DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

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COMDTINST M16465.30

12 MAR 1984

COMMANDANT INSTRUCTION M16465.30

Subj: Policy Guidance for Response to Hazardous Chemical Releases

Ref: (a) Federal Water Pollution Control Act, as amended
(b) Compréhensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
(c) COMDTINST M6260.15
(d) COMDTINST M16465.29

1. PURPOSE. This instruction provides policy guidance concerning the nature and extent of Coast Guard hazardous chemical response activities. It describes the response functions that marine safety units shall carry out, subject to resource availability, and the training, equipment, staffing standards, and procedures associated with those functions.

2. DIRECTIVES AFFECTED. Commandant Instruction 16465.16 of 16 May 1979 is cancelled.

3. DISCUSSION.

a. The Coast Guard provides the predesignated Federal on-scene coordinator (OSC) for response to hazardous chemical releases occurring in the coastal zone, Great Lakes waters, and specified inland ports and harbors. In the 1970s, reference (a) and the Port and Tanker Safety Act provided our response authority for discharges impacting navigable waters and immediate waterfront areas. In December 1980, the passage of reference (b) further expanded our jurisdiction and authority to include releases of hazardous substances, pollutants, or contaminants into all environmental media - air, land, ground water, and surface waters. Reference (d) provides explicit guidance on matters of Coast Guard jurisdiction within the coastal zone.

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3. b. This instruction establishes chemical response policy and the scope of response activities at units predesignated as OSC. It also describes the requirements to be met before unit personnel enter hazardous environments during a response. It is organized in the following manner:

(1) Chapter 1 sets forth OSC responsibilities for chemical response, the policy to carry out these responsibilities, and related staffing and medical monitoring standards.

(2) Chapter 2 describes unit allowances for personnel protective equipment.

(3) Chapter 3 outlines chemical response training.

(4) Chapter 4 summarizes pre-incident preparations for chemical response activities.

(5) Chapter 5 discusses response organization, response planning, and on-scene safety.

(6) Chapter 6 describes the procedures for entry of Coast Guard personnel into hazardous chemical environments.

c. Marine safety offices, COTPs, and district(m) staffs are encouraged to submit suggestions for more effective execution of chemical response activities.

4. ACTION.

a. On-scene coordinators shall:

(1) Implement the guidance contained herein as policy to be followed during pollution response efforts involving hazardous chemicals.

(2) Assess the threat of chemical releases and existing response capability within their zone and identify the appropriate level of entry capability.

(3) Advise the district commander, by 1 June 1984, of their level of entry capability and, if necessary, the additional personnel, training, and equipment required to upgrade unit capability to meet the program goals outlined in Chapter 1.

4. b. District commanders shall:

(1) Evaluate the need to develop and maintain a hazardous chemical response entry capability based on the threat of chemical releases and existing response capability within their district.

(2) Coordinate the development and maintenance of the appropriate level of response capability in areas where the Coast Guard provides predesignated OSCs.

(3) Review and consolidate information submitted by OSCs and report to Commandant (G-WER), by 1 August 1984, the level of entry capability of each OSC and any additional resource requirements to upgrade response capability to meet the program goal.

(4) Coordinate and monitor the status of personnel protective equipment inventories at subordinate commands, redistribute equipment between units as necessary, and consolidate equipment funding requests for submission through appropriate channels.

c. Area commanders shall direct the National Strike Force to:

(1) Implement the guidance contained herein as policy to be followed during pollution response efforts involving hazardous chemicals.

(2) Provide advice and assistance for hazardous chemical response as requested by on-scene coordinators.

d. Commandant (G-WER) shall:

(1) Develop budget initiatives to request the necessary additional resources identified beyond what can be funded through existing operating funds.

(2) Allocate appropriations to districts for procurement and support of chemical response-related equipment and training.

(3) Coordinate with appropriate Headquarters program and support managers to carry out the provisions of this instruction.

[illegible]
Chief, Office of Marine
Environment and Systems

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

CHAPTER 1. CHEMICAL RESPONSE POLICY

A. Response Activities.

1. Under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the Coast Guard provides predesignated Federal on-scene coordinators (OSC) for response to hazardous chemical releases in the coastal zone, Great Lakes waters, and specified inland ports and harbors. The OSC's jurisdiction and authority within this zone includes releases of hazardous substances, pollutants, or contaminants into all environmental media - air, land, ground water, and surface waters.

2. The response functions that Coast Guard OSCs carry out in the event of a chemical release are divided into seven separate areas:

   a. Conducting local contingency planning for response to hazardous chemical releases.

   b. Conducting traditional COTP response measures such as restricting access to the affected area and controlling marine traffic; notifying facilities operating vulnerable water intakes of the release; coordinating with state and local emergency forces; and assisting as resources and capabilities permit.

   c. Conducting a preliminary assessment of the incident to: (1) evaluate the magnitude of the threat to the public health and welfare and the environment, (2) determine if response action by the spiller and/or the state and local government is adequate, (3) establish jurisdiction for a Federal response, and (4) collect the data necessary to formulate a response plan if a Federal response is warranted.

   d. Contacting the owner and/or operator of the source of the release, if known, to inform them of their potential liability for government removal costs, to explain the Coast Guard's role as OSC, and to gather information for response and port safety purposes. Administrative orders shall be used when appropriate to direct actions of the responsible party.

   e. Based on the findings of the preliminary assessment, carrying out first aid mitigation actions if the situation warrants immediate action. First aid mitigation actions are those response actions taken by OSC personnel necessary to address immediate concerns prior to the arrival of cleanup contractors or action by the responsible party.

1-A-2 f. Monitoring cleanup actions of responsible parties or, in the case of Federal removals, providing on-scene supervision of removal activities, ensuring the employment of a sound removal strategy. The OSC is not expected to be capable of designing and carrying out a complex removal plan. In certain situations, support from Special Forces (e.g. National Strike Force(NSF), EPA Environmental Response Team (ERT), NOAA Scientific Support Coordinator (SSC)) may be necessary to assist in the development or review of a removal strategy. In either case, the OSC shall ensure that guidelines regarding worker safety are adhered to by all parties involved in the response.

g. For Federal removals, arranging for the services of contractors and supervising their actions, ensuring that response costs are documented as required by Chapter 86 of the Marine Safety Manual.

B. Level of Response Capability.

1. The National Strike Force shall develop and maintain Level A entry capability as described in Chapter 2. They shall maintain continued expertise in state-of-the-art response methods and provide advice and assistance as required by OSCs.

2. The program goal is that a unit predesignated as OSC shall be capable of performing the OSC functions described above. However, the actual level of response capability to be maintained at a unit shall be based on the risk of chemical releases occurring in the OSC's zone and the mix of industry, state, local, and other Federal response capability already in place.

3. In those zones where the district commander and OSC determine there is a significant risk of chemical releases, and the existing response capabilities (CG and others) within these zones are inadequate, units shall develop Level A or B entry capability as described in Chapter 2. When this is not possible because of insufficient trained personnel or inadequate protective equipment, as set forth in Chapters 2 and 3, the OSC shall seek the necessary additional resources and adopt a conservative response posture until these requirements are met. Specifically, they shall perform those OSC functions described in 1.A.2. not requiring entry of unit personnel into hazardous environments.

4. The integration of Coast Guard resources with existing response organizations is an important consideration. This means of achieving the required level of capability is appropriate where: (1) the existing response organizations routinely respond to chemical releases, and (2) they can perform the survey actions (sampling, environmental monitoring, etc.) essential for assessing the hazards presented by a release. Units relying on outside organizations to provide the required response capability must periodically reassess the ability of these organizations to provide an adequate response.

1-B-5. Predesignated OSCs with jurisdiction over zones where the risk of a chemical release is low, or where existing response capability is already adequate, shall adopt a conservative response posture, relying on augmenting forces for entry capability as described in the following paragraph.

6. In those instances where the pre-designated OSC cannot achieve the desired level of response capability due to insufficient protective equipment or staffing, the district commander should identify or develop interim means of rapidly providing that unit with the necessary capability in the event of a release. Appropriate mechanisms for providing the required response capability include, but are not limited to the following:

   a. Augmenting with available Special Forces (e.g. NSF, ERT).

   b. Augmenting units with resources from other MSOs or COTPs within the district having the required entry capability.

7. It is important to note that the Federal predesignated OSC can not relinquish that responsibility, no matter who is carrying out the actual response, and shall monitor the response as necessary to ensure its adequacy. If a response is not adequate, the OSC shall, to the extent that resources are available, provide advice to responders or assume control of the response.

8. The above policies notwithstanding, there are occasions which necessitate certain calculated risks be taken to protect the public health and welfare. <u>In such cases, risks to personnel will be reduced to the minimum level possible consistent with the operational situation and shall not be incurred for purely environmental purposes</u>.

9. The Commandant recognizes the significance of the cautious approach which the Coast Guard has adopted for the chemical response mission area. The high training and staffing thresholds will limit the response capability of some units, and in many areas sources of support will not be available to fill the void. As a consequence, there will be occasions when a unit will be unable to mount a complete response to a serious incident. This circumstance is preferred to attempting a complex and potentially hazardous job without the necessary staffing, training, and equipment.

C. <u>Personnel Requirements</u>.

1. The requirements of carrying out varied missions place different demands upon unit personnel resources. Those demands fall into two categories: preparation and execution. Preparation consists primarily of contingency planning and training and execution entails performance of the other OSC functions described in paragraph 1.A.2. Of these, the initial on-scene assessment of a release is the most manpower intensive for a unit to perform.

1-C-2. An on-scene assessment may be necessary to determine the extent of or effects of a release. An effective assessment may require response personnel to work in or near the area of the release, gathering information on the nature of the pollutant and the extent of its impact.

3. The number of persons required to perform on-scene activities at any one time is determined to a large extent by the level of personnel protection that must be used. In any case, response actions in hazardous areas shall always be conducted by a team of individuals trained in chemical response. Table 1.1 outlines the minimum numbers of personnel required to support response activities requiring the use of personnel protective equipment.

D. Medical Monitoring.

1. All personnel involved in chemical spill response shall participate in a medical monitoring program as described in COMDTINST M6260.15. This program shall include an initial baseline physical, annual testing, and immediate examination if there is reason to believe that an individual has been exposed to hazardous substances during a response. In addition, a history shall be maintained in the persons medical record of those substances that the individual may have been exposed to during response operations.

Table 1.1

Personnel Requirements for Response Actions Incurring Exposure Risks

1. The following table represents the minimum manpower requirements for entry into areas that may present chemical exposure risks. It is recommended that a somewhat larger number of personnel normally be assigned to this type of operation in order to be capable of safely meeting any contingencies and to assist personnel in donning equipment, etc..

2. All participating personnel specified in the table shall be highly trained and proficient in the use of response equipment and chemical response procedures. This normally would involve the completion of Schedule II training as described in Chapter 2. A safe response cannot be accomplished without properly trained personnel.

LEVEL A

Protective Clothing Required: Fully encapsulating outfit, pressure-demand SCBA.

A) Team Leader	1
B) DECON Team	2
C) Rescue Team	2
D) Entry Team	2
Minimum total	7

LEVEL B

Protective Clothing Required: Boots, gloves, splash suit w/hood, face protection, pressure-demand SCBA.[1]

A) Team Leader	1
B) DECON Team	1
C) Rescue Team	(2)[2]
D) Entry Team	2
Minimum total	4 (6)[2]

LEVEL C

Protective Clothing Required: Boots, gloves, disposable splash suit or coveralls, particulate filter mask or air-purifying respirator, face/eye protection.[4]

A) Team Leader	1
B) Entry Team	2
C) DECON Team	(1)[3]
Minimum total	3 (4)[3]

[1] Certain substances present only a respiratory hazard and, thus, require use of an SCBA or an air-purifying respirator, but not splash gear. This type of entry organization and equipment complement is not represented here because the percentage of potential pollutants requiring it is relatively low.

[2] Required if OSHA Immediately Dangerous to Life or Health (IDLH) concentrations of substances are present or known to exist. The IDLH concentration is the maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.

[3] This manning complement not required when any necessary decon can be accomplished by Entry Team without assistance.

[4] Air-purifying respirators are normally not appropriate for initial entry. An SCBA must be used unless it has been determined by a compete individual that the conditions for using air-purifying devices are met.

CHAPTER 2. PERSONNEL PROTECTIVE EQUIPMENT

A. <u>Background</u>. On-scene coordinators may find it necessary for Coast Guard personnel to enter hazardous environments to carry out OSC responsibilities. These personnel must be protected against the four routes of potential chemical exposure. (See Chapter 4.A.) In order to minimize those risks, personnel protective equipment must be worn. Additionally, OSCs must have a working knowledge of protective equipment to ensure compliance with the worker health and safety provisions of the NCP (40 CFR 300.71).

B. <u>Levels of Protection</u>.

1. The Coast Guard will adopt the EPA standard "Levels of Protection" for personnel protective equipment. Each level provides for various combinations of respiratory and dermal equipment to protect personnel against hazards encountered during a response.

2. The following is a short description of each level of protection and its use. It should be noted that these protection levels are guidelines only and do not preclude other safe applications and combinations of equipment.

   a. LEVEL A - Level A protection (Self-contained breathing apparatus (SCBA); fully-encapsulating suit) provides the highest level of respiratory, skin, eye, and mucous membrane protection. It is generally used in those situations where extremely hazardous substances are known to be present in high atmospheric concentrations and where Level B splash gear does not offer adequate protection against any dermally-active substances present or where materials and concentrations are unknown.

   b. LEVEL B - Level B protection (SCBA and splash gear) provides the highest level of respiratory protection but a lesser level of skin and eye protection. It is generally used in those situations where the chemical is known, the atmosphere is oxygen deficient, contains IDLH concentrations of substances which pose a respiratory hazard, or where dermal contact with a hazardous substance is highly unlikely. This level of protection will normally be the minimum used for an initial response unless the respiratory hazards associated with a released substance(s) allow for a lesser level of respiratory protection than an SCBA.

   c. LEVEL C - Level C protection (air-purifying respirator and splash gear) is suitable when the type of airborne substance is known, concentrations measured, criteria for using air-purifying respirators met, and skin exposure is unlikely. Use of this level of protection requires continuing measurement of air contaminants to ensure

2-B-2-c. (Cont'd) that IDLH concentrations do not exist and that the concentrations of contaminants present do not exceed the service limits of the canister.

d. LEVEL D - Level D protection is primarily a work uniform and should not be worn in any hazardous environment. It is used when there is no indication of hazardous conditions and the work function precludes contact with any hazardous substances.

C. Equipment Inventory. On-scene coordinators shall maintain inventories of equipment within the following parameters:

1. Inventory scope.

a. Tables 2.1 and 2.2 list the minimum levels of equipment corresponding to response capabilities described in Chapter 1. These levels are flexible enough to enable commanding officers to tailor their equipment inventory to the major hazards arising within their jurisdiction. This flexibility should be a function of the magnitude and frequency of the hazards most likely to be encountered, as well as other regional resources available to address those hazards. It is not desirable or efficient for a command to have equipment to meet every conceivable need.

b. Equipment levels should not exceed the command's ability to maintain and remain trained in its use. The Coast Guard is one resource among local, state, Federal, and industry resources. Equipment inventories should complement other resources whenever practicable. For instance, a command may be able to refill SCBA's by purchasing the service or by using a local fire department's compressor rather than procuring a refill system along with attendent recurring costs of maintenance, training, and storage. Similarly, command resources should be oriented toward short duration incidents with regional and national resources used to support unusual or prolonged operations.

2. Equipment types.

a. The primary criteria for selecting items for the unit's inventory is that each piece of equipment must be safe for the environment in which it is used. Since the state-of-the-art is continually being improved and no single type of equipment is suitable for every application, the purchase or use of specific brand names or materials is not required. This does not mean that units should mix brands of the same equipment type. To the extent possible, equipment types within districts should be standardized to reduce maintenance efforts, ensure compatability during unit augmentation, and to facilitate the transfer of equipment between units.

2-C-2-b. There is no single type of chemical-resistant clothing or fully-encapsulated suit that is either in widespread Coast Guard use or that can be recommended as protection against all substances. Commandant (G-DMT-3) is currently developing a Coast Guard-modified ILC DOVER "Chemturion" encapsulated suit and is also researching various types of splash gear. Until specific suits and splash gear for use throughout the Coast Guard are identified, units should select commercially available outfits. This selection should include materials offering adequate impermeability against the highest risk chemicals handled in the port area as determined by local contingency planning. This may require having more than one suit material in the inventory for both splash gear and encapsulating suits.

c. Units must develop their inventory considering local conditions, cost-effectiveness of the item for its intended use, and the advice of other experts, e.g. local contractors, chemical shippers/manufacturers, the NSF, the EPA Environmental Response Team (ERT), or the Hazardous Chemical Training Course (HCTC) staff at the Marine Safety School. Where appropriate, equipment must be independently certified for the intended use. For example, breathing apparatus and respirators must be certified by the National Institute of Occupational Safety and Health (NIOSH). Electrical instruments used in explosive atmospheres must be certified "intrinsically safe" by independent testing organizations such as Factory Mutual (FM) or Underwriters Laboratories (UL). In addition, care must always be taken to evaluate the suitability of a protective suit material or an instrument for the situation at hand. For example, an instrument certified "intrinsically safe" for Class 1, Division 1, Group C and D environments may be an ignition hazard on a barge carrying butadiene, a Group B hazard.

3. Minimum Quantities. The equipment listings in Tables 2.1 and 2.2 are minimum quantities that should be maintained by units. Greater numbers of individual equipment items may be required, depending on the response capability maintained at the unit.

D. Equipment Maintenance. COMDTINST 16465.26 established a Preventive Maintenance System (PMS) for major Marine Environmental Response equipment items. Units shall ensure that all chemical response equipment is maintained in accordance with this instruction where applicable, and with manufacturers recommendations. For major equipment items in widespread use, such as SurvivAir SCBAs, EEBAs, and the Biomarine 900, units should use annual maintenance contracts arranged by Headquarters.

2-E. Equipment Procurement Procedures.

1. Units shall determine their needs according to the level of protection required in their area of responsibility and make the necessary requisitions through appropriate channels (e.g. CERCLA funding, OG-30, OG-46). An up-to-date listing of protective equipment on hand, maintenance requirements, and requisitioned equipment and costs should be maintained. District commanders should coordinate and monitor the status of equipment inventories at subordinate commands and consolidate unit equipment funding requests for submission. CERCLA Trust Fund accounts for chemical response equipment and training should be used whenever appropriate.

Table 2.1
Equipment for General Levels of Protection

The following lists provide minimum quantities of equipment for each Level of Protection. Where minimum amounts are not specified, the unit must determine the appropriate amount based on the relevance of the item to the entire outfit. Minimum required amounts of like items in different Levels are not cumulative, i.e. the minimum number of SCBAs for a unit having both Level A and B capability is eight, not fourteen.

Key
- COTP - All units designated as COTP including MSOs
- NSF - Each strike team
- R - as required, number and type to be commensurate with unit needs

Level A - Provides the highest level of respiratory, skin, and eye protection.

	COTP	NSF
Pressure-demand, self-contained breathing apparatus, MSHA/NIOSH approved, 60 minute duration recommended.	8	16
Fully encapsulating chemical-resistant suit, (minimum is for each suit material).	6	12
Cool vest or suit ,compatable with suit (essential when wearing suit in high temperatures).	4	8
Cotton (or flame retardant) coveralls	15	60
Underwear, long cotton underwear		
Gloves (outer), chemical-resistant	15	60
Gloves (inner), chemical-resistant	15	60
Overgloves, Leather (when appropriate)	R	R
Boots, chemical-resistant, steel toe and shank. (Depending on suit boot, worn over or under suit boot)	8	16
Boots, (outer), chemical resistant, disposable	R	R
Hard hat (under suit)	6	12
Protective suit, disposable (Worn over fully encapsulating suit)	R	R

Level B - Provides the highest level of respiratory protection, but a lesser degree of skin protection.

	COTP	NSF
Pressure-demand, self contained breathing apparatus, MSHA/NIOSH approved, 30 or 60 minute duration.	6	16
Chemical-resistant clothing (e.g. hooded, one or two-piece splash suit; hood and apron; disposable coveralls) (each suit material).	15	60
Cotton (or flame retardant) coveralls	15	60
Gloves (outer) chemical-resistant	15	60
Gloves (inner) chemical-resistant	15	60

Table 2.1 (Cont.)
Equipment for General Levels of Protection

	COTP	NSF
Boots (outer) chemical-resistant, steel toe and shank	8	16
Boots (outer) chemical-resistant, disposal	R	R
Hard hat (face shield)	6	12

Level C - Provides protection against selected known types and concentrations of airborne substances with use of the proper air purifying respirators and filter canisters. Skin protection is comparable to Level B.

	COTP	NSF
Full-face, air purifying canister respirator (MSHA/NIOSH approved)	8	16
Replacement canisters (Acid gases; Organic Vapors; Combination; etc.)	R	R
Chemical-resistant clothing (e.g. hooded, one or two-piece splash suit; hood and apron; disposable coveralls)	15	60
Cotton (or flame retardant) coveralls	15	60
Gloves (outer) chemical-resistant	15	60
Gloves (inner) chemical-resistant	15	60
Boots, steel toe and shank, chemical-resistant	8	16
Boots (outer), chemical resistant, disposable	R	R
Hard hat	6	12
Emergency escape breathing apparatus	6	12

Level D - Provides minimal protection and augments the regular work uniform. It is not adequate in areas with respiratory or skin hazards.

	COTP	NSF
Cotton (or flame retardant) coveralls	R	R
Gloves	R	R
Boots/shoes, safety or chemical-resistant, steel toe and shank	R	R
Hard hat and eye or face protection	R	R
Emergency escape breathing apparatus	R	R

Table 2.2
Ancillary Materials and Equipment

This list is not all-inclusive; nor is it mandatory except where specified or where the item is followed by numbers indicating minimums. Thorough material lists are topics of training courses such as the CG Hazardous Chemical Training Course and the EPA Hazardous Materials Incident Response Operations Course. A unit's inventory of ancillary equipment must be developed by trained unit personnel who must consider other regional, local, and unit resources when determining the need for a given level of hardware.

	COTP	NSF
1. Support Materials/Equipment		
Communications (e.g. Throat-mike adaptation for MX-350s or equivalent, headset radios)	4*	8
Reference Library	1	1
Qualitative respirator fit-test supplies	R	R
Spare air-purifying respirator canisters	R	R
Spare SCBA cylinders	4	8
Decontamination kit	1	1
Portable eyewash	1	1
First aid kit	1	1
Tool Kit (i.e., basic mechanic tools, ax, wheel wrench, wrecking bar)	1	1
Cascade/compressor air refilling system		1
Organic vapor monitors; personal		R
Warning placards, marking tape, spray paint	R	R
Sealing tape for chemical-resistant clothing	R	R
2. Documentation, detection, and monitoring		
Investigation Kit	1	1
Sampling Kit	1	1
Oxygen/Combustible gas instrument	2	4
Colorimetric Chemical detector kit	2	3
Litmus paper or pH meter	1*	1
Digital dust meter**		
Remote air sampler**		
Organic vapor analyzer**		1
HNU Photoionizer (or equivalent)**	1*	2
3. Pollution Response Vehicle	1*	1

* Only required for COTPs with Level A or B capability.

** These are sophisticated electronic instruments with high initial cost and high recurring costs for maintenance and operator training. Before procuring this equipment, commands must ensure that there will be: a local need for instrument; dedicated man-hours to develop competent operators; and that there is inadequate availability of the instrument's capability through other sources (i.e., NSF, ERT, Technical Assist Teams (TAT), contractors, labs, universities, health officials, etc.).

