporize at normal temperatures and atmospheric pressures or which are readily dispersed in air and burn readily are assigned a flammability rating of 4. Liquids and solids which can be ignited under almost all temperature conditions are given a rating of 3. If exposure to relatively high ambient temperatures is necessary for ignition, flammability ratings of 2 may be assigned. Materials which require considerable preheating prior to ignition (including most ordinary combustible materials) are given a rating of 1. Those materials which will not burn are given a flammability rating of 0.

The highest reactivity rating of 4 is given to those materials capable of spontaneous detonation, explosive decomposition or reaction at normal temperatures and pressures. Materials which require heating in confinement, strong

initiating force, or mixing with water to detonate or generate an explosive reaction are rated 3. Normally unstable materials which readily undergo violent chemical change short of detonation at elevated temperatures and pressures or which react violently in or from potentially explosive mixtures with water are given a rating of 2. Normally stable materials which can become unstable at elevated temperatures and pressures or which release moderate energy in reaction with water are rated at 1. A rating of 0 is given to those materials which are stable, even under fire conditions, and do not react with water.

SECTION 7. HAZARDOUS SUBSTANCE PRIORITY LISTING

The need for some kind of priority listing of hazardous substances subject to spills has been expressed in the past. Such a priority system should provide weighting to both anticipated frequency of occurrence (based upon historical spill data) and hazard to on-site spill monitoring and clean-up personnel and the public. The approach followed in this report attempts to establish a balance between the frequency of occurrence of the spilled material and the three primary hazards to spill personnel, namely toxicity, combustibility, and reactivity.

The priority system is designed to fulfill several functions. It should:

1. Call attention to those chemicals

   a. of high occurrence likelihood

   b. providing unusual hazard to on-site personnel

   c. requiring special or unusual protective equipment or techniques.

2. Help to identify areas in which spill-personnel preparedness is less than adequate with respect to equipment and/or training.

3. Provide some guide to the allocation of resources for the monitoring of hazardous materials.

4. Suggest those areas which warrant precedence in research and developmental activities for detection, identification, and monitoring of hazardous substances.

The specific hazard designations employed in the priority listing, (Table 1) are those contained in the CHRIS and NFPA documents (U.S. Coast Guard, 1974) (NFPA 1972, 1975). The spill frequency data were obtained from the Oil and Hazardous Materials Spill Information Retrieval System (OHMSIRS)* and cover the 4-year period from 1970-1974. The following formula was used to establish the Hazard Priority Numbers (P) presented in Table 1:

$$P = (T^2 + F^2 + R^2) + f$$

Where
- T = Toxicity hazard (0-4)
- F = Fire hazard (0-4)
- R = Reactivity (explosion) hazard (0-4)
- f = Frequency of occurrence (from 1970-1974)

* System run for U.S. EPA by COMNET (Computer Network)

The power function is used with each hazard category to provide a level of discrimination commensurate with an increased hazard level, e.g., T = 1 vice T = 2. Asterisks next to certain priority numbers indicate that one or more of the hazard values were not available. The priority number was assigned according to the known values.

TABLE 1. PRIORITY LIST OF CHEMICAL SPILL HAZARDS.

See text for equational components necessary to compute hazard priority numbers (P). Asterisk denotes one or more hazard values unknown; P computed with known values.

	T	F	R	f	P
Sulfuric acid	3	0	2	82	95
Sodium hydroxide	3	0	1	67	77
Ammonia anhydrous	3	1	0	37	47
Phenol	3	2	0	34	47
Toluene	2	3	0	32	45
Xylenes	2	3	0	32	45
Acrylonitrile	4	3	2	13	42
Hydrochloric acid	3	0	0	33	42
Hydrogen cyanide	4	4	2	4	40
Vinyl chloride	2	4	1	18	38
Styrene	2	3	2	16	33
Ethylene oxide	2	4	3	3	32
Dinitro-o-sec butyl phenol	3	2	4	3	32
Methyl parathion	4	3	2	3	32
Acrylonitrile polymer mixture	4	3	2	1	30
Amine nitrate solution	2	3	4	1	30
Ammonium nitrate	2	1	3	16	30
Ethyl parathion	4	3	2	1	30
Oxygen	2	4	3	1	30
Phosphorus pyridide	2	3	4	1	30
Propane	1	4	0	13	30
Chlorine	3	0	1	19	29
Isopropyl acetate	1	3	0	18	28
Cyanopyridene	4	1	3	1	27
Dimethylamine	3	4	0	2	27

(Continued)

TABLE 1. PRIORITY LIST OF CHEMICAL SPILL HAZARDS.

See text for equational components necessary to compute hazard priority numbers (P). Asterisk denotes one or more hazard values unknown; P computed with known values (Continued).