CHAPTER 3. CHEMICAL RESPONSE TRAINING

A. General.

1. Since Coast Guard personnel may incur risks of exposure to hazardous chemicals, it follows that OSCs must ensure that personnel involved in chemical response are trained to recognize hazardous conditions and to work safely in contaminated areas. The training requirements for chemical response are based on the character of the mission, not on the degree of training which each marine safety unit can conveniently accomodate. It is recognized that smaller marine safety units may not have sufficient personnel to support the training, equipment maintenance, and entry procedures associated with chemical response. This has been accounted for by identifying two levels of training, one more extensive than the other. These levels correspond to the level of response capability maintained by the unit as identified in Chapter 1. Any forthcoming revisions to the Marine Safety training and qualification program that affect the levels of training will be incorporated when the changes are implemented.

2. The Environmental Response Division (G-WER) and the Training and Education Division (G-PTE) are pursuing two projects in an effort to reduce the resident training requirements for chemical response. The first is the broadening of curricula at Marine Safety School courses with the complementary elimination of non-Coast Guard resident courses from the training requirement. The second concerns the development of a sophisticated training program that would employ "alternative delivery systems", such as video-disc presentations and computer-assisted instruction. This program should not only provide quality instruction at the unit, but will also serve to augment or replace certain elements of resident training.

3. Chapter 1 described the program goals and standards that an OSC must consider when preparing for or conducting a response to a hazardous chemical release. The training requirements to support these levels of response are designed to provide the knowledge and skill-levels to accomplish these functions. This training emphasizes three areas: (1) applicable statutes and associated Coast Guard policies; (2) response actions such as entry into a hazardous environment, on-scene assessment, and monitoring or supervision of removal actions; and (3) activities in support of a response such as unit training, contingency planning, medical monitoring, and equipment maintenance.

4. Training requirements for chemical response have been separated into resident, National Strike Force, and unit instruction. Note that these are not annual training requirements, but minimum levels of training which the unit should demonstrate at all times.

3-A-5. It is recognized that due to scheduling conflicts, personnel transfers, and workload many units may require additional time to achieve the level of training described in this chapter. While this may limit response capability, the failure to conduct all required training does not preclude the unit from carrying out the response functions not requiring unit personnel to use protective equipment.

B. Resident Training.

1. The resident training requirement for chemical response shown in Table 3.1 consists of two complementary schedules of training. Schedule I courses provide broad coverage of the various aspects of the chemical response mission. They apply equally to all units pre-designated as OSC. This level of training is not designed to prepare marine safety personnel for actual entry into hazardous environments. Rather, it provides a limited familiarity with all major aspects of chemical response so that units may effectively monitor and supervise a removal operation. Schedule II courses provide the additional training required to support a response capability that includes the use of Level A or B personnel protective equipment. Information concerning the subject matter, duration, and location of these courses is included in Table 3.2.

2. Units shall request quotas for resident training courses by following the procedures in Chapter 5-5 of the Marine Safety Manual. Requests for quotas to courses not listed in Table 3.1 shall include justification demonstrating that: (1) the unlisted course provides beneficial instruction that is not provided by Table 3.1 courses; or (2) the unlisted course deals with the <u>same</u> subject matter as one of the Table 3.1 courses, <u>and</u> attendence at the unlisted course would be more convenient and cost-effective for the unit. Since funding for resident training is limited, any prioritizing of Headquarters funding will give preference to those courses included in Table 3.1. For those courses requiring the submission of applications, Commandant (G-WER) will normally make application to the sponsor for all attendees. If this will not be the case, the attendee will receive an application form with his orders for the course. The form shall be completed and submitted directly to the course sponsor.

3. The Commandant will distribute whatever information is available concerning class offerings of chemical response courses prior to the annual training solicitation. This should allow units to correspond their training request to actual course offerings. Also, recognizing the difficulties that some units may experience in observing the training requirements for chemical response, Commandant will arrange sequential class offerings of Table 3.1 courses whenever possible. Most often, this will result in regulator repair training being integrated into certain HCTC classes, and the EPA Incident Mitigation and Treatment Course class being scheduled at Yorktown immediately before or after a MGOPRC class.

3-C. Unit Training.

1. In addition to meeting the resident training requirements, units shall include chemical response training in the unit training program required by Chapter 11, Marine Safety Manual. This training should involve both classroom and "hands-on" instruction in a wide range of response topics, both to supplement resident training and to discuss areas not covered in the resident environment. "Hands-on" instruction involves the actual dressing-out of entry team personnel in protective equipment and the use of environmental monitoring devices in a simulated spill response. The purpose of these exercises are to familiarize response personnel with the wearing and use of equipment utilized during a response. Commanding officers must use their best judgement when formulating unit training programs, taking into account the level of response capability maintained at the unit. While the frequency of chemical incidents within the units jurisdiction may influence the need to concentrate unit training in certain areas, a sound and comprehensive unit training program must be carried out in any case. Periodic retraining and practice sessions serve to create a high degree of awareness of the hazards associated with chemical response and help to maintain proficiency in the safe use of response equipment.

2. Table 3.3 lists topics recommended for inclusion in a unit training program. This listing is not all inclusive and may require modification to meet the needs of an individual unit. The frequency of training on each topic will depend on the needs of individual units.

3. Operation of a unit training program may require funding for expendable equipment, supplies, etc. Requests for funding of unit training should be included in the annual CERCLA budget request. Unit training costs may include, but are not limited to:

   a. the procurement of video tapes, slide presentations, and publications;

   b. the support costs of drills and other forms of "hands-on" training; and

   c. costs of providing instruction, by other than Coast Guard personnel, specifically for the unit (e.g., SCBA regulator repair training at the unit).

D. NSF Training

1. The National Strike Force shall conduct oil and chemical response training at units in conjunction with their annual training visit. The primary purpose of this training is to provide the unit with an opportunity to examine its state of preparedness for pollution response and to identify possible

3-D-1 (cont.) areas for improvement. This training will include "hands-on" exercises and review of support activities such as unit training and equipment maintenance.

3-D-2. The following chemical response elements will normally be included in the NSF training program. The training will be tailored as much as possible to the stated needs of an individual unit.

a. Review and discussion of unit training program, unit procedures for equipment maintenance and storage, unit coordination with local response organizations, and local contingency planning for chemical incidents.

b. Discussion of chemical response directives.

c. Conducting a "hands-on" exercise emphasizing the selection of personnel protective equipment, entry procedures, survey techiques, and the evaluation of information gathered during an initial assessment of a release.

E. The HCTC staff of the Marine Safety School should serve as the primary source of informal guidance to the commanding officer concerning the relative value of chemical response courses and aids for unit training. The staff monitors available chemical response courses and receives copies of course critiques submitted by Coast Guard personnel to Commandant (G-PTE). Units may contact the HCTC staff directly at FTS: 827-2532.

Table 3.1
Resident Training Requirement for Chemical Response

1. Schedule I: Training necessary to support response activities, other than those incurring exposure risks.

   a. All participating members - Marine Environment & Systems Petty Officer Course, Marine Safety Basic Indoctrination Course, or Marine Safety Basic Indoctrination Course Mod II as appropriate (USCG)

   b. All participating members - Hazardous Chemical Training Course (USCG)

   c. Minimum of one officer or senior petty officer - Hazardous Materials Incident Response Operations Course (EPA)

   d. Minimum of one officer - Occupational Health Toxicology Instruction (NIOSH)

   e. Minimum of one officer - Middle Grade Officer Pollution Response Course (USCG)

   f. One officer - Incident Mitigation and Treatment Methods (EPA)

2. Schedule II. Training necessary to support a response capability that includes use of Level A or B personnel protective equipment.

   a. One petty officer - Regulator Repair School (manufacturer)[1]

   b. One petty officer - Occupational Respiratory Protection (NIOSH)

   c. One petty officer - Emergency Medical Treatment[2]

   d. 50% of entry team members (but minimum of three persons) - Hazardous Materials Incident Response Operations Course

[1] If the unit conducts regulator maintenance using the services of the manufacturer or a factory trained technician, this training requirement may be waived.

[2] This training requirement need not be met if the unit can otherwise provide for on-scene EMT support during those response activities incurring exposure risks.

Table 3.2
Chemical Response Resident Training Courses

TITLE	PREREQUISITES	DURATION	TOPICS
Marine Safety Basic Indoctrination Course (MSBIC) Marine Safety Basic Indoctrination Course Mod II (MSBIC Mod II) Marine Environment and Systems Petty Officer Course (MESPOC) RTC Yorktown, VA	none	12 wks 4 wks 5 wks	-Structure of a COTP office -Statutory Authorities and Associated Policies -Coast Guard Response Policy -Chemical Reference Sources -Occupational Health Monitoring -Package Hazardous Material Regulations -National Contingency Plan -Unit Allowance List for Personnel Protective Equipment
Hazardous Chemical Training Course (HCTC) RTC Yorktown, VA	MSBIC, MESPOC or MSBIC MOD II	2 wks	-Emergency Response Policy -Chemical and Toxicological Properties -Utilization of Chemical Information Sources -Respiratory Protection: Theory, Selection, Use, and Maintenance -Environmental Monitoring Devices: Theory, Selection, Use, and Maintenance -Sampling of Hazardous Materials -Contingency Planning -Management of Response Efforts Involving Hazardous Chemicals -Practical Field Exercises in Use of Response Equipment -Medical Monitoring Requirements -Team Entry and Decontamination Procedures -Non-Marine Modes of Transportation
Incident Mitigation & Treatment Methods EPA Regional Offices RTC Yorktown VA	none; completion of HCTC recommended	5 days	-Hazard Identification -Dispersion Pathways -Containment Methods -Physical, Chemical, and Biological Treatment of Hazardous Materials -Criteria and Guides for Cleanup -Environmental Trade-offs & Considerations

Table 3.2 (Cont'd)
Chemical Response Resident Training Courses

TITLE	PREREQUISITES	DURATION	TOPICS
Regulator Repair Location based on regulator type	HCTC	1 day	-Maintenance and repair of regulator, alarm,and valve assembly of a Specifi make of respirator -Provides certification to perform maintenance on specific respirators
Occupational Respiratory Protection Various Locations	HCTC	4 days	-Types of Respirators -OSHA Regulatory Requirements For Respiratory Protection -Fit Testing -Protection Factors -Selection Decision Logic -Unit Respiratory Protection Programs
Middle Grade Officer Pollution Response Course (MGOPRC) RTC Yorktown, VA	MSBIC or MSBIC MOD II	5 days	-Administrative and Management Concerns for Pollution Response -Funding of Chemical Response Operation -Funding of Chemical Response Support Costs(e.g., unit training and equipme -Impact of RCRA on Response Operations -Policy On Response to Waste Site Relea -Policy On Scope of Coast Guard OSC Response Functions
Hazardous Materials Incident Response Operations Course USEPA Edison, NJ	HCTC	5 days	-Personnel Protective Equipment -Environmental Monitoring Devices -Response Organization; Team Entry Meth -Decontamination Procedures -Personnel Monitoring -Safety Practices
Emergency Medical Treatment USCG EMT Course Petuluma, CA; Local courses	none, but completion of HCTC recommended	var.	-Anatomy and Physiology of Respiratory and Cardio-vascular Systems -Emergency Treatment for dyspena, heat cramps, heat exhaustion, heat stroke, cardiac problems, injuries
Occupational Health Toxicology RTC Yorktown, VA	HCTC	3-5 days	-Characteristics of Chemical Contaminan -Physiology of Routes of Entry -Toxic Effects of Chemical Contaminants Systemic and Respiratory Diseases -Personnel Monitoring -TLV Concept; Dosage/Time/Concentration Calculations -Physiology of Heat Stress

Table 3.3
Unit Training

The following is a recommended list of topics to be included in the unit training program. This listing is not all inclusive and may require modification to meet the needs of the individual unit. (This listing is not meant to imply a one-to-one correlation between topics and training sessions.)

1. Statutory authorities for chemical response and associated Coast Guard policies
2. Coast Guard policy regarding OSC responsibilities for chemical response; policy regarding risk to response personnel; local unit response posture
3. Local contingency plan and action plans
4. Commonly used physical and hazard parameters for chemical substances (flash point, specific gravity, TLV, etc.)
5. Chemical information sources
    a. Manuals (CHRIS, Merck Index, NIOSH/OSHA Guidelines, etc.)
    b. Computer modeling and data base systems (HACS, OHMTADS, SANSS, RTECS)
    c. Special Forces & RRT
    d. Industry (CHEMTREC, NACA Pesticide Safety Teams, etc.)
6. Medical monitoring requirements for marine safety personnel
7. Personnel protection
    a. Theory and use of personnel protective equipment
    b. Selection of appropriate level of protective equipment
    c. Team entry procedures
    d. Decontamination
8. Assessment of release
    a. Theory and Use of Environmental Monitoring Devices
    b. Sampling
        (1) Occasions when necessary
        (2) Techniques
        (3) Packaging and Shipment
    c. Documentation which may be available at scene of release
        (1) DOT placards, labels, manifests
        (2) RCRA records and manifests
9. Procedures for monitoring/supervising removals
10. Funding mechanisms for response operations (procedures for accessing funds, documentation requirements)
11. Removal Methods
    a. First aid response techniques (relate to local action plans)
    b. Federal government resources (NSF, EERU)
    c. Local contractor capabilities (if any)
    d. Guidelines for determining endpoint of removal
    e. Impact of RCRA disposal requirements
12. Maintenance and storage requirements for personnel protective equipment and environmental monitoring devices

Table 3.3 (Cont'd)
Unit Training

13. Physical Exercises
    a. Monthly, conduct dress out of entry team in personnel protective clothing. Emphasize:
        (1) Dexterity exercises
        (2) Personnel protective clothing emergency procedure
    b. Monthly, conduct exercise on use of environmental monitoring devices; calibration and survey techniques
    c. Once every 6 months, conduct a mock response to a chemical release. If possible, employ local emergency response organizations as participants. Emphasize:
        (1) Personnel protection measures
        (2) Spill assessment techniques
        (3) Evaluation of hazards and of potential for first aid response measures

CHAPTER 4. PREPARATIONS FOR RESPONSE TO HAZARDOUS CHEMICAL INCIDENTS

A. General Considerations.

1. Conditions at the scene of an incident vary widely, consequently response personnel are subjected to a broad range of risks which must be considered before entry into hazardous environments. For instance: (1) toxic chemicals can affect response personnel directly; (2) personnel may fall, trip, or be struck by objects; (3) personnel may be endangered by electrical, water, or heavy equipment hazards; and (4) injury or illness may occur due to physiological or psychological stress. All responses, therefore, require that the health and safety of response personnel be protected from the hazards which may be encountered.

2. In determining the level of personnel protection necessary in any situation, two types of exposure must be considered: acute and chronic. Acute exposures involve short-term exposure to contaminants whose concentrations are high relative to the type of substance and its protection criteria. Chronic exposures occur over a longer time period at relatively low concentrations with no apparent negative effect. While most responses involving Coast Guard personnel will present acute exposure hazards, any effective personnel protection program must address both hazards.

3. There are four basic routes of entry to be considered when protecting personnel from exposure to hazardous substances:

   a. INHALATION. Inhalation poses the most serious threat to response personnel. Adverse effects through inhalation may include:

      (1) tissue damage, destruction, or irritation by inhaled dust, mist, or vapors;

      (2) acute poisoning due to short term exposure to relatively high concentrations of toxic materials;

      (3) chronic poisoning due to long term exposure to low concentrations of toxic materials which accumulate in the body or produce cumulative damage;

      (4) cancer which may result from limited exposure to carcinogenic materials; and

      (5) unconsciousness and death caused by oxygen deficiency or chemical asphyxiation.

   b. CONTACT. Direct contact is the next most serious threat to response personnel. Potential adverse effects include:

4-A-3-b. (1) irritation of the eyes by airborne vapors, mist or dust or by splashes of irritating or corrosive liquid;

(2) destruction or irritation of skin tissue by highly reactive compounds such as strong acids or bases; and

(3) substances which are known or suspected to have carcinogenic potential from skin contact.

c. INGESTION. Ingestion is usually the least serious threat to response personnel provided that certain common sense procedures are followed. Workers must be required to remove contaminated clothing and clean their bodies before leaving the area for any reason. Obviously, eating, smoking, drinking, and personal hygiene functions should not be allowed in the contaminated area, nor until personnel have been thoroughly decontaminated.

d. INJECTION. A sharp object that is contaminated may accidently puncture any protective clothing and puncture the skin resulting in direct entry of a hazardous substance to the body. This route should be preventable by following routine safety procedures.

B. Pre-Incident Preparations. Responding to releases of hazardous substances requires extensive preparation and pre-planning prior to actual entry into the hazardous environment. While much of this pre-planning must be incident-specific, certain preparations must occur independent of incident-specific planning. The following paragraphs describe pre-incident preparations in the areas of physical fitness, medical monitoring, training, respiratory protection, and contingency planning. It is essential that these criteria be met as part of a unit's preparation for response actions.

1. Physical Fitness.

a. Personnel engaged in hazardous substance response operations involving the use of substantial personnel protective equipment may be subjected to high levels of physiological and psychological stress. As a result, they should be in good to excellent physical condition.

b. As a general rule, response personnel should participate in a fitness program attaining a minimum of 30 aerobic points per week as described in Commandant Instruction M6110.3, Physical Fitness Guidelines.

2. Medical Monitoring. Chapter 1.D. states that all personnel with the potential for exposure while involved in hazardous substance responses participate in a medical monitoring program. The purpose of the program is to serve as a check on the effectiveness of the personnel protective equipment program

4-B-2. (Cont'd) and to provide for early detection, diagnosis, and treatment of health effects resulting from toxic exposures. Medical monitoring of response personnel falls into two categories - a baseline evaluation with recurring monitoring, and exposure-specific monitoring.

a. Baseline and Recurring Monitoring - The primary purpose of the baseline evaluation is to determine the existence of any medical conditions which could be aggravated by chemical exposures or the stresses encountered during a response. It also serves as a reference for comparison to the recurring testing and to determine the individuals physical and psychological fitness to participate in response operations using personnel protective equipment. After the initial baseline evaluation, recurring testing, either annually or at some other specified interval, serves to detect or monitor changes in an individual's health.

b. Exposure-Specific Monitoring - The primary purpose of exposure-specific monitoring is to determine or monitor the effects of any suspected exposure to hazardous substances. This monitoring is tailored to detect the effects of exposures to specific substance(s) and is performed only when there is reason to believe that personnel have been exposed to a hazardous substance.

c. To assist in the interpretation of changes in medical monitoring criteria, records of all exposures and potential exposures of an individual shall be maintained. These records shall include as much detailed information as is available concerning a specific exposure (e.g. the date, length of exposure, substance(s) exposed to, concentrations (if known), and any protective equipment worn). Individual health records shall be annotated to reflect the pertinent information.

3. Training. Personnel involved in incident response operations must be adequately trained for the tasks they will perform. All units involved in response to chemical incidents shall meet the training requirements described in Chapter 3.

4. Respiratory Protection. The NCP states that OSCs must conform to applicable OSHA requirements and guidance. OSHA regulations in 29 CFR 1910.134 require the establishment of a respiratory protection program which includes: (1) standard procedures for the selection and use of respirators; (2) training in the proper use and limitations of respirators; (3) a program for routine inspections and maintenance of respiratory equipment; and (4) surveillance and evaluation to determine the continued effectivness of the program. All units using respiratory protection equipment for chemical spill response shall maintain

4-B-4. (Cont'd) a respiratory protection program. This program shall meet the standards described in COMDTINST M6260.2A, Technical Guide: Practices for Respiratory Protection. Table 4.1 lists the essential elements of a respiratory protection program.

5. Contingency Planning. The potential for harm to public health and welfare and to the environment from chemical releases underscores the necessity for pre-planning a response strategy. Such a strategy can only be developed through the formulation of hazardous substance spill response action plans. Contingency planning for these incidents should be in accordance with the requirements outlined in Chapter 86 of the Marine Safety Manual.

Table 4.1
Elements of a Respiratory Protection Program

An effective respiratory protection program must include the following elements:

1. All respirator users must be physically-fit for respirator use and be included in the medical monitoring program.

2. All respirator users must be trained in the proper use and limitations of respiratory protective equipment.

3. Personnel shall be fit-tested for the respiratory protective equipment used.

4. Personnel should be provided respiratory equipment that is applicable and suitable for the purpose intended. Where practicable, respirators should be assigned to individuals for their exclusive use.

5. Written procedures concerning the selection and use of respirators must be established.

6. All respiratory protective equipment must be inspected and maintained in accordance with manufacturers recommendations and OSHA regulations. Records of all inspections and maintenance shall be kept at the unit.

7. Units shall designate an individual responsible for their respiratory protection program.

8. Only NIOSH/MSHA-approved respiratory equipment shall be used.

9. Any facial hair that comes between the facepiece-to-face seal or interferes with respirator valve function is not allowed.

10. Environmental monitoring must be performed to confirm the use of the appropriate respirator.

CHAPTER 5. PRE-ENTRY RESPONSE ORGANIZATION

A. Introduction.

1. Every pollution incident is unique. However, sufficient similarities and recurring elements are found in each incident to justify the development of standard response procedures to hazardous substance incidents. While the organization and planning for chemical response is similar to that for oil, the execution of their respective response plans varies greatly.

2. The flow chart in Figure 5.1 outlines the major steps of a hazardous substance release and the key considerations that must be addressed. Many of the steps in the flow chart may actually occur simultaneously or slightly out of order as determined by the circumstances. It is for this reason that the flowchart is best considered as an overview of the general flow of events rather than a step-by-step account of the actions themselves. Note that many steps occur before the actual entry into a hazardous environment. The purpose of this chapter is to discuss the incident-specific preparations that occur before personnel conduct on-scene entry.