	T	F	R	f	P
Hydrogen sulfide	3	4	0	2	27
Liquid natural gas	3	4	1	1	27
Nitric acid	4	0	1	10	27
Tetraethyl lead	3	2	3	5	27
Butadiene	2	4	2	2	26
Vinyl acetate	2	3	2	9	26
Butadiene nitrile	2	4	2	1	25
2-Hydroxy methyl-2-nitro-1, 3-propane	2	2	4	1	25
Methyl ethyl ketone peroxide	2	2	4	1	25
Vinylidene chloride	2	4	2	1	25
Ethylene	1	4	2	3	24
Methanol	1	3	0	14	24
Diamine (Hydrazine)	3	3	2	1	23
Dichloropropene	3	3	1	5	23
Nitrocellulose	2	3	3	1	23
Phosphine oxide (Mapo-Metepa)	3	3	2	1	23
Potassium	3	3	2	1	23
Adiponitrile	4	2	0	2	22
Calcium carbide	1	4	2	1	22
Epichlorohydrin	3	3	2	1	22
Acetic acid	2	2	1	12	21
Chlordane	4	0	0	5	21
Ethyl methacrylate monomer	3	2	3	1	21
Formaldehyde	2	2	0	13	21
Mercury	4	2	0	1	21
Methyl chloride	2	4	0	1	21
Phosphorus white	3	3	1	2	21
Ethylene glycol	1	2	0	18	20
Methyl methacrylate	2	3	2	3	20
Pentane	1	4	0	3	20
Toxaphene	4	0	0	4	20
Turpentine	3	2	2	3	20
Ethanol	0	3	0	10	19
Ethyl acrylate	2	3	2	2	19
LPG (liquefied hydrocarbon gas)	1	4	0	2	19
Methyl acrylate	2	3	2	2	19
Parathion	4	1	0	2	19
Acrylic acid	3	2	2	1	18
Benelate	3	2	2	1	18
Benzene	2	3	0	5	18
Butane	1	4	0	1	18

(Continued)

TABLE 1. PRIORITY LIST OF CHEMICAL SPILL HAZARDS.

See text for equational components necessary to compute hazard priority numbers (P). Asterisk denotes one or more hazard values unknown; P computed with known values (Continued).

	T	F	R	f	P
Copper cyanide	3	2	2	2	18
Hydrofluoric acid	4	0	0	2	18
Isobutyl methyl ketone	2	3	2	1	18
Lead compounds	3	2	2	1	18
Methyl methacrylate resin	2	3	2	1	18
Naphtha	3	2	4	1	18
Acetone	1	3	0	7	17
Ammonium hydroxide	3	1	0	7	17
Bromine	4	0	0	1	17
Chlorine gas	3	1	0	7	17
Chromic acid	3	1	0	7	17
Hydrogen fluoride gas	4	0	0	1	17
Polystyrene	2	2	2	5	17
Sodium	3	1	2	3	17
Carbon disulfide	2	3	0	3	16
Chlorinated benzenes	2	3	0	3	16
Chlorosulfonic acid	3	0	2	3	16
Ethyl benzene	2	3	0	3	16
Latex	2	0	2	8	16
Hexamethylene diamine	3	1	0	6	16
PCB	2	0	0	12	16
Phenolic waste	3	2	0	3	16
Propionaldehyde	2	3	1	2	16
Sulfur dichloride	3	2	0	3	16
Tetrahydrofuran	2	3	1	2	16
Acetonitrile	2	3	0	2	15
"Antiknock" mixture	3	2	0	2	15
n-Butyl alcohol	1	3	0	5	15
Cadmium oxide	3	2	1	1	15
Cyclohexane	1	3	0	5	15
Isopropanol	1	3	0	5	15
Mesityl oxide	3	2	0	2	15
Methyl ethyl ketone	1	3	0	5	15
Phenyl ethylene	2	2	2	3	15
Phosphorus pentasulfide	3	1	2	1	15
Phosphorus trichloride	3	0	2	2	15
Toluene diisocyanate	3	1	1	4	15
Valeraldehyde	2	3	1	1	15
Aniline sulfate	3	2	0	1	14
Cresol oil	3	2	0	1	14
Cresylic acid	3	2	0	1	14
Dichloromethane (Methylene chloride)	2	1	0	9	14

(Continued)

TABLE 1. PRIORITY LIST OF CHEMICAL SPILL HAZARDS.

See text for equational components necessary to compute hazard priority numbers (P). Asterisk denotes one or more hazard values unknown; P computed with known values (Continued).