B. Information Needs.

1. Prior to formulation of a response plan, certain information must be collected to assist in evaluating the hazards associated with a chemical release and to make an initial determination of the level of protective equipment required. The following is a list of preliminary information necessary to formulate a response plan.

   a. Person reporting incident

   b. Location of the incident

   c. Time of occurrence

   d. Environmental medium affected

   e. Identification of substances involved (trade name, common name, CAS Number, UN Number, etc.,)

   f. Quantities of substances released or potential release/release rate

   g. Source of release

   h. Type of container(s) involved in release

   i. Cause of release

   j. Name of carrier

5-B-1-k. Name of shipper/manufacturer

l. Description of area of release

(1) terrain

(2) population density and locations of towns/cities

(3) accessibility

m. Weather conditions on scene

(1) Wind speed/direction

(2) Temperature

(3) Cloud Cover/precipitation

(4) Forecasted weather

n. For spills involving waterways:

(1) Current set and drift

(2) Width and depth of waterway

(3) Location of water intakes

o. Mitigation or cleanup action started or planned

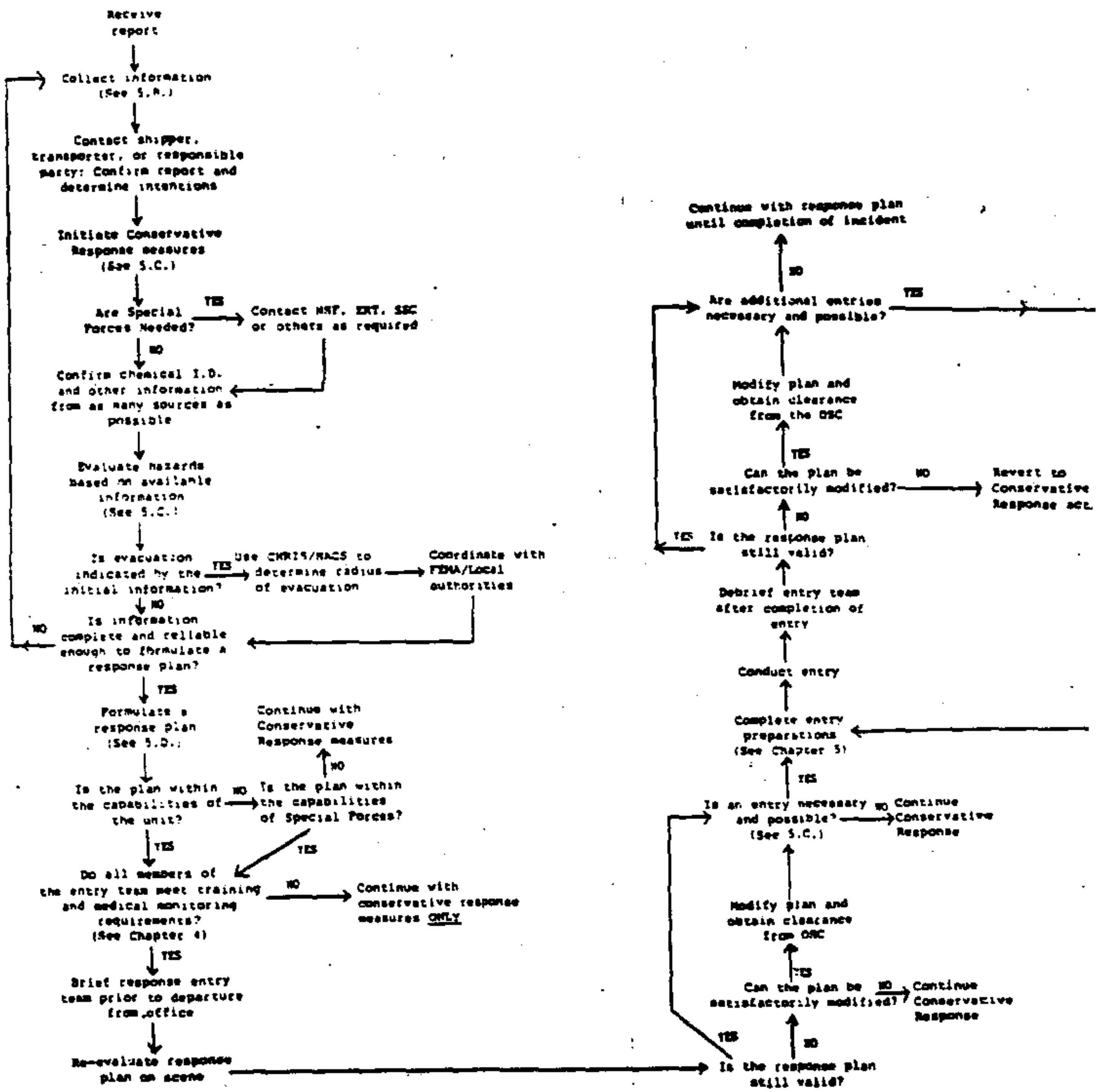
2. Possible sources of the above information would include the reporting party, carrier, shipper/manufacturer, local authorities on-scene, and shipping papers/manifests.

C. Initial Evaluation of Information.

1. Once information is collected, an initial evaluation must be made of the potential hazards associated with the released substances and to determine the level of response required by the Coast Guard.

2. Various sources of information exist for evaluating the dangers associated with a hazardous substance. Table 5.1 lists some available information sources that may be useful in hazard evaluation. Note that the chemical data contained in the various references may be outdated or incorrect, thus it is recommended that more than one source be used to crosscheck the information. Figure 5.2 provides a sample format for recording the physical/chemical properties and hazard characteristics associated with a particular substance.

3. Once the hazards associated with an incident are identified, the appropriate level of Coast Guard response must be identified - a conservative response or an active response.



RESPONSE FLOWCHART
Figure 5.1

5-C-3-a. A conservative response includes all coordination, information collection, and control functions carried out by the OSC which do not require the entry of Coast Guard personnel into a hazardous environment. This could include the dispatching of personnel to the vicinity of the incident to assist in information collection and to provide on-scene communications, command, and control.

b. An active response is one in which Coast Guard personnel must enter an area requiring the use of personnel protective equipment. Coast Guard personnel should normally be involved in on-scene entry only for the following activities:

(1) emergency lifesaving rescue;

(2) on-scene survey for preliminary assessment and environmental monitoring;

(3) first aid mitigation actions which must be undertaken before cleanup contractors or the responsible party can arrive on scene; and

(4) monitoring or supervision of contractor cleanup activities.

4. The following general policies shall be considered when determining the level of Coast Guard response.

a. An initial conservative response, consisting of recommending evacuation of the affected area to appropriate authorities and maintaining a safe perimeter, will normally be undertaken whenever the identity of the released substance(s) is unknown or uncertain. Active entry by Coast Guard personnel shall occur only after the chemical pollutant has been positively identified and a clear plan of action has been established.

b. Active entry shall not occur unless the minimum number of trained personnel and adequate protective equipment are available. In most hazardous materials responses involving a potential entry by Coast Guard personnel, a commissioned officer should normally be assigned as the on-scene representative of the OSC.

c. Prior to initiating an active entry, a response plan shall be developed and all members of the response team thoroughly briefed on its contents. Chapter 5.D. describes the elements of a response plan.

Figure 5.2
HAZARDOUS SUBSTANCE DATA SHEET

NAME OF SUBSTANCE:

COMMON: ______________________________ CHEMICAL: ______________

I. PHYSICAL/CHEMICAL PROPERTIES

				SOURCE
Normal Physical State:	____ Gas	____ Liquid	____ Solid	________
Molecular Weight		________		________
Density		________	gm/ml	________
Specific gravity		____ @ ____	,F/,C	________
Solubility: Water		____ @ ____	,F/,C	________
Solubility:	________	________	,F/,C	________
Boiling Point		________	,F/,C	________
Melting Point		________	,F/,C	________
Vapor pressure		____ mmHg ____	,F/,C	________
Vapor Density		____ @ ____	,F/,C	________
Flash Point		________	,F/,C	________
Other:	________	________		________
	________	________		________

II. HAZARDOUS CHARACTERISTICS

A. TOXICOLOGICAL HAZARD

TOXICOLOGICAL HAZARD	HAZARD	CONCENTRATIONS	SOURCE
Inhalation	Yes No	________	________
Ingestion	Yes No	________	________
Skin/Eye Absorption	Yes No	________	________
Skin/Eye Contact	Yes No	________	________
Carcinogenic	Yes No	________	________
Teratogenic	Yes No	________	________
Mutagenic	Yes No	________	________
Aquatic	Yes No	________	________
Other:	Yes No	________	________

B. FIRE HAZARD

FIRE HAZARD		CONCENTRATIONS	SOURCE
Combustibility	Yes No	________	________
Toxic Byproducts:	Yes No	________	________
________			
________			
Flammability	Yes No		
LFL		________	________
UFL		________	________
Explosibility	Yes No		
LEL		________	________
UEL		________	________

Figure 5.2 (Cont'd)
HAZARDOUS SUBSTANCE DATA SHEET

C. REACTIVITY HAZARD — Yes No — CONCENTRATIONS — SOURCE

______ ______ ______
______ ______ ______

D. CORROSIVITY — HAZARD — CONCENTRATIONS — SOURCE

pH ______ Yes No ______

Neutralizing agent:

______ ______ ______
______

E. RADIOACTIVE HAZARD — Yes No — EXPOSURE RATE — SOURCE

Background	______	______
Alpha Particles	______	______
Beta Particles	______	______
Gamma Radiation	______	______

III. INCIDENT RELATED:

Quantity Involved ______

Release Information ______

______

Monitoring/Sampling Recommended ______

______

IV. RECOMMENDED PROTECTION:

Public ______

______

Environment ______

______

Worker ______

______

d. Units are encouraged to consult with Special Forces (NSF, ERT, SSC), the Centers for Disease Control (CDC) Public Health Advisors, Coast Guard industrial hygiene/occupational health resources, or commercial resources as necessary to assist in planning and carrying out a response. Table 5.1 at the end of this chapter provides a brief description of the capabilities of these resources.

e. Certain situations may require that calculated risks be taken to protect the public health and welfare. Risks to personnel should be reduced to the minimum level possible consistent with the operational situation and <u>shall not be incurred for purely environmental purposes</u>.

D. <u>Formulation of a Response Plan</u>.

1. Once it is determined that personnel must enter a hazardous environment, a response plan must be developed. The plan should cover the following areas:

   a. The objectives of the on-scene entry

   b. On-scene organization and coordination

   c. Identification of the hazards associated with the substances present

   d. Personnel protective equipment requirements

   e. On-scene work plans

   f. Communications procedures

   g. Emergency contingency plans

   h. Decontamination procedures

   i. On-site safety and health plan

2. The following paragraphs provide a detailed description of the individual parts of the response plan. In addition, Appendix I provides a generic response plan for use as a guide when preparing for a chemical incident response.

   a. Entry objectives - Before an entry occurs, participating personnel should be aware of what is to be accomplished during the entry. Objectives can range from the gathering of information that is not available or is of questionable accuracy, to the monitoring or supervision of on-scene removal activities. Identification of on-scene objectives should minimize the unnecessary presence of personnel in the hazardous environment.

5-D-2-b. On-scene organization and coordination - A system for directing and managing a response must be established. This organizational structure should identify the job functions of personnel involved in the response and establish a chain of command for the response operation. It also establishes and details the control of on-scene activities.

(1) Job functions - The following is a list of job functions which must normally be carried out during a response. The number of persons required to carry out these functions will vary with the magnitude of the response and resource availability. The job descriptions for these functions are generally the same as for an oil pollution response.

(a) On-Scene Coordinator

(b) Scientific Support Coordinator

(c) Safety Officer

(d) On-Scene Coordinator's Representative

(e) Public Information

(f) Security

(g) Documentation and Record-Keeping

(h) Logistics Officer

(i) Financial Officer

(j) Team Leader

(k) Response Entry Team and support personnel

(2) On-Scene Control - One of the most important initial steps towards mitigating the impact of a hazardous chemical incident is to establish positive physical control of the site of the incident. There are several elements to this control.

(a) Evacuation. Local authorities may already have initiated efforts to evacuate areas surrounding the incident. The on-scene coordinator shall act quickly to determine if such efforts are sufficent in light of the given circumstances. If additional evacuation is believed advisable, the OSC shall recommend and coordinate with FEMA, state, and local authorities to implement such actions as necessary. OSCs shall not order or carry out an evacuation themselves, but may assist local authorities if requested.

5-D-2-b-(1)-(b) Access Control. Another integral element of the initial response effort is the establishment of an exclusionary zone from which all unauthorized personnel are barred. This exclusionary zone will generally encompass the entire immediate on-scene area and is not confined to the contamination reduction boundaries diagrammed in Figure 5.3. Local law enforcement agency personnel will normally be utilized to maintain the exclusionary zone. Where applicable, COTP action to implement a safety or security zone may also be required.

(c) Command Post (CP). The establishment of a command post upwind of the contaminated zone is another necessary step in the initial response process. Communications with key personnel on-scene and coordination of the OSC's forces are the primary functions of the command post.

(3) Boundary Placement

(a) To conduct active entry operations, it is necessary to classify the areas of the spill scene according to their potential for being contaminated. This classification serves to identify areas where protective equipment may be required and helps to prevent the spread of contamination outside the scene of the actual release.

(b) Weather conditions must be considered when establishing the boundaries of the spill scene. Surface air movements are extremely important in determining boundary placement. Under no circumstances should the Command Post or decontamination line be placed or allowed to continue to operate downwind of the Exclusion Area.

(c) Figure 5.3 shows the elements of idealized on-scene control. These areas are generally divided into a clean zone, a contamination reduction zone, and a contaminated (or "Hot") zone. Only personnel whose presence is required within these boundaries should be permitted to pass beyond the access control points, and then only if wearing the appropriate protective equipment.

(i) Clean Zone. This zone is an area on-site which is free of hazards and/or sources of contamination. It will provide the staging

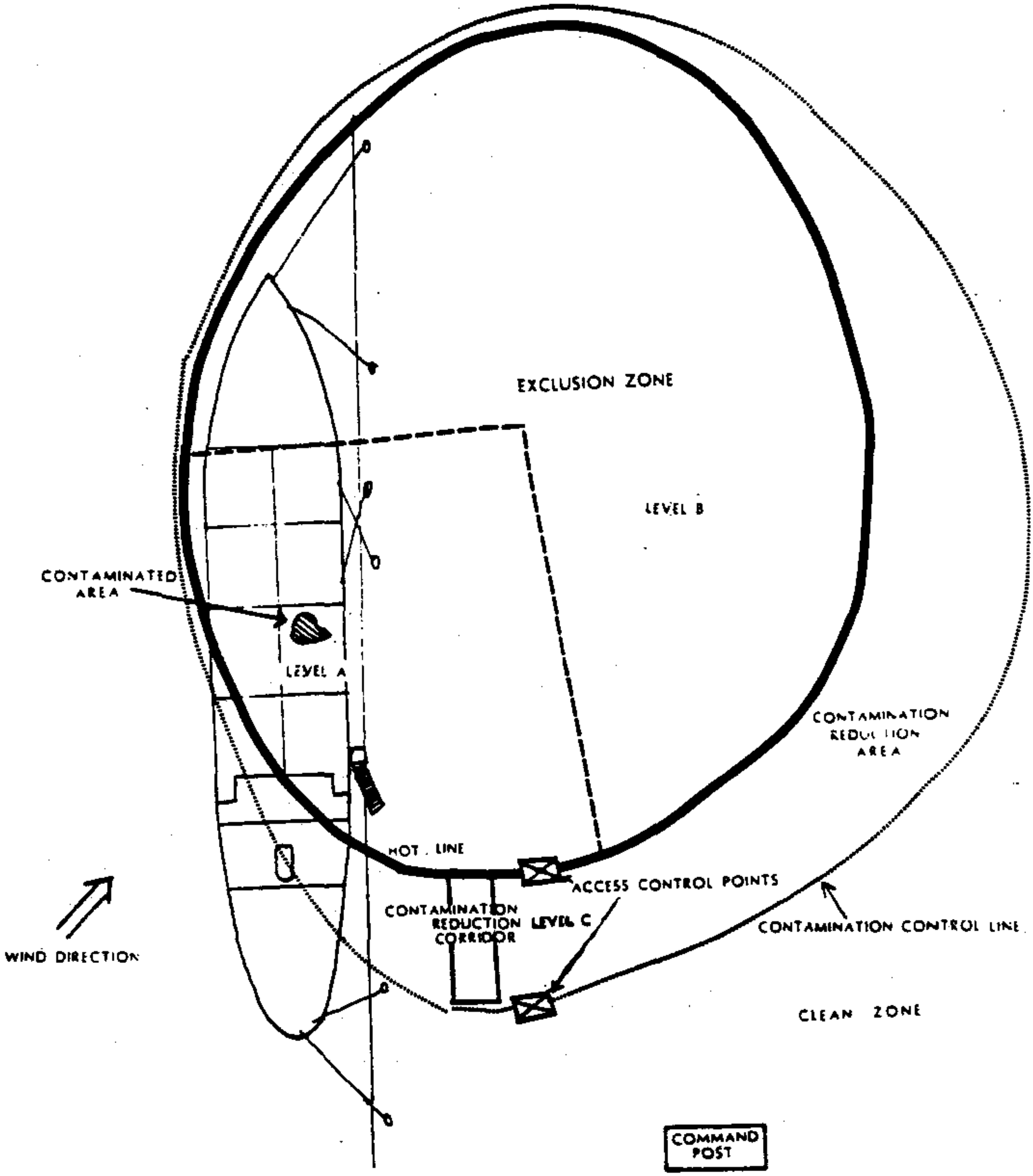


Figure 5.3
On-Scene Control and Work Zones

5-D-2-b-(3)-(c)-(i) (Cont'd) area from which the response activities will be mobilized, and should be continually monitored for possible changes in potential hazardous conditions which would require its relocation. The clean zone is outside of the contamination reduction area and hot line, and would normally contain the command post and access control points.

(ii) Contamination Reduction Area (CRA). The CRA is upwind from the hot line and downwind from the CP and has facilities for decontamination of personnel, protective clothing, and equipment.

(iii) Hot Line. The hot line is a arbitrarily selected line separating the contaminated area from the contamination reduction area. The location of the contamination area boundary and other reference points will be a matter of professional judgement on the part of the OSC or his representative, with the single provision that, except under extraordinary circumstances, the contamination area boundary (hot line) shall not be established closer than 150 feet to the actual spill location.

(iv) Contaminated (Hot) Area. This area contains the hazardous substances and possible dangerous conditions which require control procedures to minimize the risk of injury or death to the public and response team personnel. No person should enter this area unless they are wearing the appropriate protective clothing and performing approved activities as directed by the OSC or his representative.

(d) The use of a three-zone system, access control points, and exacting decontamination procedures provides a reasonable assurance against the spread of contaminating substances. This control system is based on a "worst case" situation. Less stringent site control and decontamination procedures may be utilized if definitive information is available on the substances involved and the contaminating hazards they present.

5-D-2-b-(3)-(e) The distances between the Hot Line, Contamination Control Line, and Command Post and the size and shape of each zone must be based on conditions specific to each incident. Considerable judgement is needed to assure that the distances between zone boundaries are sufficiently large to allow room for the operations and to prevent the spread of contaminants. Factors such as the area's physical and topographical features, hazard characteristics of the substances meteorological conditions, and the results of on-scene environmental monitoring should be considered when establishing the area dimensions and boundary distances.

c. Hazard Identification - The hazards expected to be encountered during the entry should be listed. See Section 5.C. for information on hazard evaluation.

d. Personnel protective equipment - The plan should identify the levels of protective equipment to be used at various locations on-scene. Selection of the appropriate level should be based on the exposure assessment that defines the chemical hazards, the potential for exposure, and the job function of the individuals. Normally, personnel involved in support functions such as air monitoring or decontamination will require a lesser level of protection than those conducting sampling or other work within the hot zone. Figure 5.3 shows an example of specified levels of protection for various areas during a hazardous substance response. Selection of the appropriate level of protection is discussed in Appendix II.

e. On-scene Work Plans - These plans should identify the specific tasks which will be completed within the hazardous environment and provide a detailed outline of the steps necessary to accomplish the tasks. The extent of detail required will depend on the nature of the actual tasks. For example, the work plan for monitoring cleanup activities will generally only involve the assignment of entry team members to carry out monitoring functions in a particular area on-scene. This contrasts with the work plan for completing "first aid" mitigation measures, where each step for completing the task would be detailed and probably rehearsed prior to entry.

f. Communications Procedures - The plan should describe the communications systems to be used by personnel at the scene of the incident. Communication systems will generally include radio and visual systems. In addition, emergency systems should be established in case of failure of the primary system. Chapter 6 contains a detailed description of communications systems.

5-D-2-g. Decontamination Procedures - The plan should indicate the decontamination procedures for personnel and equipment leaving the contaminated area. The purpose of decontamination is to prevent the spread or transfer of contaminants outside of the contaminated area. Chapter 6.E. discusses decontamination procedures. The extent of decon required will depend on the contaminants present and the hazards associated with these substances.

h. On-site Safety and Health Plan - The response plan should include safety procedures. It should include provisions for the availability of medical resources, emergency procedures, the identity of personnel responsible for on-scene safety, the monitoring of personnel involved in the response, and for periodic environmental monitoring. The following is a description of an on-site safety plan (also see Appendix 1):

(1) The safety and health plan must contain information concerning emergency medical care and treatment for response personnel. This should include:

(a) The name(s) of personnel on-scene that are EMT-qualified.

(b) The names, addresses, telephone numbers, and travel time to the nearest medical facilities.

(c) The name of the person(s) at each facility that has been briefed on the situation, the potential hazards, and the substances involved.

(d) The name, telephone number, and response time for ambulance services. Whenever possible, arrangements should be made for on-scene standby of this equipment.

(e) The location of on-scene first aid equipment, emergency showers, and eyewash fountains.

(2) Identification of the person responsible for on-scene safety. This person coordinates safety-related activities (e.g. air monitoring, on-site safety and health plan implementation, etc.) and provides recommendations to the OSC for any modifications of practices on scene to improve safety.

(3) The names and tasks of personnel who will participate in the entry.

(4) Standardized emergency procedures to be used while on scene. This would include emergency signals for on-scene evacuation, escape routes from the area, and criteria for initiating an evacuation from the contaminated area.

5-D-2-h-(5) A description of the environmental monitoring program for concentrations of such parameters as combustible gases, hazardous substances, or safe oxygen levels.

(6) A description of the personal monitoring to be carried out. This would range from testing to ascertain such physical conditions as body temperature, blood pressure, and weight loss to the use of personal monitoring devices to measure the exposure of individuals. This personal exposure monitoring of individuals is used to document exposures to specific concentrations of substances for recording in a medical record or exposure log and as supporting information during recurring or exposure-specific medical monitoring.

i. Industrial Hygiene Exposure Monitoring - During some responses, it may be appropriate or the OSC may be asked to carry out industrial hygiene exposure monitoring of involved personnel. The purpose of this monitoring is to collect data on potential hazardous substance exposure. The type of monitoring necessary will depend on the substances involved and the data required. The monitoring could range from personal sampling of individuals, using passive dosimeters or sampling pumps, to area sampling that is used to characterize the general conditions at the scene. Any exposure data collected should be compiled and recorded in the medical records of involved personnel. The recorded data should include a list of substances potentially exposed to; concentrations, if known; durations of known or potential exposure; type of personnel protection used; and the work operation conducted.

Table 5.1
Suggested Chemical Response Information Sources

A. Publications.

1. When responding to a hazardous chemical spill, an early concern is assessing the hazards associated with materials involved in the incident. Many reference sources exist for collecting the necessary data.