	T	F	R	f	P
Dichloropropane	2	3	0	1	14
Diethyl amine	2	3	0	1	14
Diethyl aniline	3	2	0	1	14
Ethylene diamine	3	2	0	1	14
Ethylene dichloride	2	3	0	1	14
n-Ethyl morpholine	2	3	0	1	14
Formic acid	3	2	0	1	14
Guthion	4	1	0	1	14
Hydrogen peroxide	2	0	3	1	14
Nitrobenzene	3	2	0	1	14
Oil, crude	1	3	0	4	14
Propyl alcohol	2	3	0	1	14
Sodium sulfate	3	0	0	5	14
o-Toluidine	3	2	0	1	14
n-Butyl acrylate	2	2	2	1	13
Creosote	2	2	2	1	13
Nitrogen liquid	3	0	0	4	13
Styrene "tar"	2	2	2	1	13
Biphenyl	3	1	0	2	12
Carbon black	3	0	0	3	12
Carbon tetrachloride	3	0	0	3	12
Diethyl sulfate	3	1	1	1	12
Endrin	3	1	0	2	12
Gasoline	1	3	0	2	12
Hexane	1	3	0	2	12
Octyl alcohol	2	2	0	4	12
Zinc chloride	3	0	0	3	12
Arsenic acid	3	0	0	2	11
Butyl acetate	1	3	0	1	11
Calcium oxide	1	0	1	9	11
p-Cymene	2	2	1	2	11
Ethyl butyraldehyde		3	0	2	11*
Iron ore	1	2	2	2	11
Isopropyl acetate	1	3	0	1	11
Latex liquid	2	0	2	3	11
Methyl propyl benzene	2	2	0	3	11
Monoethanolamine	2	2	0	3	11
Pentachlorophenol	3	0	0	2	11
Phosphoric acid	2	0	0	7	11
Potassium hydroxide	3	0	1	1	11
Quinoline	3	1	0	1	11
Silicone tetrachloride	3	0	0	2	11
Sodium chromate	3	0	0	2	11

(Continued)

TABLE 1. PRIORITY LIST OF CHEMICAL SPILL HAZARDS.

See text for equational components necessary to compute hazard priority numbers (P). Asterisk denotes one or more hazard values unknown; P computed with known values (Continued).

	T	F	R	f	P
Sulfonic acid	3	0	0	2	11
Sulfurous acid solution	3	1	0	1	11
Titanium tetrachloride	3	0	1	1	11
Vinyl toluene	2	2	1	1	11
Aldrin	3	0	0	1	10
Aluminum sulfate	3	0	0	1	10
Ammonium oxalate	3	0	0	1	10
Ammonium sulfate	3	0	0	1	10
Arsenic tetrachloride	3	0	0	1	10
Arsenic trioxide	3	0	0	1	10
Benzyl chloride	2	2	1	1	10
Berrylium fluoride	3	0	0	1	10
Calcium fluoride	3	0	0	1	10
Cellosolve solvent	2	2	0	2	10
Copper sulfate	3	0	0	1	10
Diazinon	3	0	0	1	10
Dibromoethane	3	0	0	1	10
Dibromomethane	3	0	0	1	10
Fluoboric acid	3	0	0	1	10
o-Dichlorobenzene	2	2	0	2	10
Iodine	3	0	0	1	10
Iron floc	1	2	2	1	10
Iron sulfide	1	2	2	1	10
MSMA (monosodium methane arsonate)	3	0	0	1	10
Naptha resin	2	2	1	1	10
Perchloroethylene	2	0	1	5	10
Sevin (Carbaryl)	2	2	0	2	10
Sodium cyanide	3	0	0	1	10
Sodium oxide	3	0	0	1	10
Sulfur dioxide	3	0	0	1	10
Zinc chromate	3	1	0	1	10
Zinc cyanide	3	0	0	1	10
Camphene		2	2	1	9*
Cyprex (Dodene)	2	2	0	1	9
DDT	2	2	0	1	9
Formaldehyde resin	2	2	0	1	9
Furfural	2	2	0	1	9
Methyl ethyl pyridine	2	2	0	1	9
Potassium bromate	2	2	0	1	9
Propionic acid	2	2	0	1	9
Propylene glycol acetate	2	2	0	1	9
Sodium chlorate	1	0	2	4	9

(Continued)

TABLE 1. PRIORITY LIST OF CHEMICAL SPILL HAZARDS.

See text for equational components necessary to compute hazard priority numbers (P). Asterisk denotes one or more hazard values unknown; P computed with known values (Continued).