2. The listing below is not intended to be comprehensive. It is derived from a review of a wide range of available literature. The listed references are considered to be useful resources for units carrying out hazardous chemical responses. Commandant(G-WER) has provided an initial distribution for most of these references and will provide updates as available. These sources should be readily available at the unit in the response library.

   a. The Condensed Chemical Dictionary. Rose, Arthur, & Elizabeth
      Reinhold Book Corp. GSA Contract GS-018-6393

   b. Matheson Gas Data Book
      Matheson Gas Products,
      P.O. Box 85
      East Rutherford NJ 07073 (201) 933-2400

   c. OHMTADS (Microfiche)

   d. Chemical Hazards Response Information System (CHRIS)
      COMDTINST M16465.12 Volumes 1, 2, 3 and 4

   e. Dangerous Properties of Industrial Materials
      by N. Irving Sax
      Reinhold Publishing Corp. NY

   f. Hazardous Materials Emergency Response Guidebook
      U. S. Department of Transportation

   g. TLV's for Chemical Substances in Workroom Air
      American Conference of Governmental Industrial Hygienists
      P.O. Box 1937
      Cincinnati, OH 45201

   h. Documentation of TLV Guidelines , ACGIH

   i. Fire Protection Guide on Hazardous Materials
      National Fire Portection Association
      470 Atlantic Avenue
      Boston, MA 02210

Table 5.1 (Cont.)
Suggested Chemical Response Information Sources

j. Handling Guide for Potentially Hazardous Materials
Richard B. Cross CO
103 South Howard Street
P.O. Box 405
Oxford, IN 47971

k. Matheson, Effects of Exposure to Toxic Gases/First Aid and Medical Treatment
Matheson Gas Products
P.O. Box 85
East Rutherford, NJ 07073

l. NIOSH/OSHA Pocket Guide to Chemical Hazards
NIOSH Publication 78-210

m. List of Industrial Hygiene Consultants (latest update)
American Industrial Hygiene Association
475 Wolf Ledges Parkway
Akron, OH 44311

n. NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards
NIOSH Publication 81-123

o. The Merck Index
Merck & Co., Inc.
Rahway, NJ

p. GATX Tank Car Manual
General American Transportation Company
120 South Riverside Plaza
Chicago, IL 60606

q. Fundamentals of Industrial Hygiene
National Safety Council
444 N. Michigan Ave.
Chicago, IL 60611

r. SCBA - A Fire Service Guide to the Selection, Use, Care, and Maintenance of Self-Contained Breathing Apparatus
National Fire Protection Association
470 Atlantic Ave.
Boston, MA 02210

Table 5.1 (Cont.)
Suggested Chemical Response Information Sources

B. Industry Assistance.

1. The extent that emergency response assistance may be provided varies with each manufacturer. Assistance ranges from an emergency response team capable of mitigating the effects of a discharged chemical to only providing advice pertinent to the situation and the product involved. Normally, industry emergency response assistance is accessed by contacting CHEMTREC (800-424-9300). Direct industry contact is recommended for contingency planning in order to confirm capability and response times for a given region.

2. The following is a partial listing of industry firms known to possess some form of chemical expertise.

   a. Union Carbide
      Charleston, West Virginia
      304-744-3487 (24 Hrs)

   b. Dupont (E.I. Dupont de Nemours & Co.)
      Wilmington, DE
      302-774-7500 (24 hrs.)

   c. Dow Chemical Corporation
      Midland, MI
      517-636-4400

   d. Texaco
      Beacon, NY
      914-831-3400 (24 hrs.)

   e. Shell Oil
      Woodriver, IL
      618-254-7331
      Houston, TX
      713-473-9461

   f. Stauffer Chemical Company
      Westport, CT
      203-226-6602

   g. Monsanto
      St. Louis, MO
      314-694-3100

   h. American Cyanimid
      Wayne, NJ
      201-835-3100

   i. Hercules
      Wilmington, DE
      302-654-8900

Table 5.1 (Cont.)
Suggested Chemical Response Information Sources

j. Sun Oil Company (Sun Transport Company)
(advisory only)
Philadelphia, PA
215-964-0161

k. Atlantic Richfield (ARCO)
Newtown Square, PA
215-353-8300

l. Chevron
Richmond, CA
415-233-3737

3. In addition to chemical manufacturers, the railroad companies also possess emergency response capabilites.

a. Seaboard Coast Line (SCL) - Part of Family Lines System
(advisory only)
Jacksonville, FL
904-359-1592 (Op Center)

b. Chicago-Milwaukee-St. Paul-Pacific RR
Chicago, IL
312-648-3696

c. Union Pacific RR
(advisory only)
Omaha, NB
800-642-8343 (Nebraska only)
800-228-9948 (Outside Nebraska)

d. Southern RR
Atlanta, GA
404-529-1784 or 529-1786

e. Norfolk & Western RR
Roanoke, VA
703-981-4751

f. Southern Pacific RR
San Francisco, CA
415-362-1964 or 1952

g. Burlington Northern RR
St. Paul, MN
612-298-2121 Ext. 2666

h. Missouri-Pacific RR
St. Louis, MO
314-622-2224

Table 5.1 (Cont.)
Suggested Chemical Response Information Sources

i. Illinois Central Gulf RR
Chicago IL
312-565-1600 Ext. 2726

4. For certain products, manufacturers work together in accident situations. Two such response networks that provide expert assistance for specific commodities are the Chlorine Institute's CHLOREP (Chlorine Emergency Plan) and the Agricultural Chemicals Association PSTN (Pesticide Safety Team Network). This expertise is available on a 24 hr/day basis and can be obtained by contacting CHEMTREC.

   a. CHLOREP provides response expertise throughout the continental U. S. for any accident situation involving a chlorine product. The nearest producer will respond to the scene irrespective of where the product originated or what transportation mode was used.

   b. The PSTN also has response teams located throughout the continental U.S. Upon notification of an incident involving a pesticide, they will evaluate the problem and, if necessary, send a safety team to the scene.

5. The American Industrial Hygiene Association periodically publishes an updated list of industrial hygiene consultants which may be obtained upon request. A current list should be maintained by each unit.

C. Computerized Information Sources.

1. Hazard Assessment Computer System (HACS). HACS, a part of the Chemical Hazard Response Information System (CHRIS), is a computerized simulation system which models the physical behavior of hazardous material spills, and provides information describing the extent of the hazards associated with these spills. HACS can be used under emergency conditions involving the accidental discharge of hazardous materials to assist personnel in formulating response plans. In non-emergency operations the system can be used to aid in the development of contingency plans. Further description of this system can be found in Chapter 10 of the Marine Safety Manual.

2. Chemical Information Systems (CIS). CIS is a collection of scientific databases available on-line through an interactive computer program. These databases contain a wide variety of information on hazardous chemicals and there associated properties. Further information on this system can be found in COMDTINST 16484.2, Chemical Information Systems.

   a. The Oil and Hazardous Materials Technical Assistance Data System (OHMTADS) provides information pertinent to emergency spill response efforts. The OHMTADS database contains a wide variety of physical, chemical, biological, and toxicological data on over 14,000 chemicals with emphasis placed on their harmful effects on water quality.

Table 5.1 (Cont.)
Suggested Chemical Response Information Sources

b. The Structure and Nomenclature Search System (SANSS, is a reference database with the capability of searching for information on approximately 225,000 compounds via its formula, structural characteristics, CAS registry number, the full or partial name, or its synonyms. The data obtained on a particular substance includes structural diagrams, systematic names, and common synonyms for that substance.

c. The Registry of Toxic Effects of Chemical Substances (RTECS) database permits online, interactive searching of over 69,000 toxicity measurements pertaining to approximately 42,000 specific chemical substances. This type of information is useful to response personnel when determining what level of protection to wear at the site of an actual or potential release.

D. Industrial Hygiene/Occupational Health Support

1. National Strike Force (NSF). The Atlantic, Gulf, and Pacific Strike Teams can provide a wide range of chemical response support. A detailed description of NSF capabilities that could support an OSC is found in Chapter 86, Marine Safety Manual.

2. EPA Environmental Response Team (ERT). The ERT can provide advice or assistance to an OSC in selection of spill response and mitigation techniques, hazard assessment, personnel protection and safety precautions, and other chemical response support. They can also provide specialized equipment for use in removing a released pollutant. A detailed description of ERT capabilities is found in COMDTINST 16465.28, The EPA Environmental Response Team, dated 15 April 1982.

3. Centers for Disease Control (CDC) Public Health Advisors. The CDC Public Health Advisors are located in most EPA regional offices. These persons have a wide range of expertise and can provide advice in many areas, including assessment of public health threats, evaluation of the appropriate level of personnal protection measures, assisting in the development of or reviewing on-scene safety and response plans, and investigating health complaints.

4. Coast Guard Industrial Hygiene/Occupational Health Support. Resources are available within the Coast Guard that can provide advice and support to OSCs in the areas of industrial hygiene and occupational health. These resources are available through the following sources:

Table 5.1 (Cont.)
Suggested Chemical Response Information Sources

a. Commandant (G-CSP) - The Safety Programs Division can provide industrial hygiene advice and limited field support for chemical response activities. Additional information on available support can be found in COMDTINST M5100.29, the Coast Guard Occupational Safety and Health Manual or by contacting Commandant (G-CSP) FTS 426-1885.

b. Commandant (G-KOM) - The Operational Medicine Division can provide guidance on medical monitoring and support for occupational medical monitoring. In addition, G-KOM coordinates Public Health Service Environmental Health Officers and CERCLA-funded Occupational Medical Monitors in LANTAREA, PACAREA, and the Fifth, Seventh, and Ninth Districts which are available to provide on-scene support to OSCs. Support may be obtained through Commandant (G-KOM) at FTS 453-3074.

CHAPTER 6. ENTRY INTO HAZARDOUS ENVIRONMENTS

A. General Safety Considerations.

1. The following personal safety practices should be followed by all personnel to minimize the risk of exposure during hazardous substance responses.

a. Eating, drinking, chewing gum or tobacco, smoking, etc. are prohibited inside the contaminated area. Personnel exiting the contaminated area should be thoroughly decontaminated before these activities are authorized.

b. Decontamination procedures should include a thorough washing of the entire body as soon as possible after protective clothing is removed.

c. Facial hair that interferes with the mask-to-face seal is not allowed on any personnel required to wear respiratory protection equipment.

d. Contact with contaminated surfaces should be avoided, i.e. do not walk through puddles or other discolored surfaces; kneel on ground; or place equipment on containers and the ground.

e. Prescription drugs should not be taken by response personnel unless specifically approved by a qualified physician. Consumption of alcoholic beverages should be avoided.

f. Response personnel must be thoroughly familiar with standard safety procedures and the site safety plan.

2. The following safety considerations will apply for all entries of Coast Guard personnel to hazardous environments.

a. Within the contaminated area, the entry team shall work in the "buddy" system. A two-person rescue team shall be standing by when the entry is made into IDLH atmospheres.

b. Entrance and exits from the contaminated area must be planned and emergency escape routes identified.

c. Wind indicators visible to all personnel should be set up throughout the on-scene area.

d. Only essential personnel and equipment should be in the contaminated area.

e. The entry team shall be thoroughly briefed prior to each entry. They should also be debriefed after decontamination.

6-A-2-f. The length of work periods in the hazardous area must account for the stress on personnel, the time necessary to enter and leave the area, and decontamination time. A safety factor should also be included to allow for unforeseen occurrences during the entry.

3. Stress. Both physiological and psychological stress can affect response personnel by contributing significantly to accidents or other types of harm. To reduce physical stress or mental anxiety, entry team personnel should be both physically and psychologically fit for working in personnel protective equipment. Recurring training and hands-on exercises in the use of protective equipment will assist in acclimating the response team to working under response conditions.

   a. Heat Stress. The lack of natural body ventilation while working in protective clothing can lead to heat stress. If not properly accounted for by frequent rest periods, excessive heat can lead to the development of heat rashes, cramps, exhaustion, or heat stroke.

   b. Cold Stress. Working in cold temperatures can result in frostbite on the extremities or systemic hypothermia due to reduced body temperature.

4. Heat Stress Detection. Response personnel should be familiar with the symptoms of heat stress and be monitored if conditions warrant. Heat rash results from continuous exposures to heat or humid air. Heat cramps are caused by profuse perspiration with inadequate fluid intake and results in muscle spasms and/or pain on the extremities and abdomen. Heat exhaustion occurs when body organs attempt to keep the body cool. Symptoms include shallow breathing; pale, cool, and moist skin; profuse sweating; or dizziness. Heat stroke is the most severe form of heat stress, and immediate action must be taken to cool the body before serious injury or death occurs. The symptoms are red, hot, dry skin; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; or coma. The following procedures should be followed on warm days to reduce to possibility of heat stress:

   a. Provide entry personnel with plenty of liquids to make up for loss of body water and electrolytes. A 0.1% salt water solution or commercial mix is recommended.

   b. Provide cooling devices (cool vests, etc.) to aid natural body ventilation. Since these devices add weight, their use must be balanced against worker efficiency. Long cotton underwear helps absorb moisture and protects the skin from direct contact with heat-absorbing protective clothing.

   c. Install field showers or hose-down areas to reduce body temperature and/or cool protective clothing.

6-A-4-d. Adjust work/rest periods based on ambient temperatures. As a general rule, there should be a minimum of 30 minute rest period for every hour of work. If possible, conduct discretionary activities in early morning or evening.

e. Rotate entry personnel between job functions to minimize overstress or overexertion in one job task.

f. Provide shelter or shaded areas to protect personnel during rest periods.

5. Heat Stress Monitoring. Personnel wearing protective clothing should be monitored when the ambient temperature is above 70,F. It may also be necessary at lower temperatures if there is high humidity. The frequency of monitoring will depend on the ambient temperature and the recovery rates of personnel. When the temperature exceeds 85,F, the entry team should be monitored after every work period. The following techniques have been useful in monitoring the body's recuperative ability to excess heat:

a. Heart rate (HR) should be measured by the radial pulse for 30 seconds early in the resting period. The HR at the beginning of the rest period should not exceed 110 beats per minute. If the HR is higher, the next work period should be shortened by 10 minutes (or 33%), while the length of the rest period stays the same. If the HR is 110 beats per minute at the beginning of the next rest period, the following work cycle should be further shortened by 33%.

b. Body temperature should be measured orally with a clinical thermometer early in the rest period. The oral temperature (OT) should not exceed 99,F. If it does, the next work period should be shortened by 10 minutes (or 33%), while the length of the rest period stays the same. However, if the OT exceeds 99,F at the beginning of the next rest period, the following work cycle should be further shortened by 33%. OT should be measured again at the end of the rest period to make sure that it has dropped below 99,F.

c. Body water loss (BWL) due to sweating should be measured by weighing the entry personnel in the morning and evening. The clothing worn should be similar at both weighings. The scale used should be accurate to plus or minus 1/4 lb. BWL should not exceed 1.5% of the total body weight. If it does, the fluid intake of the person should be adjusted to account for the loss. Ideally, body fluids should be maintained at a constant level during the work day. This requires replacement of salt lost through sweating.

6-A-5-d. Clothing should be permitted to dry as much as possible during rest periods. Personnel noticing skin problems should immediately consult medical personnel.

6. Cold Stress Monitoring. Frostbite can be detected by loss of feeling in body extremities, a waxy or white skin appearance, or skin tissue becoming cold, pale, and solid. The symptoms of hypothermia usually occur in five stages: (1) shivering, (2) apathy, listlessness, sleepiness, and occasional rapid cooling of the body to less than 95,F, (3) unconsiousness, glassy stare, slow pulse, and slow respiratory rate, (4) freezing of the extremities, and (5) death. The effects of cold can be lessened by attempting to work in areas protected from wind and providing a heated rest area for entry team personnel.

B. Entry Team Assembly and Roles.

1. Hazardous chemical entries by Coast Guard personnel are labor-intensive operations requiring support personnel to back-up the entry team, particularly during incidents using Level A or B protection. Also, the stresses associated with wearing substantial protective equipment may require the use of fresh personnel at frequent intervals.

2. Table 1.1 in Chapter 1 sets out the minimum personnel requirements for entry into areas presenting chemical exposure risks. These requirements, based on the level of protection needed, provide only for personnel directly involved in the actual entry. Additional personnel for support functions may be necessary. A larger number of personnel are normally assigned to the operation to meet contingencies and to carry out support activities outside the contaminated area.

3. All entry team personnel shall be trained and proficient in the equipment and procedures associated with a chemical response. This will normally involve completion of the training described in Chapter 3.

4. The following is a brief description of the roles and responsibilities of personnel involved in the entry:

   a. Team Leader - Has responsibility for supervision of the overall entry operation. The team leader coordinates the activity of the entry team, the decontamination team, and the rescue team. They also act as the field safety observer, maintaining continuous communications with the entry team. Team leaders will normally perform their functions outside of the contaminated area.

   b. Decontamination Team - The decon team is responsible for setting up and operating the decon system for personnel and equipment leaving the contaminated area. They will assist the entry team in donning and doffing protective equipment and will perform the appropriate decontamination

6-B-4-b. (Cont'd) procedures on equipment and personnel. Since these personnel perform tasks in the contamination reduction zone, they must use the personnel protective equipment identified as safe for use in that area. This level is usually less than that of the entry team.

c. Rescue Team - The rescue team is a two-man team that remains on standby outside the contaminated area whenever the entry team is working in IDLH atmospheres. This team will be dressed out in the same level of protection as the entry team and in an emergency be capable of expeditiously entering the contaminated area to assist the entry team.

d. Entry team - The entry team will be the only persons who normally enter the contaminated area. They will be responsible for carrying out the tasks identified in the response plan and for any environmental monitoring done to define the contaminated area. An absolute minimum of two persons will make up the entry team and will always work using the buddy system.

5. The on-scene safety officer coordinates safety-related activities on scene to ensure a safe response. Their activities include ensuring that the necessary air monitoring is carried out, recommending levels of protection, monitoring safety conditions on scene, implementing the on-site safety and health plan, and recommending modifications to the OSC as necessary to ensure continued safety.

C. Communications.

1. A critical factor in carrying out an entry is the ability to maintain communications. The primary method of communications on-scene will be by radio. The communications system should be organized such that the team leader and entry team have a designated frequency. This reduces the possibility of interfering radio traffic on the entry team radios. Use a separate frequency for command and control on-scene outside of entry team activities.

2. In addition to radio communications, the entry team should be familiar with standard hand signals if radio communications fail. (See Table 6.1)

Table 6.1 Standard Hand Signals

Signal	Meaning
Hand Gripping Throat	Out of Air; Can't Breathe
Grip partners wrist or both hands around waist	Leave Area Immediately
Hands on Top of Head	Need Assistance
Thumbs Up	OK, I Am Alright, I Understand
Thumbs Down	No, Negative

6-C-3. Entry personnel shall remain in contact with the team leader. If possible, the entry team should remain within sight of the team leader or other individual outside the contaminated area to facilitate the use of visual signals. If not in visual contact, entry personnel should leave the contaminated area if radio communications fail. A loud hailer could be used as a backup for passing directions when primary communications fail.

4. In addition to radio comms, a method of emergency signaling must be available when personnel are in the hazardous environment. A pre-arranged signal, such as a blast from an air horn, should be used to indicate immediate evacuation by the entry team.

D. Site Entry.

1. Initial Entry. The initial entry usually characterizes the existing hazardous conditions or the need for mitigation actions. (See Chapter 5.C. for the criteria for Coast Guard entry) Before the team enters the site, as much information as possible should be collected. Based on the preliminary information available, the entry team must assess the hazards, determine the need for site entry, and identify initial safety requirements.

2. Protective Equipment Selection. While Appendix II provides detailed criteria for selection of the appropriate level of protective equipment, in general, Level B will be the minimum level of protection for an initial entry. The information necessary to select Level C protection is rarely available during initial entries.

3. Initial On-Site Evaluation. This normally determines the existence of hazardous conditions that may affect the public health, the environment, or response personnel. The following dangers are of concern - fire, explosion, oxygen-deficient atmospheres, airborne contaminants, and released chemicals that could affect the cleanup effort. Table 6.2 lists each of these potential dangers and recommended action levels for each. The time necessary to conduct the initial evaluation will depend on the urgency of the situation, type of incident, information needed, size of the affected area, availability of resources, level of protection, etc. As a result, the initial survey of the area may take many hours and require multiple entries.

4. Entry teams should enter the contaminated area from upwind.

5. While in the contaminated area, entry teams should make visual observations which would help in hazard evaluation - for example, dead fish or other animals; land features; wind direction; labels or placards on containers; and conditions conducive to splash or contact with liquids, sludges, or solids.

6-E. Environmental Monitoring.

1. To assist in characterizing hazardous conditions, monitoring instruments will normally be used in the initial entries. These instruments include combustible gas indicators, oxygen detectors, colorimetric tubes, and organic vapor monitors. The priority for their use will depend on the situation. In general, for poorly ventilated spaces such as ship holds, pumprooms, buildings, or depressed areas outdoors (gullies, ditches, trenches), monitoring for oxygen deficiency and combustible gases/vapors is a higher priority than toxic vapor monitoring. In open, well-ventilated areas, combustible gases and oxygen-deficiency are normally lesser hazards than toxic vapors.

2. It is imperative that personnel using monitoring instruments be thoroughly familiar with their limitations and operating characteristics. All instruments have inherent constraints in their ability to detect/quantify the hazards they are designed for. Unless these instruments are used and assessed by trained personnel, their readouts can be grossly misinterpreted, thereby endangering the health and safety of response personnel. Direct-reading instruments are designed for specific purposes and will not detect or measure all substances. Thus, negative readings should not be interpreted as the complete absence of airborne toxic substances. Verification of negative results can only be done by collecting air samples and analyzing them in a laboratory.

3. Monitoring surveys made during initial entry usually evaluate atmospheric hazards. In general, the results of this survey will lead to more comprehensive analyses for specific components. A program therefore must be established for sampling, monitoring, and evaluating hazards throughout the response. Since on-scene activities and weather conditions change, a continuous program for monitoring on-scene changes must be implemented using stationary area monitoring, personnel monitoring, or walk-through monitoring with direct-reading instruments.

4. In addition to the contaminated area, monitoring should occur in the contamination reduction area and the clean area. This will ensure that the control boundaries remain valid indicators of on-scene safety.

5. Any indication of atmospheric hazard should be viewed as a sign to proceed with care and deliberation. Readings indicating non-explosive atmospheres, low concentrations of toxic substances, or other conditions may increase or decrease suddenly, changing the associated risks. Extreme caution should be exercised any time atmospheric hazards are indicated.

Table 6.2
Atmospheric Hazard Guidelines

Monitoring Equipment	Hazard	Ambient Level	Action
Combustible Gas Indicator	Explosive Atmosphere	< 10% LEL	Continue investigation
		10%-25% LEL	Continue on-site monitoring with extreme caution as higher levels are encountered
		> 25% LEL	Explosion hazard; Leave area immediately
Oxygen Concentration Meter	Oxygen	< 19.5%	Monitor wearing SCBA. Note: Combustible gas readings not valid in atmospheres with < 19.5% oxygen.
		19.5%-25%	Continue investigation with caution. Deviation from normal level may be due to oxygen displacement.
		> 25%	Leave area; fire hazard potential from oxygen-enriched atmosphere
Colorimetric tubes	Organic and inorganic vapors/gases	Depends on species	Action level dependent on TLV/PEL for species. Concentration > TLV normally requires respiratory protection
HNU photoionizer OVA Organic Vapor Analyzer	Organic vapors/gases	Total response mode	Action level dependent on substances known to be present; instrument readings may vary due to calibration gas, etc. Consult users manual.

6-E-6. Personal Monitoring. When practical, the monitoring program of the entry team should include personal sampling pumps or passive exposure monitors. The results of these samples are useful in determining the exposures of entry personnel and as a check on the effectiveness of personnel protective equipment. Data from this monitoring should be abstracted in an individuals exposure records and be made available during the recurring medical monitoring.

F. Decontamination.

1. Personnel protective equiment helps prevent the wearer from exposure while good work practices help minimize contamination of protective clothing, instruments, and equipment. Even with these safeguards, contamination may occur. Harmful materials can be transferred into clean areas, exposing unprotected personnel. In addition, personnel may come in contact with contaminants while removing protective clothing. To prevent such occurences, methods to reduce contamination must be developed before anyone enters a suspected contaminated area. Decontamination consists of physically removing contaminants and/or changing their chemical nature to innocuous substances. The extent of decontamination required will depend on the type of contaminant involved and the level of exposure. Since the extent of decontamination will depend on the incident, only general guidelines can be given.

2. Initial decontamination planning should assume that persons leaving the contaminated area are grossly contaminated. A system is set up to wash and rinse all the protective clothing worn. This is combined with a sequential doffing of equipment, starting at the first station with the most heavily contaminated outer clothing and ending at the last station with the least contaminated article. The spread of contaminants is further reduced by separating each step in the decon process by at least 3 feet. After more information is obtained, the initial system may be modified by eliminating unnecessary stations or adapting it for site conditions. Appendix III provides information on worst-case decon procedures for each level of protection.

3. The decon plan must be adapted to conditions found at the incident. These conditions may result in more or less decon being required. The following factors should be considered in determining the extent of decon required:

a. Type of Contaminant. The extent of decon will depend on the hazard characteristics involved and the chemical's routes of entry. Generally, the more toxic the substance, the more extensive the decon required.

b. Amount of Contamination. The amount of contamination on protective clothing is normally determined visually. If gross contamination is evident, a thorough decon procedure

6-F-3-b. (Cont'd) is required. In addition, higher air concentrations of substances or direct contact may result in permeation or degradation of the clothing material. Swipe tests may help in determining the type and quantity of surface contaminants.

c. Level of Protection. The level of protection to a certain extent influences the extent of decon required. Wearing disposable clothing over the primary protective equipment may reduce direct exposure.

d. Work Functions. The work being performed by the entry team determines their exposure potential. Cleanup monitors, photographers, and perimeter air samplers performing tasks that will not bring them in direct contact with substances will normally require less decon than those performing tasks involving direct contact with contaminating substances.

e. Reason for Leaving Site. The reason for leaving the contaminated area may influence the extent of decon. Personnel leaving the area to pick up or drop off equipment or to change out air cylinders or respirator canisters normally do not require full decontamination. Personnel departing for a lunch break or end of workday must be thoroughly decontaminated to avoid spread of contaminants to the clean area.

4. Effectiveness of Decontamination. There is no method for immediately determining how effective the decon procedure is. Discoloration, stains, corrosive effects, and substances adhering to clothing may indicate that contaminants have not been completely removed. Also, contaminants may not be easily observed, and permeation of suit material may not be evident. Swipe testing may be used to identify surface contamination. Testing for permeation will require a piece of the exposed material. If there is any question on the effectiveness of the decon procedure, the contaminated clothing may need to be disposed of.

5. Decontamination Equipment. Equipment for decon can be easily procured. Soft-bristle, long-handle scrub brushes are used to remove contaminants. Water in buckets or garden sprayers can be used for rinsing. Galvanized wash tubs or childrens wading pools can be used for holding contaminated water, and plastic garbage bags may be used for storing contaminated equipment and clothing. A trench lined with visqueen can be used for storing contaminated water prior to removal by vac truck or on-site treatment.

6. Decontamination Solutions. Equipment is usually decontaminated by scrubbing with a detergent-water solution followed by rinsing with copious amounts of water. While this process may not be fully effective in removing contaminants, it is

6-F-6. (Cont'd) relatively safe compared with using a chemical decon solution. Decon chemicals may be appropriate when the exact contaminants are known and a decon material is useful to neutralize or change the contaminant to a less harmful substance. Chemical decon solutions should be used only in consultation with an experienced chemist.

7. Equipment Decontamination. Any equipment exposed to a hazardous chemical environment must be considered potentially contaminated, and handled accordingly. The extent of decon required will vary with the type of equipment and magnitude of the potential contamination. In most instances, washing and rinsing will remove any gross contamination. In some situations, swab sampling and lab analysis may be required to ascertain the efficiency of the decontamination procedure.

8. Emergency Decontamination. Some situations, such as secondary releases, accidents on-scene, or unanticipated exposures may result in the need for a quick exit from the contaminated zone. Since the normal decon procedure is time consuming, an abbreviated decontamination procedure is necessary for removal of gross levels of contamination prior to exit from the contaminated zone. Generally, this emergency decon would be an abbreviated version of decon procedures including washdown and removal of equipment and protective clothing and removal of potentially contaminated underclothing. If prompt life-saving first aid and/or medical treatment is required, decon procedures should be omitted or minimized. Life-saving care should be instituted immediately, although every precaution should be taken to minimize the spread of contaminants to medical personnel. The outer garments can be removed if they do not cause delays, interfere with treatment, or aggravate the problem. In any case, steps should be taken to minimize the spread of contamination from injured personnel to medical personnel.

9. Use of Protective Equipment Covers. An excellent way to control contamination is with the use of protective equipment covers. These covers can be disposable or reusable. Reusable covers, however, should be decontaminated after use. Disposable covers are the most convenient to use. Clear plastic bags can be used over such equipment as organic vapor detectors or radios. Some equipment, such as atmospheric sniffers, cannot be entirely encapsulated since they need direct access to ambient air. Plastic covers and masking (duct) tape can be used, however, to cover many parts of the equipment. Upon completion of the response, these covers are removed and bagged for disposal.

Appendix I
GENERIC RESPONSE PLAN

The purpose of this generic plan is to be able to rapidly plan a response to a hazardous chemical release. It is not all inclusive and should only be used as a guide when planning for a particular incident.

A. **INCIDENT DESCRIPTION**

Date____________ Location________________________

Source of release________________________

Area affected________________________

Surrounding population________________________

Topography________________________

Weather conditions________________________

Additional information________________________

B. **ENTRY OBJECTIVES** - The objective of the entry to the contaminated area is to (describes actions, tasks to be accomplished; i.e. identify contaminated soil; monitor activities of cleanup contractors, etc.)

C. **ON-SCENE ORGANIZATION AND COORDINATION** - The following personnel are designated to carry out the stated job functions on scene.

OSC REPRESENTATIVE ________________________

SSC REPRESENTATIVE ________________________

SAFETY OFFICER ________________________

PUBLIC INFORMATION ________________________

SECURITY COORDINATION________________________

DOCUMENTATION AND RECORDS________________________

LOGISTICS AND FINANCE________________________

ENTRY TEAM LEADER ________________________

ENTRY TEAM MEMBERS ________________________

(Note: One person may carry out more than one job function)

OTHER FEDERAL AGENCY REPS (i.e. EPA, NIOSH)

STATE AGENCY REPS ____
____
____

LOCAL AGENCY REPS ____
____
____

CONTRACTOR(S) ____
____
____
____

All personnel arriving or departing the scene should log in and out with the documentation officer.

All activities on scene must be cleared through the OSC representative.

D. ON-SCENE CONTROL

(Name of individual or agency) has been designated to coordinate access control and security on scene. A safe perimeter has been established at (distance or description of controlled area)
____
____

for this incident. No unauthorized persons should be within this area.

The on-scene command post and staging area have been established at ________
____
____.

The prevailing wind conditions are ____________________. This location is upwind from the spill area.

Control boundaries have been established and the contaminated area, hot line, contamination reduction area, and clean zones have been identified and designated as follows: ____
(describe boundaries and/or attach map of controlled area)
____
____
____

These boundaries are identified by ____
(marking of zones, i.e. red boundary tape - hot line; clean area - traffic cones; etc.)
____
____

E. HAZARD EVALUATION

The following substance(s) are known or suspected to be involved in this incident. The primary hazards of each are identified.

SUBSTANCES INVOLVED	CONCENTRATIONS(IF KNOWN)	PRIMARY HAZARDS
(chemical name)		(e.g. toxic on inhalation)

The following additional hazards are expected on scene: ______________
(i.e. slippery ground, uneven terrain, etc.) ______________.

Hazardous substance data sheets for the involved substance(s) have been completed and are attached.

F. PERSONNEL PROTECTIVE EQUIPMENT

Based on evaluation of potential hazards, the following levels of personnel protection have been designated for the applicable work areas or tasks:

Location	Job Function	Level of Protection
Contaminated Area	______________	A B C D Other
	______________	A B C D Other
	______________	A B C D Other
	______________	A B C D Other
Contamination Reduction Area	______________	A B C D Other
	______________	A B C D Other
	______________	A B C D Other
	______________	A B C D Other

Specific protective equipment for each level of protection is as follows:

Level A
Encapsulated suit
SCBA
(disposable coveralls)

Level C
Splash gear(type)
Full-face canister resp.

Level B
Splash gear(type)
SCBA

Level D

Other ______________

The following protective clothing materials are required for the involved substances:

Substance (chemical name)	Material (material i.e. Viton)
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________

If air-purifying respirators are authorized, (filtering medium) is the appropriate canister for use with the involved substances and concentrations. It has been determined by a competent individual that all criteria for using this type of respiratory protection have been met.

NO CHANGES TO THE SPECIFIED LEVELS OF PROTECTION SHALL BE MADE WITHOUT THE APPROVAL OF THE ON-SCENE SAFETY OFFICER AND THE OSC REP.

C. ON SCENE WORK PLANS

The size of the entry team will be _____ persons who will perform the following job tasks:

Team Leader (name) ______ Coordinate actions of entry team ______

____

____

Entry Team # 1 ______________ ______________________

____

______________ ______________________

____

Entry Team # 2 ______________ ______________________

____

______________ ______________________

____

Rescue Team* ______________ ______________________

______________ ______________________

____

____

Decon Team ______________ ______________________

______________ ______________________

____

____

* Required for entries to IDLH environments.

The entry team was briefed on the contents of this response plan at ______________________________.

H. COMMUNICATIONS PROCEDURES

Channel _____ has been designated as the entry team radio frequency only. All other on-scene communications will use channel ____.

The entry team should remain in constant radio communications or within sight of the team leader. Any failure of radio communications requires an evaluation of requiring the entry team to leave the contaminated area.

__(horn blast, siren, etc.)__ is the emergency signal to indicate that all personnel should leave the contaminated area. In addition, a loud hailer is available if required.

The following standard hand signals will be used in case of failure of radio communications:

Hand gripping throat ------------ Out of air, Can't breathe
Grip partners wrist or ---------- Leave area immediately
both hands around waist
Hands on top of head ------------ Need assistance
Thumbs up ----------------------- OK, I am alright, I understand
Thumbs down --------------------- No, negative

Telephone communications to the command post should be established as soon as practicable. The phone number is ______________________.

I. DECONTAMINATION PROCEDURES

Personnel and equipment leaving the contaminated area shall be thoroughly decontaminated. The standard Level ___ decon protocol shall be used with the following decon stations: (1)____________ (2)____________
(3)____________ (4)____________ (5)____________ (6)____________
(7)____________ (8)____________ (9)____________ (10)____________

Emergency decon will include the following stations: ____________________
____
____
____

The following decon equipment is required: ______________________________
____
____
____
____

__(normally detergent and water)__ will be used as the decontamination solution.

J. ON-SITE SAFETY AND HEALTH PLAN

1. ________(name)________ is the designated safety officer and is directly responsible to the OSC rep for safety recommendations on scene.

2. Emergency Medical Care

- ___(names of qualified personnel)___ are the qualified EMT's on scene.
- ___(medical facility names)___, at ___(address)___________, phone _______________ is located _____ minutes from this location. ___(name of person)_________ was contacted at ___(time)___ and briefed on the situation, the potential hazards, and the substances involved. A map of alternative routes to this facility is available at ___(normally command post___.

- Local ambulance service is available from ____________________ at phone ________________. Their response time is _____ minutes. Whenever possible, arrangements should be made for on-scene standby.

- First aid equipment is available on scene at the following locations:

First aid kit	____________________
Emergency eye wash	____________________
Emergency shower	____________________
____________	____________________

- Emergency medical information for substances present:

Substance	Exposure Symptoms	First Aid instructions

- List of emergency phone numbers:

Agency/Facility	Phone #	Contact
Police		
Fire		
Hospital		
Airport		
CDC Rep		
____________		
____________		
____________		

3. Environmental Monitoring

The following environmental monitoring instruments shall be used on scene (cross out if not applicable) at the specified intervals

Combustible Gas Indicator -	continuous/ hourly/ daily/ other_________
O_2 Monitor -	continuous/ hourly/ daily/ other_________
Colorimetric tubes -	continuous/ hourly/ daily/ other_________
___(type)___________	____________________
____________________	____________________
____________________	____________________
HNU/ OVA -	continuous/ hourly/ daily/ other_________
Other_______________	continuous/ hourly/ daily/ other_________
____________________	continuous/ hourly/ daily/ other _______

4. Emergency Procedures (should be modified as required for incident)

The following standard emergency procedures will be used by on-scene personnel. The safety officer shall be notified of any on-scene emergencies and be responsible for ensuring that the appropriate procedures are followed.

- Personnel Injury in the Contaminated Area: Upon notification of an injury in the contaminated area, the designated emergency signal ______________________ shall be sounded. All entry personnel shall assemble at the decon line. The rescue team will enter the contaminated area (if required) to remove the injured person to the hot line. The safety officer and entry team leader should evaluate the nature of the injury, and the affected person should be decontaminated to the extent possible prior to movement to the clean area. The on-scene EMT shall initiate the appropriate first aid and contact should be made for an ambulance and with the designated medical facility (if required). No persons shall re-enter the contaminated area until the cause of the injury or symptoms is determined.

- Personnel Injury in the Support Zone: Upon notification of an injury in the support zone, the entry team leader and safety officer will assess the nature of the injury. If the cause of the injury or loss of the injured person does not affect the performance of the entry team, operations may continue, with the on-scene EMT initiating the appropriate first aid and necessary follow-up as stated above. If the injury increases the risk to others, the designated emergency signal ______________________ shall be sounded and all entry personnel move to the decon line for further instructions. Activities on scene will stop until the added risk is removed or minimized.

- Fire/ Explosion: Upon notification of a fire or explosion on scene, the designated emergency signal ______________________ shall be sounded and all entry personnel assembled at the decon line. The fire department shall be alerted and all personnel moved to a safe distance from the involved area.

- Personnel Protective Equipment Failure: If an entry team member experiences a failure or alteration of protective equipment that affects the protection factor, the entry team shall immediately leave the contaminated area. Personnel shall not re-enter the area until the equipment has been repaired or replaced.

- Other Equipment Failure: If any other equipment on scene fails to operate properly, the entry team leader and safety officer shall be notified and then determine the effect of this failure on continuing operations on-scene. If the failure affects the safety of personnel or prevents completion of the work plan tasks, all personnel shall leave the contaminated area until the situation is evaluated and appropriate actions taken.

The following emergency escape routes are designated for use in those situations where egress from the contaminated area can not occur through the decon line: (describe alternate routes to leave area in emergencies)

In all situations, when an emergency on scene results in evacuation of the contaminated area, personnel shall not re-enter until:

1. The conditions resulting in the emergency have been corrected.
2. The hazards have been reassessed.
3. The response plan has been reviewed.
4. The entry team has been briefed on any changes in the response plan.

5. Personal Monitoring

The following personal monitoring will be in effect on scene:

- Personal exposure sampling (describe any personal sampling programs being carried out on entry personnel. This would include use of sampling pumps, air monitors, etc.)

- Medical monitoring: The expected air temperature will be (,F) . If it is determined that heat stress monitoring is required (mandatory if over 70, F) the following procedures shall be followed: (describe procedures in effect i.e. monitoring body temperature, body weight, pulse rate)

All entry team personnel have read the above response plan and are familiar with its provisions.

Safety Officer	(name)	(signature)
Entry Team Leader		
Entry Team		

Appendix II
Selection of Personnel Protective Equipment

A. Introduction.

1. Protective equipment has been divided into four categories according to the degree of protection afforded:

   a. Level A: Should be worn when the highest level of respiratory, skin and eye protection is needed or when concentrations and materials onscene are unknown.

   b. Level B: Should be selected when the highest level of respiratory protection is needed, but a lesser level of skin protection. Level B protection is the minimum level recommended for initial entries. Once the hazards have been determined, personnel protection corresponding with these findings may be utilized.

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

   d. Level D: Should not be worn at any spill scene with respiratory or skin hazards. Is primarily a work uniform providing minimal protection.

2. In general, the initial on-scene survey is to characterize the immediate hazards and, based on these findings, establish preliminary safety requirements. As this data is obtained and analyzed, the level of protection and other safety procedures are then modified as appropriate. No standard method can be used to select a level of protection for all incidents. Each situation must be examined individually. Some general guidance can be given, however, for judging the situation and determining the level of protection required. The following sections describe criteria to be considered when selecting the level of protection appropriate for a particular situation. In addition, Tables II.1 and II.2 provide basic decision logics for respirator and protective clothing selection.

B. Selecting Levels of Protection.

1. Level A Protection

   a. Selection Criteria - Meeting any of the following criteria warrants the use of Level A protection:

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

Table II.1
Protective Clothing Decision Logic

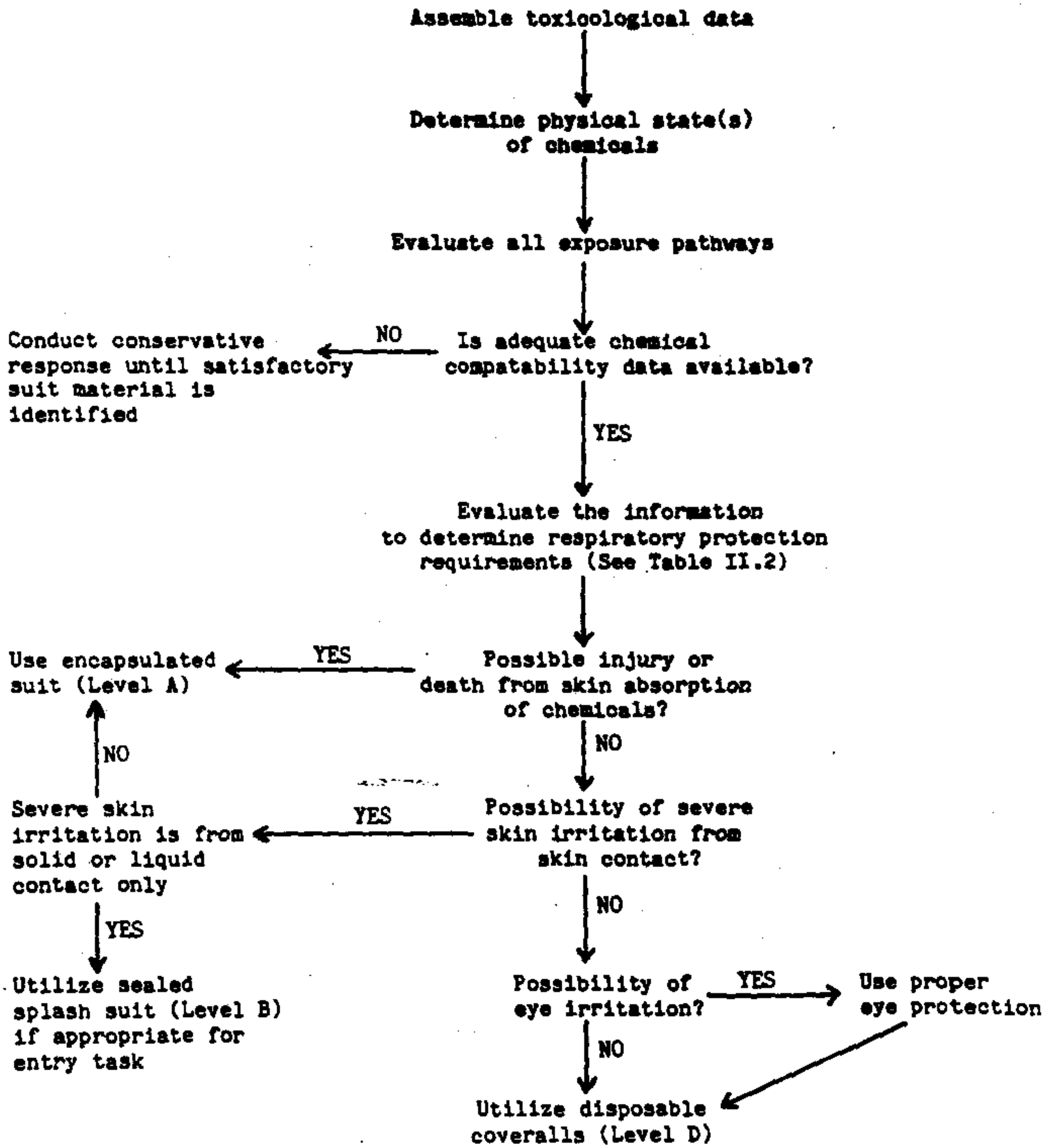


Table II.2
Respirator Decision Logic
SCBA vs Air-Purifying

1. Is there an oxygen deficiency? (less than 19.5%)

   If yes - Use SCBA

2. Have available personnel been successfully fit-tested?

   If no - Do not use respirator - Use SCBA

3. Is there any chance of eye irritation from the contaminant?

   If yes - Use only full-facepiece respirator

4. Is the contaminant at I.D.L.H. concentrations?

   If yes - Only use SCBA

5. If the contaminant is a particulate, is the TLV greater than or less than .05 mg/m^3?

   If greater than, use a dust, mist, or fume filter
   If less than, use a high efficiency filter

6. If the contaminant is gaseous, is the concentration greater than that recommended by the manufacturer of the selected canister?

   If yes - Use SCBA

7. Is the contaminant concentration greater than the maximum use limit (MUL) for the selected respirator? (MUL = P.F. x TLV)

   If yes - Use SCBA

8. Does the contaminant have adequate warning properties?

   If no - Use SCBA

9. Will the contaminant generate a high heat of reaction with the sorbent inside the canister?

   If yes - Use SCBA

10. Is the contaminant one that the manufacturer recommends that their respirator not be used for?

    If yes - Use SCBA

11. Is the contaminant a known or suspected carcinogen?

    If yes - Use SCBA only

12. Will the canister withstand breakthrough long enough to permit sufficient entry time?

    If no - Use SCBA

B-1-a-(1)-(a) Measured or potential for high concentration of atmospheric vapors, gases or particulates (i.e. vapor clouds, visible emissions, IDLH levels, etc.); or

(b) On-scene operations and job functions involving high potential for splash, immersion, or exposure to unexpected liquids, vapors, gases or particulates.

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

(3) Potential exists for contact with skin-destructive substances.

(4) Operations must be conducted in confined or poorly ventilated areas, until the absence of hazards requiring Level A protection is demonstrated. These areas are conducive to accumulating high concentrations of substances.

(5) The type of chemical, concentration, or exposure potential is unknown or uncertain. In this situation, the highest level of protection would be appropriate until the hazards can be better characterized.

b. Additional Guidance on Selection Criteria

(1) The fully-encapsulating suit provides the highest degree of protection to skin, eyes, and respiratory system if the suit material is resistant to the chemical(s) of concern at the measured or anticipated concentrations. While Level A provides maximum protection, clothing material may be rapidly permeated or penetrated by certain chemicals. These limitations should be recognized when selecting the type of chemical-resistant garment. Whenever possible, the suit material should be matched with the substance being protected against. Appendix IV provides data on compatability of suit materials and chemicals. Units are encouraged to consult with an industrial hygenist or other qualified person when making this selection.

(2) The use of Level A protection requires that the problems of physical stress, in particular heat stress associated with the wearing of impermeable protective clothing, be evaluated. Response personnel must be carefully monitored for physical tolerance and recovery.

(3) Encapsulated suits, being heavy and cumbersome, decrease dexterity/agility, visual acuity, etc., and increase the potential for accidents. This potential decreases as less protective equipment is required.

B-1-b-(4) Many hazardous substances are difficult to detect or to measure with field instruments. When such substances (especially those readily absorbed by or destructive to the skin) are known or suspected to be present and personnel contact is probable, Level A protection should be worn until more accurate information can be obtained.