	T	F	R	f	P
Sodium hypochlorite	2	2	0	1	9
Tetralin	2	2	0	1	9
Methyl styrene	1	2	1	2	8
Trichloroethylene	2	1	0	3	8
Zinc	1	2	1	2	8
Chromium	0	2	0	3	7
2,4-D	2	0	0	3	7
Diisobutyl ketone	1	2	0	2	7
Glyoxal	2	1	0	2	7
Methyl amyl acetate	1	2	0	2	7
Petroleum wax: Paraffin	1	2	0	2	7
Sulfur monochloride	2	1	1	1	7
Adipic acid	1	1	0	4	6
Aluminum oxide	2	0	0	2	6
Diesel	0	2	0	2	6
Ferric chloride	2	0	0	2	6
Kerosene	0	2	0	2	6
Magnesium ore	0	1	2	1	6
Naphtha (Stoddard solvent)	0	2	0	2	6
Nonanol	1	2	0	1	6
Paraformaldehyde	2	1	0	1	6
Phthalic anhydride	2	1	0	1	6
Rotenone	2	1	0	1	6
Sodium sulfide	2	1	0	1	6
Sodium sulfite	2	0	0	2	6
Amine ethyl ethanolamine		2	0	1	5*
Calcium napthanate	2			1	5*
Cobaltous napthanate	2			1	5*
Glycerine	1	1	0	3	5
Heptanol	0	2	0	1	5
Hybar	2			1	5
Methylene chloride	2	0	0	1	5
Polyethylene glycol	1	1	0	3	5
Propanethiol	2	0	0	1	5
Rubber (natural latex)	2	0	0	1	5
2,4,5-t	2	0	0	1	5
Urea formaldehyde	1	1	0	3	5
Alum (Potassium aluminum sulfate)	1	0	0	3	4
Ammonium phosphate	0			4	4*
Carbon	1	1	1	1	4
DMDT (Methoxychlor)	1	0	0	3	4
Iron oxide	1	0	0	3	4

(Continued)

TABLE 1. PRIORITY LIST OF CHEMICAL SPILL HAZARDS.

See text for equational components necessary to compute hazard priority numbers (P). Asterisk denotes one or more hazard values unknown; P computed with known values (Continued).

	T	F	R	f	P
Sodium dichromate	1	0	1	2	4
Tallow	0	1	0	3	4
Titanium dioxide	1	0	0	3	4
Urea	0	1	0	3	4
Aluminum stearate	1	1	0	1	3
Cooking oil	0	1	0	2	3
Dowtherm	1	1	0	1	3
Isooctyl alcohol	1	1	0	1	3
Mirex	1			2	3*
Oleic acid	0	1	0	2	3
Phosphorus red	0	1	1	1	3
Propylene glycol	0	1	0	2	3
Sodium nitrate	1	0	1	1	3
Triethanolamine	1	1	0	1	3
Zinc oxide	1	0	0	2	3
Borax	1	0	0	1	2
Carbonic acid (CO_2)	1	0	0	1	2
Captan	1	0	0	1	2
DMT				2	2*
Hexamethylamine diamine methyl ethyl ketone				2	2*
Iron sulfate	1	0	0	1	2
Methyl acetylene propadiene				2	2*
Nonyl phenol		1	0	1	2*
Potassium chloride	0	0	0	2	2
Potassium permanganate	1	0	0	1	2
Silver nitrate	1	0	0	1	2
Sodium silicate	1	0	0	1	2
Zinc ammonium chloride	1	0	0	1	2
n-Aminethal piperazine				1	1*
Amylase				1	1*
1,2-Benzisco cyazalone				1	1*
Diethylene benzene				1	1*
Isopropanal				1	1*
Polyvinyl chloride				1	1*
Pyranol				1	1*
Sodium isthiate				1	1*
Thimet				1	1*

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15. SUPPLEMENTARY NOTES

This volume is for use with its companion volume, Part B.

16. ABSTRACT

This two-part document is intended to serve as a guide to the hazards associated with a broad range of chemical compounds which may be encountered in hazardous materials spills. The document addresses 655 chemicals identified on the basis of known toxicity or spill history and designated "hazardous" by the U.S. Environmental Protection Agency.

Part A of this document is a safety and first aid reference for personnel responding to spills of hazardous materials which may involve any of the chemicals addressed. It includes safety considerations, first aid procedures, and descriptions of protective equipment; a description of the hazard-rating system used in Part B; and a priority listing of hazardous materials based on their hazard ratings and reported spill frequency.

Part B of this document is an index of the 655 chemicals. Part B includes a data sheet for each chemical showing its CAS number, synonyms, and hazard priority number, and giving information on hazards, safety measures, and exposure. This part is provided in a form for loose-leaf binding to facilitate addition, revision, and update as new data become available.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
hazardous materials toxicology, toxicity first aid, safety chemical properties flammability chemical reactivity	hazardous chemical spills, spill monitors, spill response	11 06J 06T 13L

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