2. <u>LEVEL B Protection</u>.

a. Selection Criteria - Meeting <u>any</u> of the following criteria warrants use of Level B Protection:

(1) The type and atmospheric concentration of toxic substances are known and require the highest degree of respiratory protection, but a lower level of skin and eye protection. This would include atmospheres:

(a) with OSHA Immediately Dangerous to Life and Health (IDLH) concentrations; or

(b) exceeding the limits of protection afforded by a full-face, air-purifying respirator; or

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

(2) The atmosphere contains less than 19.5% oxygen.

(3) Potential skin contact due to on-scene operations or work assignments is highly unlikely from splashes of hazardous substances to the small, unprotected area of the head or neck.

b. Additional Guidance on Selection Criteria

(1) The chemical-resistant clothing required for Level B is available in a wide variety of styles, materials, construction, permeability, etc. These factors all affect the degree of protection afforded. Therefore, selection of the most effective chemical-resistant clothing should be based on the known or anticipated hazards and/or job function. The information on permeability in Appendix IV will be useful when making this selection.

(2) The selection of Level B protection is made by:

(a) Comparing the concentrations of known or possible substances in the air with skin toxicity data.

(b) Determining that the substances present are not destructive to and/or readily absorbed through the skin if unanticipated exposures due to liquid

B-2-b-(2)-(b) (Cont'd) splashes, high vapor, gas or particulate generation, or other means of direct contact occur.

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

(2) For on-scene entry and reconnaissance in an open area, Level B Protection (with good quality, hooded, chemical-resistant clothing) is normally adequate to protect response personnel, providing the conditions described in selecting Level A are known or judged to be absent. For continous operations in these areas, the aforementioned criteria must be evaluated.

3. LEVEL C Protection.

a. Selection Criteria - Meeting all the following criteria permits use of Level C protection:

(1) All contaminants on scene have been identified and their air concentrations measured. Also, this concentration will be reduced by the air-purifying respirator to below the substance's exposure limit and is within the service limit of the canister.

(2) Atmospheric contaminant concentrations do not exceed OSHA IDLH levels.

(3) Exposure of unprotected areas of the body to air contaminants, liquid splashes, or other direct contact will not adversely affect the skin.

(4) Job functions have been determined not to require a higher level of protection.

(5) The oxygen content of the atmosphere must be at least 19.5%.

(6) Recurring air monitoring is carried out to confirm contaminant concentrations.

b. Additional Guidance on Selection Criteria

(1) Level C protection is distinguished from Level B by the equipment used to protect the respiratory system, assuming the same type of chemical-resistant clothing is used. The main selection criterion for Level C is that conditions permit wearing air-purifying devices. (See Table II.2) Making these determinations requires a competent individual (e.g. NSF, ERT, industrial hygienist, or other local expertise), to evaluate the factors listed above and to coordinate the necessary air monitoring.

B-3-b-(2) The air-purifying device must be a full-face mask (MSHA/NIOSH approved), equipped with a canister suspended from the chin or on a harness. Canisters must be appropriate to remove the substances encountered. Quarter or half-masks or cheek cartridge full-face masks should be used only with the approval of a qualified individual, such as an industrial hygienist. Use of this type of respirator must take into account the shorter breakthrough time of the cartridge vs. a canister.

(3) The decision to use Level C protection must be based on the best available information. Factors to consider include:

(a) The presence of respirable particulates.

(b) Possible errors associated with both the instruments and monitoring procedures used.

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

(d) The potential for higher concentrations in the ambient atmosphere or in the air adjacent to specific on-scene operations.

4. LEVEL D Protection.

a. Selection Criteria - Meeting all of the following criteria allows use of Level D protection:

(1) No hazardous air pollutant has been measured.

(2) Work functions preclude splashes, immersion, or potential for unexpected inhalation of any hazardous substances.

c. Additional Guidance on Selection Criteria - Level D protection is primarily a work uniform. It can be worn in areas where only boots may be contaminated and there no inhalable toxic substances.

C. Additional Considerations.

1. Protective Clothing - No comprehensive criteria are available, similar to the respiratory protection decision-logic, for selecting protective clothing. (See Table II.1) A concentration of a known substance in the air approaching a Threshold Limit Value or Permissible Exposure Limit for the skin does not automatically warrant a fully encapsulating suit. A hooded, high quality, chemical-resistant suit may provide adequate protection. The selection of Level A over Level B is a judgement that should be make by a qualified individual considering the following factors:

C-1-a. Effect of the substances on skin. Whether the substances are easily absorbed through the skin causing systemic effects or severe skin destruction. Liquids are generally more hazardous than vapors/gases and particulates.

b. Concentration of the substance. Higher concentrations of any specific material represent a greater risk, thereby increasing the potential for exposure to the material in the areas unprotected by Level B or C chemical-resistant clothing.

2. Atmospheric conditions such as inversion, temperature, wind direction, wind velocity, and pressure determine the behavior of contaminants in air or the potential for volatile material getting in air. These parameters must be considered when determining the appropriate Level of Protection.

3. Escape Masks - The use of escape masks is an option in Level C and D protection. Their application should be considered on a case-by-case basis. Escape masks could also be strategically located on-scene in areas that have higher possibilities for vapor, gas, or particulates.

D. Chemical Compatability.

1. Chemical compatability information is available in protective clothing equipment brochures but is limited in the number of chemicals covered. The information normally available represents the ability of a material to structurally withstand exposure to a chemical and does not address permeability. An EPA study completed in March 1983 compiled manufacturers data on breakthrough times for various suit materials. Excerpts from this report are included in Appendix IV. Since the compatibility characteristics of primary interest for protective clothing is its permeability, the data found in Appendix IV should be considered a limited indicator. It constitutes a preliminary guideline which needs to be verified by further testing. In the permeability testing accomplished to date, cases have been found where existing structural compatibility information (such as that in Appendix IV) indicated good or excellent resistance, yet the materials failed permeability testing. A great deal of caution is called for when evaluating compatibility information to select protective clothing items. Permeability characteristics are the much preferred basis for making protective clothing selections. Unfortunately, this type of compatibility information is mostly unavailable. Commandant (G-DMT) is presently conducting extensive permeability testing of suit materials to improve the information available to OSCs. Until better permeability test data is available, gross contamination of protective clothing requires an immediate exit from the contaminated area and decontamination of the affected persons. Units are encouraged to consult with the NSF, ERT, NIOSH, or G-DMT for guidance in material selection.

2. Secondary Materials - Nearly every piece of protective clothing is constructed of multiple types of material. The secondary material

D-2. (Cont'd) of construction, which comprise a small percentage of the overall design, are often overlooked when evaluating the chemical compatibility information. Ignoring this factor increases the vulnerability of the wearer to receiving an inadvertent exposure.

3. Since there is no single suit material safe for all chemicals, response team inventories should include a number of suit materials. In cases where resource availability limits the types of suit materials at the unit, selection of the appropriate material(s) stocked should be based on the substances most likely to be encountered in a response as identified through local contingency planning.

E. Dermal Toxicity Data.

1. The chemicals listed in Table II.3, Dermal Toxicity, are identified in the Oil and Hazardous Materials Technical Assistance Data Base System (OHMTADS) as having adverse skin effects ranging from irritation to absorption into the body. This information will be useful when selecting the appropriate level of protection. Other substances affecting the skin, but not listed in OHMTADS, may be present; therefore, the chemical/physical properties of each substance must be evaluated for these effects and cross-checked against other reference sources.

2. Use of Tables.

a. Categories -Table II.3 divides chemicals into two categories:

Category 1 (more serious)

Gases having a systemic dermal toxicity rating of moderate to extremely hazardous and a penetration ranking of moderate to high.

Liquids and solids having a systemic dermal toxicity rating of extremely hazardous and a penetration ranking of moderate to high

Gases having a local dermal toxicity rating of moderate to extremely hazardous.

Liquids and solids having a local dermal toxicity rating of extremely hazardous.

Category 2 (less serious)

Gases having a systemic dermal toxicity rating of slightly hazardous and a penetration ranking of slight.

Liquids and solids having a systemic dermal toxicity rating of moderate to slightly hazardous and a penetration ranking of moderate to slight.

Gases having a local dermal toxicity rating of slightly hazardous.

E-2-a. (Cont'd) Liquids and solids having a local dermal toxicity rating of moderate to slightly hazardous.

b. Physical State -The physical state of the chemicals listed is their normal state. In a fire, some of the substances listed as solids or liquids could vaporize and represent a greater hazard to the skin. The chemicals listed may also be found mixed with other substances which could change how they affect the skin.

c. Skin penetration Characteristics.

- − Negligible Penetration (solid - polar)
- \+ Slight Penetration (solid - nonpolar)
- ++ Moderate Penetration (liquid, solid - nonpolar)
- +++ High Penetration (gas/liquid - nonpolar)

d. Potency (systemic)

		Lethal Amount to A 70 Kilogram Man
+++	Extreme Hazard (LD_{50}) 1 mg/kg-50 mg/kg)	drops to 20 ml
++	Moderate Hazard (LD_{50}50-500 mg/kg)	1 ounce - 1 pint (1 pound)
+	Slight Hazard (LD_{50}) 500-15,000 mg/kg)	1 pint - 1 quart (2.2 pounds)

e. Potency (local)

- +++ Extreme - Tissue destruction/necrosis
- ++ Moderate - Irritation/inflamation of skin
- \+ Slight - Reddening of skin

3. Relation of Table II.3 to Levels of Protection

a. The purpose of the table is to provide data that a qualified person can use in conjunction with other situation-specific knowledge to select protective clothing. The data relates to skin toxicity only and does not consider inhalation of chemicals; therefore, the data should not be used to select respiratory protection equipment.

b. The known or suspected presence and/or measured concentration of Category 1 chemicals at or above the listed concentrations normally warrants using Level A protection. The known or suspected presence and/or measured concentration of Category 2 chemicals at or above the listed concentrations suggests that a lesser level of skin protection (Level B or C) may be appropriate.

TABLE II.3

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
2,2 Dichloropropionic acid	solid	+	local	++	-	2
2,4,5 - T Acid	solid	+	systemic local	+ ++	10 mg/m^3/8h	2
2,4,5 - T Amines	solid	+	systemic local	+ ++	10 mg/m^3/8h	2
2,4,5 - T Esters	solid	+	systemic local	+ +	10 mg/m^3/8h	2
2,4,5 - TP Acid	solid	+	systemic local	+ ++	10 mg/m^3/8h	2
2,4,5 - TP Acid Esters	liquid	++	systemic local	+ +	10 mg/m^3/8h	2
2,4,5 - T Salts	solid	+	systemic local	+ +	10 mg/m^3/8h	2
2,4 - D Acid	solid	+	systemic local	+ ++	10 mg/m^3/8h	2
2,4 - Dichlorophenol	solid	+	systemic local	+ ++	-	2
2,4 - D - Esters	liquid	++	systemic local	+ +	10 mg/m^3/8h	2
2 - Ethylhexyl Acrylate	liquid	++	local	+++	-	2
2 - Methyl - 5 - ethyl pyri-	liquid	++	local	+	-	2

TABLE II-3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
2 - Napthol	solid	+	local	++	-	2
3,5 - Xylenol	solid	+	systemic local	++ +	-	2
Acetaldehyde	liquid	+	local systemic	++ +	100 ppm/8h 180 mg/m^3/8h	2
Acetic Anhydride	liquid	+	local systemic	++ +	5 ppm/8h 20 mg/m^3/8h	2
Acetone	liquid	+++	local	++	750 ppm/8h	2
Acetone Cyanohydrin	liquid	++	systemic	+++	10 ppm/8h	1
Acetoacetone	liquid	++	local	++	-	2
Acetyl Bromide	fuming liquid	+++	local	+++	5 ppm/15 min	1
Acetyl Chloride	fuming liquid	+++	local	+++	5 ppm/15 min	1
Acridine	solid	+	local sensitizer	+++	-	2
Acrolein	liquid	+	local sensitizer	+++	0.1 ppm/8h .25 mg/m^3/8h	2
Acrylonitrile	liquid	+++	systemic local	+++ ++	2 ppm/8h	1

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Adipic Acid	solid	+	local	+	-	2
Adiponitrile	liquid	+++	systemic	+++	10 mg/m^3/8h	1
Alkyldimethyl 3,4 - Dichlorobenzylammonium Chloride	liquid	+	local	+	-	2
Allyl Alcohol	liquid	++	systemic local	++ ++	2 ppm/8h 5 mg/m^3/8h	2
Allyl Chloride	liquid	++	local	++	1 ppm/8h 3 mg/m^3/8h	2
Ammonia	gas	+	local	+++	25 ppm/8h 18 mg/m^3/8h	1
Ammonium Bicarbonate	solid	+	local	++	-	2
Ammonium Bichromate	solid	+	local	++	-	2
Ammonium Bifluoride	solid	+	local	++	-	2
Ammonium Bisulfite	solid	+	local	+++	-	2
Ammonium Carbamate	solid	+	local	+	-	2
Ammonium Carbonate	solid	+	local	++	-	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Ammonium Citrate (Dibasic)	solid	+	local	+++	-	2
Ammonium Ferrocyanide	solid	+	local	+	-	2
Ammonium Hydroxide	liquid	++	local	+++	-	1
Ammonium Phosphate (Dibasic)	solid	+	local	++	-	2
Ammonium Sulfamate	solid	+	local	++	10 mg/m^3/8h	2
Ammonium Sulfide	solid	+	local	++	-	2
Ammonium Sulfite	solid	+	local	++	-	2
Ammonium Tartrate	solid	+	local	++	-	2
Ammonium Thiocyanate	solid	++	local systemic	+++ ++	-	2
Ammonium Thiosulfate	solid	+	local	++	-	2
Aniline	liquid	++	local	++	2 ppm/8h	2
Antimony	solid	+	systemic local	++ ++	0.5 mg/m^3/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Antimony Pentachloride	liquid	++	local	+++	-	2
Argon - 37 (radioactive)	gas	+++	systemic	+++	-	1
Arsine	gas	+++	systemic	+++	.05 ppm/8h	1
Arsenic	solid	++	local systemic	+++ +++	.2 mg/m^3/8h	1
Arsenic-74 (radioactive)	solid	++	systemic	+++	-	1
Arsenic-76 (radioactive)	solid	++	systemic	+++	-	1
Arsenic-77 (radioactive)	solid	++	systemic	+++	-	1
Arsenic Acid	solid	++	local systemic	+++ +++	0.5 mg/m^3/8h	1
Arsenic Disulfide	solid	++	local systemic	+++ +++	-	1
Arsenic Pentoxide	solid	++	local systemic	+++ +++	-	1
Arsenic Tribromide	solid	++	local systemic	+++ +++	0.5 mg/m^3/8h	1
Arsenic Trichloride	solid	++	local systemic	+++ +++	0.5 mg/m^3/8h	1

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Arsenic Trioxide	solid	++	local systemic	+++ +++	.25 mg/m^3/8h	1
Arsenic Trisulfide	solid	++	local systemic	+++ +++	0.5 mg/m^3/8h	1
Barium	solid	+	local	++	0.5 mg/m^3/8h	2
Benzene	liquid	++	local systemic	++ +++	10 ppm/8h	1
Benzophenone	solid	+	local	++	-	2
Benzoyl Chloride	liquid	++	local	+++	5 mg/m^3/8h	1
Benzoyl Peroxide	solid	++	local	+++	5 mg/m^3/8h	1
Benzyl Alcohol	liquid	++	local systemic	++ +	-	2
Benzyl Benzoate	liquid	++	local	++	-	2
Benzyl Bromide	liquid	++	local	++	-	2
Benzyl Chloride	liquid	++	local	+++	1 ppm/8h	2
Beryllium Nitrate	solid	+	local	++	0.25 mg/m^3/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Brombenzylcyanide	liquid <77 F-solid	++	local systemic	++ +++	-	1
Calcium Hypochlorite	solid	+	local	++	-	1
Calcium Oxide	solid	+	local	++	2 mg/m^3/8h	2
Calcium Phosphide	solid	+	local	++	-	2
Camphor	solid	+	local systemic	++ ++	2 ppm/8h	2
Captan	solid	++	local systemic	++ ++	5 mg/m^3/8h	2
Carbaryl	solid	++	local systemic	+ ++	5 mg/m^3/8h	2
Carbofuran	liquid	++	local systemic	+++ +++	0.1 mg/m^3/8h	1
Carbon Disulfide	liquid	++	local systemic	++ +++	10 ppm/8h	1
Carbon Monoxide	gas	+++	systemic	+++	50 ppm/8h	1
Carbon Tetrachloride	liquid	+++	systemic local	+++ +	5 ppm/8h	1
Cetyldimethylbenzyl-ammonium Chloride	solid	+	local	+	-	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Chloracetophenone	solid	+	local systemic	++ ++	.05 ppm/8h	2
Chlordane	solid	+	local systemic	++ ++	.5 mg/m^3/8h	2
Bromine	liquid (fuming)	++	local systemic	+++ ++	.1 ppm/8h	1
Butylamine	liquid	++	local	+++	5 ppm/8h	1
Butyl Mercaptan	liquid	++	local	++	.5 ppm/8h	2
Butyric Acid	liquid	++	local	++	-	2
Calcium Arsenate	solid	+	local systemic	++ +++	1 mg/m^3/8h	1
Calcium Arsenite	solid	+	local systemic	++ +++	-	1
Calcium Carbide	solid	+	local	++	-	2
Calcium Cyanide	solid	++	systemic local	+++ ++	5 mg/m^3/10 min	1
Chlorine	gas	+++	local	+++	1 ppm/8h 3 mg/m^3/8h	1
Chlorine - 36 (radioactive)	gas	+++	local	+++	-	1

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Chloroacetic Acid	solid	++	local	++	-	2
Chlorobenzene	liquid	++	local systemic	++ ++	75 ppm/8h 350 mg/m^3/8h	2
Chlorobutadiene	liquid	++	local	++	10 ppm/8h	2
Chloromethane	gas	+++	local systemic	+ ++	50 ppm/8h	1
Chloropicrin	liquid	++	local	+++	0.1 ppm/8h	1
Chlorosulfonic Acid	liquid	++	local	+++	5 ppm/8h	1
Chlorthion	liquid	++	local systemic	+++ +	-	2
Chromyl Chloride	liquid	++	local systemic	+++ ++	025 mg/m^3/8h	1
CMU	solid	+	local systemic	+ +	-	2
Copper Naphthenate	liquid	++	local systemic	++ ++	500 ppm	2
Coumaphos	solid	+	local systemic	++ +++	-	2
Cresyldiphenyl Phosphate	liquid	++	local	++	-	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Crotonaldehyde	liquid	++	local systemic	++ ++	2 ppm/8h	2
Cumene	liquid	++	local systemic	++ +	50 ppm/8h	2
Cupric Acetate	solid	+	local systemic	+++ ++	0.1 mg/m^3/8h	2
Cupric Acetoarsenate	solid	+	local systemic	++ ++	0.1 mg/m^3/8h	2
Cupric Sulfate, Ammoniated	solid	+	local	++	2 mg/m^3/8h	2
Cyanogen	gas	+++	systemic local	+++ ++	10 ppm/8h	1
Cyanogen Bromide	solid	++	local systemic	+++ ++	0.5 ppm/8h	1
Cyanogen Chloride	gas	+++	local systemic	++ ++	.3 ppm/ .6 mg/m^3/8h	1
Cyclohexanol	liquid	+	local systemic	++ +	50 ppm/8h	2
Cyclohexanone	liquid	+	local systemic	++ +	25 ppm/8h	2
Cyclohexylamine	liquid	++	local systemic	++ ++	10 ppm/8h	2
Decaborane	solid	+	local systemic	++ ++	.05 ppm/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Decanal	liquid	++	local	++	-	
Diacetone Alcohol	liquid	++	local systemic	++ +	50 ppm/8h	2
Diamylamine	liquid	++	local systemic	++ ++	-	2
Diborane	gas	++	local systemic	++ ++	.1 ppm/8h	1
Dicamba	solid	+	local systemic	+ ++	-	2
Dichlobinil	solid	+	local systemic	+ +	-	2
Dichlone	solid	+	local	++	-	2
Dichlorodifluoromethane	gas	++	systemic	++	1,000 ppm/8h	2
Dichloroethyl Ether	liquid	++	local systemic	++ ++	5 ppm/8h	2
Dichloromethane	liquid	++	local systemic	++ ++	100 ppm/8h	2
Dichloropropane	liquid	++	local systemic	++ +	75 ppm/8h	2
Dichloropropene	liquid	++	local	++	1 ppm/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Dichloropropene Dichloropropane	liquid	++	local systemic	++ ++	-	2
Dichlorvos	liquid	++	systemic	++	.1 ppm/8h 1 mg/m³/8h	2
Dicyclopentadiene	liquid	++	local	+++	5 ppm/8h	2
Diethanolamine	solid	+	local	++	-	2
Diethylamine	liquid	++	local	++	10 ppm/8h	2
Diethylene Glycol	liquid	+	systemic	+	-	2
Diethylenetriamine	liquid	+	local	+++	1 ppm/8h	2
Diethyl Phthalate; Ethyl Formate	liquid	++	local	+	-	2
Dimethylamine	oily liquid	++	local	+++	10 ppm/8h 18 mg/m³/8h	2
N,N - dimethylaniline	oily liquid	+++	systemic local	++ +	5 ppm/8h 25 mg/m³/8h	2
Dimethylsulfate	liquid	++	local	+++	0.1 ppm/8h	2
Dioxane (p-dioxane)	liquid	++	local systemic	++ +	25 ppm/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Diphosgene	gas	++	local	+++	-	1
Diquat		++	local systemic	++ ++	0.5 mg/m^3/8h	2
Disulfotone	liquid	++	systemic	+++	.1 mg/m^3/8h	1
Diuron		++	local systemic	++ ++	-	2
DNBP		++	systemic	+++	-	2
DNBP-NH_4-salt		++	systemic	+++	-	2
1-Dodecanol	solid	+	local	+	-	2
Endosulfan	solid	++	systemic	+++	0.1 mg/m^3/8h	2
Endothal			local	++		
Epichlorohydrin	liquid	++	local systemic	+ ++	2 ppm/8h 10 mg/m^3/8h	2
Ethion	liquid	++	systemic	++	-	2
Ethyl Acetate	liquid	++	local	++	400 ppm/8h 1400 mg/m^3/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Ethyl Acrylate	liquid	++	local systemic	++ ++	5 ppm/8h 20 mg/m^3/8h	2
Ethyl Benzene	liquid	++	local systemic	++ ++	100 ppm/8h	2
Ethyl Chloride	liquid	++	local frostbite	++	1,000 ppm/8h	2
Ethylene	gas	++	local frostbite	++	-	2
Ethylene Cyanohydrin	liquid	++	systemic	+	-	2
Ethylene Dibromide	liquid	++	local systemic	++ ++	20 ppm/8h 50 ppm/5 min	2
Ethylene Dichloride	liquid	++	local systemic	++ ++	10 ppm/8h 40 mg/m^3/8h	2
Ethylene Glycol Diacetate	liquid	++	systemic	+	-	2
Ethylene Glycol Monoethyl Ether Acetate	liquid	++	systemic local	+ +	100 ppm/8h	2
Ethylene Glycol Monoethyl Ether	liquid	++	systemic	+	25 ppm/8h	2
Ethylene Oxide	liquid	+	local	+++	10 ppm/8h	2
Ethyl Ether	liquid	+	local	+++	400 ppm/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Ferbam	solid	+	local systemic	+ +	10 mg/m^3/8h	2
Ferric Hydroxide	solid	-	local	++	-	2
Ferric Nitrate	solid	-	local	++	1 mg/m^3/8h	2
Ferric Sulfate	solid	-	local	++	-	2
Ferrous Sulfate	solid	-	local	++	-	2
Ferrous Hydroxide	solid	-	local	++	-	2
Ferrous Sulfite	solid	-	local	++	-	2
Fish Oil	liquid	++	local allergen	+	-	2
Fluorine	gas	+++	local	+++	1 ppm/8h	1
Formaldehyde	liquid	++	local systemic	+++ ++	2 ppm/8h	2
Formic acid	liquid	++	local	+++	5 ppm/8h	2
Furfural	liquid	++	local	+++	2 ppm/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Gas oils	liquid	++	local	+	-	2
Glyoxal	liquid	+	local	+	-	2
Guthion	solid	++	systemic	++	-	2
Heptachlor	solid	+++	systemic local	++ +	.5 mg/m^3/8h	2
Heptane	liquid	++	local systemic	+ ++	400 ppm/8h	2
Heptanol	liquid	++	local systemic	+ ++	-	2
HETP	liquid	+++	systemic	+++	-	1
Hexaborane	liquid	++	local systemic	++ ++	-	2
Hexamethylenediamine	solid	++	local systemic	+++ ++	-	2
Hexane	liquid	++	local systemic	+ ++	500 ppm/8h	2
Hexanol	liquid	++	local	+++ ++	-	2
Hexylene Glycol	liquid	++	local systemic	++ +	25 ppm/8h 125 mg/m^3/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Hydrazine	liquid	++	local systemic	+++ ++	.1 ppm/8h	1
Hydrochloric Acid	liquid	++	local systemic	+++ +	5 ppm/8h	1
Hydrofluoric Acid	liquid	++	local systemic	+++ +	3 ppm/8h	1
^3H (Tritium) (Radioactive)	gas	+++	systemic	+++	-	1
Hydrogen Cyanide	gas	+++	systemic	+++	10 ppm/8h	1
Hydrogen Fluoride	gas	+++	local	+++	3 ppm/8h	1
Hydrogen Sulfide	gas	+++	systemic	+++	10 ppm/8h	1
Hydroquinone	solid	++	local systemic	++ ++	2 mg/m^3/8h	2
Hypochlorous Acid	liquid	++	local	+++	-	2
Indole	solid	++	local	+++	-	2
Iron Dust	solid	-	local	++	-	2
Isobutyl Alcohol	liquid	++	local systemic	+ ++	100 ppm/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Isobutyraldehyde	liquid	++	local systemic	+++ +	-	2
Isobutyric Acid	liquid	+	local systemic	+++ +	-	2
Isophorone	liquid	++	local systemic	++ ++	.5 ppm/8h	2
Isophthaloyl Chloride	solid	+	local systemic	++ +	-	2
Isopropyl Acetate	liquid	++	local systemic	+ +	250 ppm/8h	2
Isopropylamine	liquid	++	local systemic	++ ++	5 ppm/8h	2
Isopropyl Ether	liquid	++	local systemic	++ +	250 ppm/8h	2
Kepone	liquid	++	local systemic	+ ++	-	2
Krypton 85 (radioactive)	gas	+++	systemic	+++	-	1
Lead Arsenate	solid	+	local systemic	+ ++	.15mg/m^3/8h	2
Lead Fluoborate	solid	+	local systemic	++ ++	-	2
Lindane	solid	++	systemic	++	.5 mg/m^3/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Malathion	liquid	++	systemic	+++	10 mg/m^3/8h	2
MCP	liquid	++	local systemic	+++ ++	-	2
Mercaptodimethur			systemic	++	-	2
Mercuric Cyanide	solid	+	local systemic	++ +++	.01 mg/m^3/8h	2
Mercuric Nitrate	solid	+	local systemic	++ +++	.05 mg/m^3/8h	2
Methacrylonitrile	liquid	++	local systemic	+ ++	1 ppm/8h	2
Methyl Acrylate	liquid	++	local systemic	+++ ++	10 ppm/8h	2
Methyl Amyl Acetate	liquid	++	local systemic	+ ++	50 ppm/8h	2
Methyl Amyl Alcohol	liquid	++	local systemic	++ +	25 ppm/8h	2
Methyl Bromide	liquid or gas	+	local	+++	5 ppm/8h	1
Methyl Chloride	liquid	+	local	+++	50 ppm/8h	2
Methylene Chloride	liquid	++	local systemic	++ ++	100 ppm/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Methyl Ethyl Ketone	liquid	++	local systemic	+ ++	200 ppm/8h 590 mg/m³/8h	2
Methyl Isobutyl Ketone	liquid	++	local systemic	+ +	50 ppm/8h	2
Methyl Mercaptan	gas	+++	local systemic	++ ++	.5 ppm/8h	2
Methyl Methacrylate	liquid	++	local	+++	100 ppm/8h	2
Methyl Parathion	liquid	+++	systemic	+++	200 ug/m³	1
Mexacarbate	solid	++	local systemic	+ +++	-	2
Monochloroacetone	liquid	++	local systemic	++ ++	-	2
Monochlorodifluoromethane	liquid	++	local (frostbite) systemic	+++ ++	1,000 ppm/8h	2
Monoethylamine	gas	+++	local	+++	10 ppm/8h	1
Monoisopropanolamine	liquid	++	local	++	-	2
Monomethylamine	gas	+++	local	+++	10 ppm/8h	1
Morpholine	liquid	++	local systemic	++ ++	20 ppm/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Mustard Gas	gas	++	local	+++	-	1
m-xylene	liquid	++	local systemic	++ +	100 ppm/8h	2
m-xylyl Bromide	liquid	++	local systemic	++ ++	-	2
Naban	solid	++	local systemic	++ ++	-	2
Naled	liquid	++	local systemic	+ ++	3 mg/m^3/8h	2
n-amyl Acetate	liquid	++	local	++	100 ppm/8h	2
Naphthalene	solid	+	local systemic	++ ++	10 ppm/8h 50 mg/m^3/8h	2
Naphthenic Acid	solid	+	local	++	-	2
n-butyl Acetate	liquid	++	local	+	150 ppm/8h 710 mg/m^3/8h	2
n-butyl Acrylate	liquid	++	local	+++	-	2
n-butyl Alcohol	liquid	++	local systemic	++ +	50 ppm/8h	2
n-butyraldehyde	liquid	++	local	+++	-	2

TABLLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Nickel Ammonium Sulfate	solid	+	local	++	1 mg/m^3/8h	2
Nickel Carbonyl	liquid	++	local systemic	++ ++	.05 ppm/8h	2
Nitric Acid	liquid	+	local	+++	2 ppm/8h	1
Nitric Oxide	gas	++	local	+++	25 ppm/8h	1
Nitrilotriacetic Acid	solid	+	local	++	-	2
Nitrogen Dioxide	gas	++	local	++	3 ppm/8h	1
Nitrobenzene	liquid	++	local systemic	++ ++	1 ppm/8h 5 mg/m^3/8h	2
Nitrogen Chloride	liquid	++	local	++	-	2
Nitroglycerine	liquid	++	local systemic	++ ++	.05 mg/m^3/8h	2
Ozone	gas	+	local systemic	++ ++	.1 ppm/8h	2
Nitrous Oxide	gas	++	local	+++	25 ppm/8h	2
Nonane	liquid	++	local	++	-	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Nonyl Phenol	liquid	++	local	+++	-	2
n-propyl Alcohol	liquid	++	local systemic	+ +	200 ppm/8h	2
Onazone	solid	+	local systemic	++ ++	-	2
o-nitrophenol	solid	++	local systemic	+++ +	-	2
o-nitroaniline	solid	+	local systemic	+ +++	-	2
Oxydipropionitrile	liquid	++	systemic local	++ +	-	2
o-xylene	liquid	++	local systemic	+ +	100 ppm/8h	2
para-nitroaniline	solid	+	local systemic	++ ++	3 mg/m^3/8h	2
Pentanal	liquid	++	local systemic	++ +	-	2
Perchloromethyl mercaptan	liquid	+++	local systemic	++ ++	.1 ppm/8h	2
Phenolcarbylamine Chloride	liquid	++	local	++	-	2
Phenolmercuric Acetate	solid	+	local systemic	+ +++	-	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Phosgene	gas	+	local	+++	.1 ppm/8h	1
White Phosphorous (yellow)	solid	+	local systemic	+++ ++	-	1
Phosphorous Oxychloride	liquid	++	local systemic	+++ ++	-	2
Phosphorous Pentasulfide	solid	+	local systemic	+++ ++	1 mg/m^3/8h	2
Phosphorous Trichloride	liquid	++	local systemic	+++ ++	0.2 ppm/8h 1.5mg/m^3/8h	2
Phthalic-Acid-Diethyl-Ester	liquid	++	local	+	-	2
Phthalic Anhydride	solid	+	local systemic	++ +	1 ppm/8h	2
p-nitrophenol	solid	+	local systemic	++ ++	-	2
Potassium Arsenate	solid	+	local systemic	++ +++	.5 mg/m^3/8h	2
Potassium Arsenite	solid	+	local systemic	++ +++	-	2
Potassium Permanganate	solid	+	local	+++	-	2
Propane	gas	++	local frostbite	+++	1,000 ppm/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Propargite			systemic	++	-	2
Propionaldehyde	liquid	++	local	+++	-	2
Propionic Acid	liquid	++	local	++	10 ppm/8h	2
Propionic Anhydride	liquid	++	local	+++	-	2
Propyl Acetate	liquid	++	local	++	200 ppm/8h	2
Propylamine	liquid	++	local systemic	+++ ++	-	2
Propylene	gas	+++	local	+	4,000 ppm/8h	2
Propylene Oxide	liquid	++	local	++	100 ppm/8h	2
p-xylene	liquid	++	local systemic	++ +	100 ppm/8h	2
Pyrethrin I	liquid	++	local (allergen) systemic	+ +	-	2
Pyrethrin II	liquid	++	local (allergen) systemic	+ +	-	2
Pyrethrum	solid	+	local (allergen) systemic	++ ++	5 mg/m^3/8h	2

TABLE II-3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Pyridine	liquid	++	local systemic	++ +	5 ppm/8h	2
Pyrocatechol	solid	+	local systemic	++ +	1 ppm/8h	2
Quinhydrone	solid	+	local systemic	++ +	-	2
Quinine	solid	+	local systemic	+ +	-	2
Quinolene	liquid	++	local systemic	++ ++	-	2
Quinone	solid	+	local systemic	++ ++	.1 ppm/8h	2
Resorcinol	solid	+	local systemic	+++ ++	10 ppm/8h	2
Salicyaldehyde	liquid	++	local systemic	++ +	-	2
sec-Butylamine	liquid	+	local systemic	+++ ++	15 mg/m^3/8h	2
Selenium	solid	+	local systemic	++ ++	-	2
Selenium 75 (Radioactive)	solid	+	local systemic	++ +++	-	2
Sesone	solid	+	local systemic	++	-	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Silver Nitrate	solid	+	local systemic	++ ++	-	2
Simazine	liquid	++	local systemic	+ +	-	2
Sodium Anthraquinone Sulfonate	solid	+	local	++	-	2
Sodium Arsenate	solid	+	local systemic	++ +++	.5 mg/m^3/8h	2
Sodium Arsenite	solid	+	local systemic	++ +++	.5 mg/m^3/8h	2
Sodium Bisulfite	solid	+	local	++	-	2
Sodium Borate	solid	+	local systemic	++ +	-	2
Sodium Butyldiphenyl Sulfonate	liquid	++	local	++	-	2
Sodium Decylbenzene Sulfonate		+	local systemic	+ ++	-	2
Sodium Fluoride	solid	+	local	++ +++	2.5 mg/m^3/8h	2
Sodium Fluorosilicate	solid	+	local	++	2.5 mg/m^3/8h	2
Sodium Hydrosulfite	liquid	++	local	+++	-	2

TABLE II.5 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Sodium Hypochlorite	liquid	++	local	+++	-	2
Sodium Lauryl Sulfate	solid	+	local	++	-	2
Sodium Methylate	solid	+	local	++	-	2
Sodium Naphthalene Sulfate		+	local systemic	+ ++	-	2
Sodium Nitrite	solid	+	local systemic	++ ++	-	2
Sodium Octylsulfate	solid	+	local	+	-	2
Sodium Selenite	solid	+	local systemic	++ ++	.2 mg/m^3/8h	2
Strychnine	solid	+	local systemic	++ +++	.15 mg/m^3/8h .45 mg/m^3/15 min	2
Styrene	liquid	++	local systemic	++ ++	50 ppm/8h 215 mg/m^3/8h	2 2
Sulfoxide	solid	+	local	+	-	2
Sulfur	solid	+	local	++	-	2
Sulfur Dioxide	gas	+++	local	+++	2 ppm/8h	1

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Sulfuric Acid	liquid	++	local	+++	1 mg/m^3/8h	1
Sulfur Monochloride	liquid	++	local	+++	1 ppm/8h	2
TBA	solid	+	local systemic	+ ++	-	2
T-Butylhydroperoxide	liquid	+	local systemic	+ ++	-	2
TCA	solid	+	local systemic	++ ++	-	2
TDE	solid	++	systemic	+	-	2
Tert-butylamide	solid	+	local systemic	+ +	-	2
Tetraborane	liquid	++	local systemic	+++ +++	-	2
Tetradecanol	solid	+	local systemic	+ +	-	2
Tetraethylene Pentamine	liquid	+	local systemic	++ ++	-	2
Tetraethyl Pyrophosphate	liquid	++	local systemic	+ +++	-	2
Thallium	solid	+	systemic	+++	0.1 mg/m^3/8h	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Thallous Nitrate	solid	+	systemic	+++	0.1 mg/m^3/8h	2
Thiophosgene	liquid	+	local	+++	-	2
Thiram	solid	++	local systemic	++ ++	5 mg/m^3/8h	2
Titanium 44	solid	+	local	+	-	2
Titanium Chloride	solid	+	local	++	-	2
Toluene	liquid	+	local systemic	+ +	100 ppm/8h 375 mg/m^3/8h	2
Toluene diisocyanate	liquid	+	local systemic	++ ++	.005 ppm/8h .04 mg/m^3/8h	2
Toxaphene	solid	++	local systemic	+ ++	.5 mg/m^3/8h	2
Trichlorfon	solid	++	systemic	++	-	2
Trichloroethane	liquid	++	local systemic	++ ++	10 ppm/8h 45 mg/m^3/8h	2
Tricresyl Phosphate	liquid	++	local systemic	+ ++	-	2
Triethylaluminum	liquid	+	local	+++	-	1

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Triethylene Glycol	liquid	++	local systemic	+ ++	-	2
Triethylenetetramine	liquid	++	local	+++	-	2
Trimethylamine Gas	gas	++	local	+++	10 ppm/8h	1
Trimethylamine Solution	liquid	++	local	+++	10 ppm/8h	2
Trinitrotoluene	solid	++	local systemic	++ +	0.5 mg/m³/8h	2
Uranyl Nitrate	solid	+	local systemic	++ ++	.25 mg/m³/8h	2
Vanadium Oxytrichloride	liquid	++	local systemic	+++ ++	5 ppm/15 min	2
Vapam	liquid	++	local systemic	++ +	-	2
Vinyl Acetate	liquid	++	local	++	10 ppm/8h 30 mg/m³/8h	2
Vinyl Bromide	gas	+++	local systemic	+++ +++	5 ppm/8h	1
Vinyl Chloride	gas	+++	local systemic	+++ +++	5 ppm/8h	1
Vinyl Ether	liquid	++	local systemic	++ ++	-	2

TABLE II.3 (CONTINUED)

DERMAL TOXICITY

Chemical	Physical State	Skin Penetration	Dermal Toxicity	Potency	Permissible Concentration	Category
Xenon 133 (radioactive)	gas	+++	systemic	+++	-	1
Zinc Borate	solid	+	local	++	10 mg/m³/8h	2
Zinc Chloride	solid	+	local	++	1 mg/m³/8h	2
Zinc Cyanide	solid	+	local systemic	+ +++	-	1
Zinc Hydrosulfite	solid	+	local	+++	-	2
Zinc Phenolsulfonate	solid	+	local	+++	-	2
Zinc Phosphide	solid	+	local systemic	++ ++	-	2

Appendix III
Decontamination Procedures

A. Introduction

1. The full decontamination procedures outlined in this appendix are based on worst-case gross contamination levels for entry team members. These procedures may need to be modified based on actual levels of contamination.

2. Figures III.1 to III.3 show the layout of worst-case decon lines for Levels A, B, and C. The following sections describe the procedures and equipment requirements for each station in the line.

3. Figure III.5 provides a drawing and parts list for a field decon shower designed by the Strike Teams for use during decon activities. It is useful for rinsing of personnel during decon procedures at Stations 3 and 8 described below.

B. Decontamination Stations

1. Station 1: Segregated Equipment Drop

   a. Deposit equipment used on scene (tools, monitoring instruments, etc.) on plastic drop cloths or in separate containers with plastic liners. Since each item may be contaminated to a different degree, segregation at the drop reduces the possibility of cross-contamination.

   b. Equipment: Various size containers
      Plastic liners
      Plastic drop cloths

2. Station 2: Boot Cover and Glove Wash

   a. Scrub outer boot covers and gloves with detergent/water or decon solution.

   b. Equipment: Container (20-30 gallons)
      Appropriate decon solution
      2-3 long-handle, soft-bristle scrub brush

3. Station 3: Boot Cover and Glove Rinse

   a. Rinse off decon solution from Station 2 using copious amounts of water. Repeat as many times as necessary.

   b. Equipment: Container (30-50 gallons)
      or
      High-pressure spray unit
      Water
      2-3 long-handle, soft-bristle scrub brush

4. Station 4: Tape Removal

   a. Remove tape around boots and gloves and deposit in container with plastic liner.

   b. Equipment: Container (20-30 gallons)
      Plastic liners

5. Station 5: Boot Cover Removal

   a. Remove boot covers and deposit in container with plastic liner.

   b. Equipment: Container (20-30 gallons)
      Plastic liners
      Bench or stool

6. Station 6: Outer Glove Removal

   a. Remove outer gloves and deposit in container with plastic liner.

   b. Equipment: Container (20-30 gallons)
      Plastic liners

7. Station 7: Suit/Safety Boot Wash

   a. Thoroughly wash protective clothing and boots. Scrub suit and boots with long-handle, soft-bristle scrub brush and copious amounts of the appropriate decon solution. If Level B protection, wrap SCBA regulator (belt-type) with plastic to keep out water. Repeat as many times as necessary.

   b. Equipment: Container (30-50 gallons)
      Decon solution
      2-3 long-handle, soft-bristle scrub brushes
      Small buckets
      Sponges or cloths

8. Station 8: Suit/Safety Boot Rinse

   a. Rinse off decon solution using copious amounts of water. Repeat as many times as necessary.

   b. Equipment: Container (30-50 gallons)
      or
      High-pressure spray unit
      Water
      2-3 long-handle, soft-bristle scrub brushes

9. Station 9: Tank or Canister Change

   a. If the worker leaves the contaminated area to change out an air tank or respirator canister, this is the last step in the decon procedure. The workers air tank or canister is exchanged, new outer gloves and boot covers donned, and joints taped. The worker then returns to the contaminated area.

   b. Equipment: Air tanks/ respirator canisters
      Tape
      Boot covers
      Gloves

10. Station 10: Safety Boot Removal

   a. Remove safety boots and deposit in container with plastic liner.

   b. Equipment: Container (30-50 gallons)
      Plastic liners
      Bench or stool
      Boot jack

11. Station 11: Removal of Protective Clothing Garment (Note: Station 11 and 12 reversed for Level B)

   a. With assistance of decon team, remove the protective clothing garment (encapsulated suit, splash gear). Hang clothing or place in container for disposal as appropriate.

   b. Equipment: Rack
      Drop cloths
      Bench or stool
      Container (30-50 gallons)
      Plastic liners

12. Station 12: SCBA Backpack Removal (Note: Station 11 and 12 reversed for Level B)

   a. While still wearing facepiece, remove backpack and place on table. Disconnect hose from regulator valve and proceed to next station.

   b. Equipment: Table

13. Station 13: Inner Glove Wash

   a. Wash with appropriate decon solution that will not harm skin. Repeat as many times as necessary.

   b. Equipment: Basin or bucket
      Decon solution
      Small table

14. Station 14: Inner Glove Rinse

a. Rinse with water. Repeat as many times as necessary.

b. Equipment: Water
Basin or bucket
Small table

15. Station 15: Facepiece Removal

a. Remove facepiece. Deposit in container with plastic liner. Avoid touching face with gloves.

b. Equipment: Containers (30-50 gallons)
Plastic liners

16. Station 16: Inner Glove Removal

a. Remove inner gloves and deposit in containers with plastic liner.

b. Equipment: Container (30-50 gallons)
Plastic liners

17. Station 17: Inner Clothing Removal

a. Remove clothing soaked with perspiration. Place in container with plastic liner. Inner clothing should not be worn out of the decon area since some contaminants may have been transferred while removing the outer protective garment.

b. Equipment: Container (30-50 gallons)
Plastic liners

18. Station 18: Field Wash

a. If practicable, a field shower should be taken before leaving the decon area. If a shower is unavailable, thoroughly wash face and hands.

b. Equipment: Field shower
Small table
Basin or bucket
Towels

19. Station 19: Redress

a. Put on clean clothing. A dressing trailer or tent is appropriate for inclement weather.

b. Equipment: Tables
Chairs
Tent or trailer

C. Decontamination Matrix

1. The matrix shown in Figure III.4 depicts the decontamination stations required for four alternative decon situations.

Figure III.1

Level A Decontamination

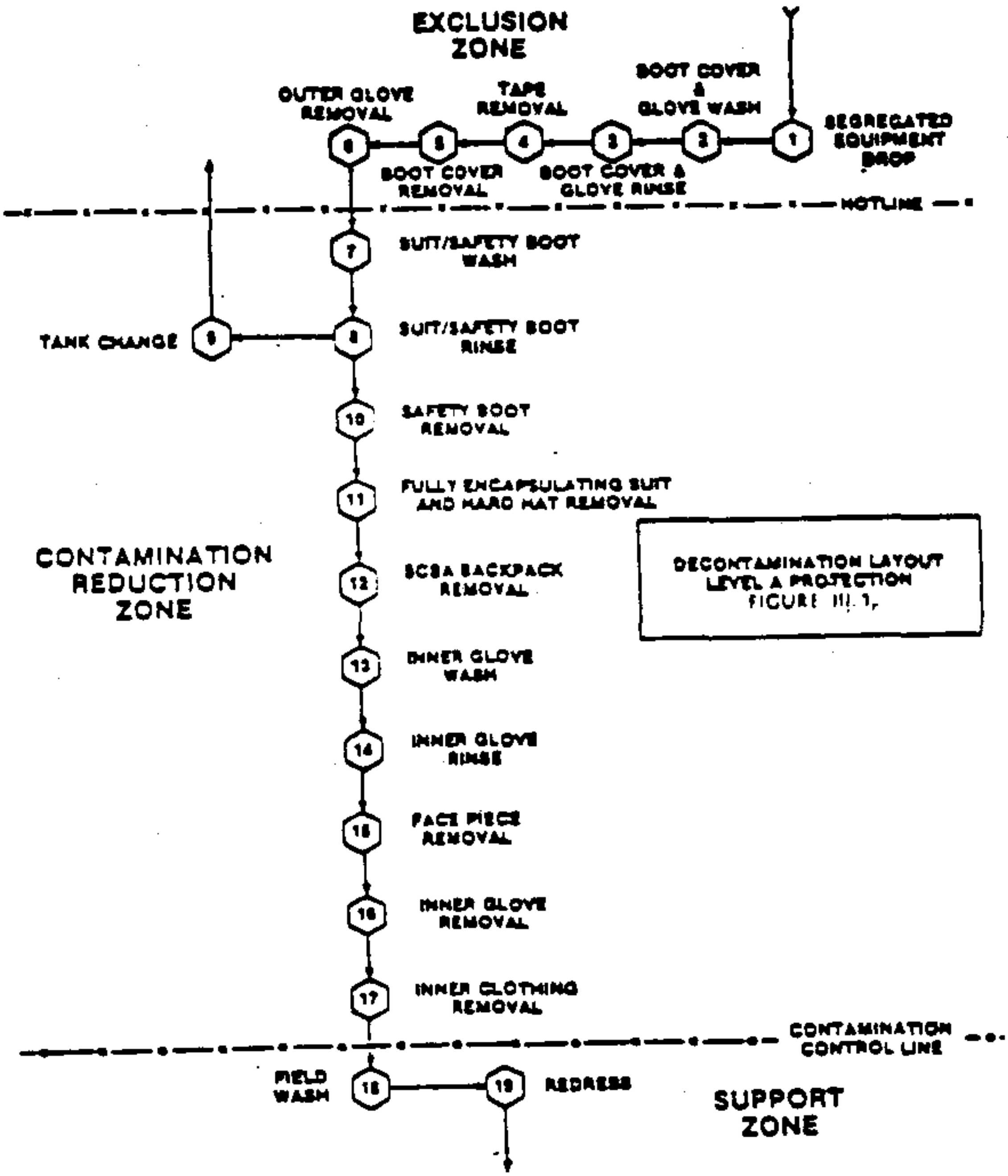


Figure III.2

Level B Decontamination

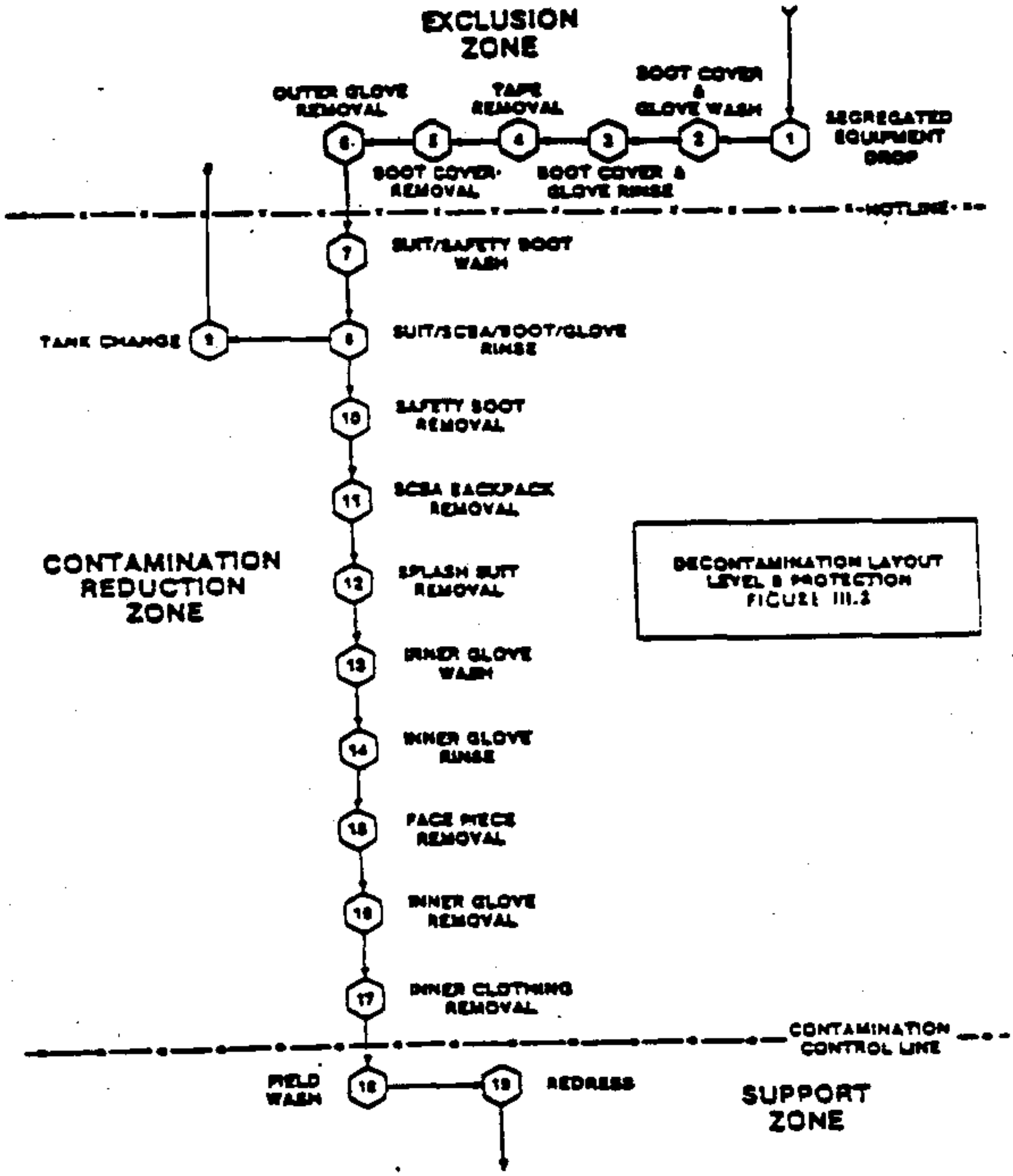


Figure III.3

Level C Decontamination

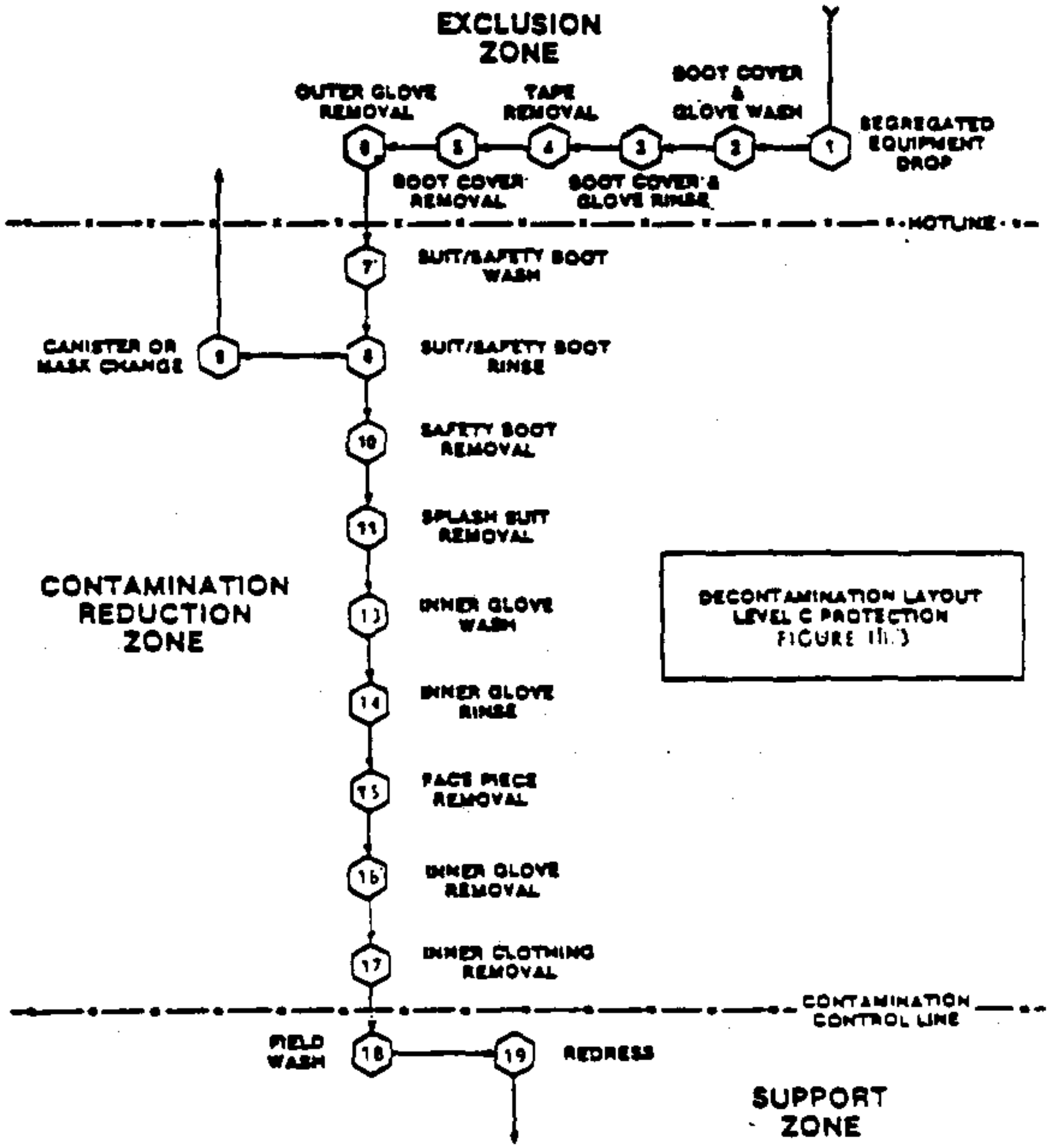


Figure III.4
Decontamination Station Matrix

STATION NUMBER

SIT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X	X	X	X										
3	X						X	X		X	X	X			X	X	X	X	
4	X						X	X	X										

Situation 1: The individual entering the Contamination Reduction Corridor(CRC) is observed to be grossly contaminated or extremely toxic substances are known or suspected to be present.

Situation 2: Same as situation 1 except individual needs new air tank/canister and will return to contaminated area.

Situation 3: Individual entering the CRC is expected to be minimally contaminated. Extremely toxic or skin-corrosive chemicals are not present. No outer gloves or boots are worn. Inner gloves are not contaminated.

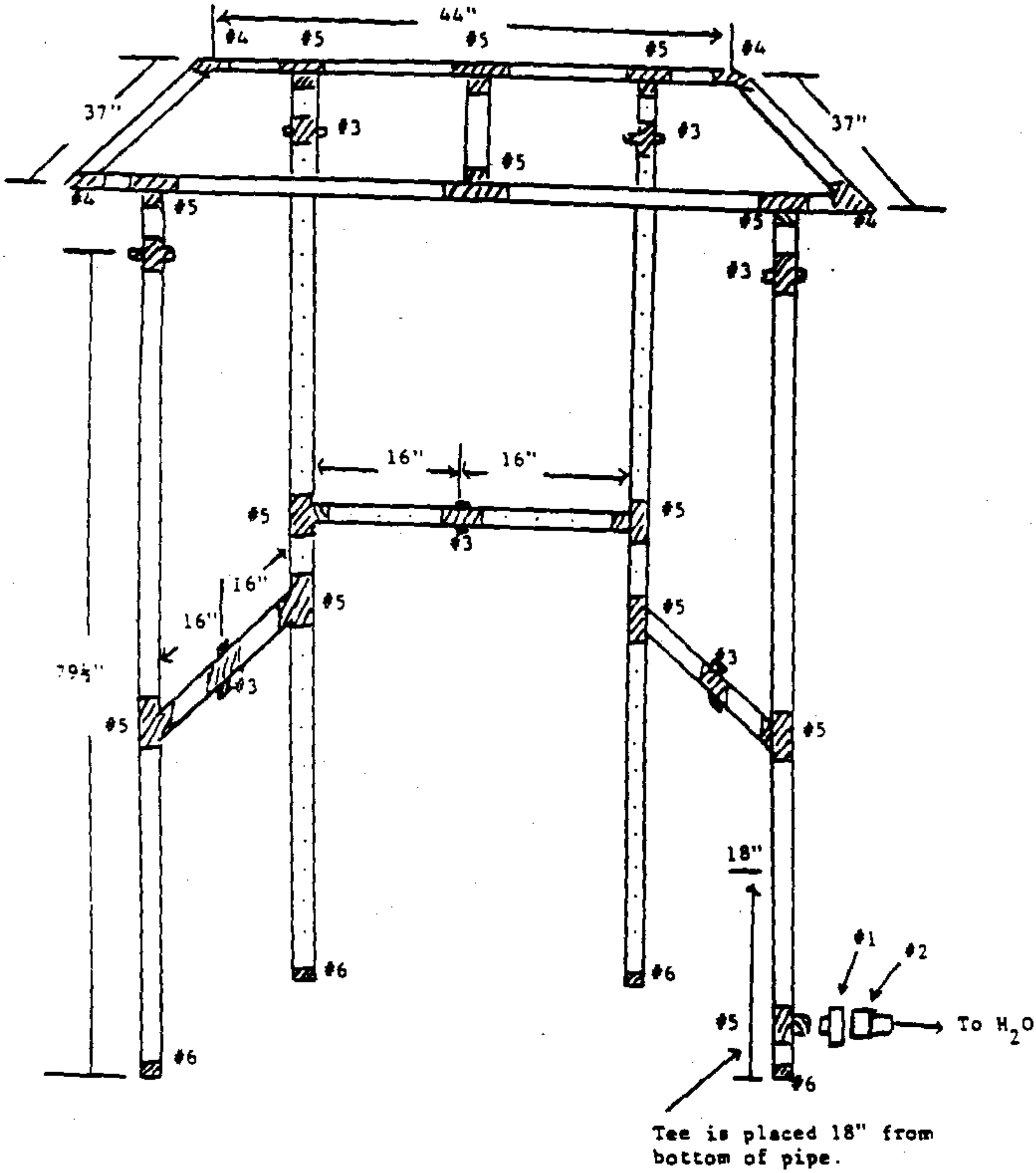
Situation 4: Same as situation 3 except individual needs new air tank/canister and will return to contaminated area.

Figure III.5

NSF DECONTAMINATION SHOWER

MATERIALS NEEDED:	Quantity Required	Part Number
1 1/4" SCHEDULE 40 PVC PIPE	60 ft.	
1 1/4" PVC UNIONS	7	#3
1 1/4" PVC 90 DEGREE ELBOWS	4	#4
1 1/4" PVC TEES	13	#5
1 1/4" PVC CAPS	4	#6
1 1/2" X 1 1/4" PVC REDUCER	1	#3
1 1/2" MALE ADAPTOR (PVC TO PIPE THREAD)	1	#2
1 1/2" ADAPTOR (PIPE THREAD TO LOCAL FIRE HOSE THREAD	1	(Not shown)
PVC CEMENT	1 Quart	
PVC CLEARER	1 Quart	

After assembly, drill 1/8" holes at random directly towards center of shower. Holes should be drilled in all pieces of pipe to ensure full coverage. The holes drilled in the top portion of the shower will have to be angled downward.



NSF DECONTAMINATION SHOWER
Figure III.5

APPENDIX IV

Guidelines for the Selection of Chemical Protective Clothing

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J.O. Jackson, Los Alamos National Laboratory
D.J. Weitzman, U.S. Environmental Protection Agency

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Cambridge, MA 02140
Sponsor: U.S. Environmental Protection Agency
Prime Contractor: Los Alamos National Laboratory

DISCLAIMER

Arthur D. Little, Inc., prepared this document with what it believes is the best currently available information. The document is subject to revision as additional knowledge and experience are gained. Arthur D. Little cannot guarantee the accuracy of information used to develop the chemical protective clothing recommendations contained herein, and the mention of company names or products does not constitute endorsement by Arthur D. Little. Arthur D. Little accepts no responsibility for damages or liabilities of any kind which may be claimed to result from the use of this document.

ACKNOWLEDGEMENTS

This *Guidelines for the Selection of Chemical Protective Clothing* was prepared by Arthur D. Little, Inc., under subcontract to Los Alamos National Laboratory for the U.S. Environmental Protection Agency. The authors are grateful to those who reviewed this document during its preparation. These include R.C. Magor, R.F. Kent, A. Smith, M.D. Royer, A.P. Nielsen, B.E. Benson, L. Walz, W.K. Keffer and R.D. Turpin of the EPA. In addition, the comments of H.J. Ettinger, R.W. Weeks, and J.T. Stampfer of Los Alamos and S.P. Berardinelli of NIOSH were particularly constructive.

The authors also acknowledge the contributions of the Arthur D. Little project team which included William Hawes, whose programming skills greatly facilitated the information organization task, M. Rourke and D. Ryan, who assisted us in gathering the information, and R.S. Stricoff and E.R. Hoyle, who reviewed the drafts. Finally we thank the typists and report production specialists who assembled the document.

SPECIAL NOTE TO USERS

This document contains comprehensive tables of recommendations to aid and facilitate the selection of chemical protective clothing (CPC). The recommendations are based on an extensive compilation and analysis of CPC vendors' literature and experimental test data published in technical journals and reports. It is imperative that users of the recommendation tables familiarize themselves with the background information that precedes and accompanies the tables. The selection of CPC must take into account the potential hazard and the conditions of use — neither is considered in this document. The recommendations are *not* nor do they imply a guarantee of safety.

Although every effort has been made to prepare this document as accurately as possible, errors can and do occur. EPA users of this document are asked to notify the Office of Occupational Health and Safety, Room 3503 Waterside Mall, (202-382-3647) of errors so that they can be corrected.

TABLE OF CONTENTS

VOLUME I

TABLE OF CONTENTS (Continued)

CHAPTER 1

OVERVIEW

A. INTRODUCTION

Skin is an organ of the human body and has a surface area of about 1.7 m^2. A principal function of skin is to protect our internal organs from exposure to potentially harmful components of the external environment. Direct contact with many chemicals can pose a significant challenge to the skin; possible reactions are:

- The skin will act as an effective barrier and there will be no detrimental effect due to the contact.
- The skin will suffer a primary irritation such as a burn, chafing due to extraction of essential oils, or dermatitis.
- The skin will become sensitized to the chemical. Once sensitized, the skin will react to quantities of chemicals much smaller than otherwise would have any effect. Some chemicals are both primary irritants and sensitizers.
- The skin will be penetrated by the chemical and the chemical and/or its metabolites will enter the blood stream. This may or may not have a health effect, depending on the chemical and the amount of exposure.

The latter type of reaction, which would include, for example, irreparable liver damage and cancer, receives a high level of attention from both the lay and the technical communities. And, of course, such debilities warrant serious consideration. However, it is also important to recognize that primary skin irritations and sensitizations account for significantly greater numbers of lost time incidents. It is estimated that skin diseases account for two-thirds of all identified job-related diseases. Furthermore, seven out of ten industrial claims paid by insurance companies are for temporary disability resulting from dermatitis.

B. CHEMICAL PROTECTIVE CLOTHING

Along with engineering controls and carefully planned work procedures, chemical protective clothing (CPC) is a key element in minimizing the potential for worker exposure to chemicals. In the context of this document, chemical protective clothing includes all items of clothing primarily intended to prevent chemical contact with the skin. These include gloves, coveralls, pants, jackets, and boots. Respirators are not included in this classification.

C. OBJECTIVE OF THE GUIDELINES

CPC in one form or another is commercially available from hundreds of vendors in the United States. Furthermore, the clothing is fabricated from a wide variety of plastic and rubber materials. In addition, the effectiveness of a particular item of clothing is highly dependent on the chemical with which it may be challenged. For example, a neoprene glove provides excellent protection from sulfuric acid but it is rapidly permeated by toluene. Finally, the conditions under which the clothing is used can affect performance. These factors combine to create a perplexing situation for those who are involved in or responsible for the protection of workers who handle chemicals – for example, at a hazardous waste site.

In recognition of this problem, the EPA's Office of Occupational Health and Safety has developed this *Guidelines for the Selection of Chemical Protective Clothing*. The objective of the Guidelines is that it be a concise, up-to-date source of information pertinent to the selection of clothing for protection from chemicals.

D. AUDIENCE AND ORGANIZATION OF GUIDELINES

The Guidelines is principally directed towards:

- Field safety personnel who are more typically faced with an immediate need to provide the best clothing for workers on a day-to-day basis, and

- Planners and researchers who, for example, have the responsibility for developing the safety plan for a particular project. These personnel may have the time to investigate peculiarities in clothing performance or to prescribe clothing testing in anticipation of particular needs.

In order to satisfy such diverse requirements, the Guidelines is divided into two volumes. Volume I is intended to be useful as a "field manual." It contains a discussion of the basic concepts of permeation and chemical resistance, an overview of CPC vendor literature, an analysis of test methods for CPC and, probably most importantly, so-called Users' Matrices for the selection of protective clothing. The matrices present clothing recommendations for fourteen major clothing materials and cover approximately 300 chemicals. The appendices include an extensive listing of CPC sources organized by product type and principal chemical barrier material. The appendices also include a glossary of CPC terms.

Volume I brings virtually all CPC performance information to one location, and provides the basic information required to select, order and intelligently use CPC. The sources are identified in the Bibliography of Volume II.

Volume II is more technical in content. It contains a more detailed discussion of permeation theory, CPC testing methods and CPC vendors' literature. Volume II also includes recommendations for actions that would benefit the CPC selection and use processes. In one sense, Volume II could be considered a supporting document for Volume I. In another, Volume II serves as the starting point for further investigation of CPC.

Together the two volumes represent the most comprehensive compilation of chemical protective clothing performance and use information available to the public. We urge the use of the Guidelines as an important means for maintaining the well-being of workers who may be exposed to potentially harmful chemicals. We, furthermore, urge all EPA users of the Guidelines to participate in its continued improvement by sending comments and criticisms to:

U.S. Environmental Protection Agency
Office of Occupational Health and Safety (PM-273)
Room 3503 Waterside Mall
401 M Street, S.W.
Washington, DC 20460
Attention: Mr. David Weitzman
Industrial Hygiene Program Manager

CHAPTER 2

CHEMICAL PROTECTIVE CLOTHING LIMITATIONS

The use of chemical protective clothing is but one component of the overall program for maintaining the health and safety of workers. It complements (and is not a substitute for) good planning, work practices. engineering and administrative controls, or personal hygiene. Several factors which should be considered in the specification and selection of CPC are discussed in the following paragraphs.

A. CHEMICAL RESISTANCE

The performance of CPC as a barrier to chemicals is determined by the materials and quality of its construction. Chemical protective clothing is based on plastic and elastomeric materials. Typically each chemical interacts with a given plastic or elastomer in a relatively unique manner. That is, each chemical/material pair has peculiar interactions. The situation becomes even more complex when multi-component solutions are involved. Three important factors to bear in mind when considering CPC are:

- In general, there is no such thing as "impermeable" plastic or rubber clothing.
- No one clothing material will be a barrier to all chemicals.
- For certain chemicals or combinations of chemicals there is no commercially available glove or clothing that will provide more than an hour's protection following contact. In these cases, it is recommended that clothing be changed as soon as it is safely possible after any contact with the chemical or chemical mixture.

B. DESIGN AND CONSTRUCTION

Design and construction factors that can influence performance are as follows:

- Stitched seams of clothing may be highly penetrable by chemicals if not overlayed with tape or sealed with a coating.

- Lot-to-lot variations do occur and may have a significant effect on the barrier effectiveness of the CPC. They may go undetected due to quality control procedures insensitive to chemical resistance issues.

- Pinholes may exist in elastomeric or plastic products due to deficiencies or poor quality control in the formulation or in the manufacturing processes.

- Thickness may vary from point to point on the clothing item. Depending on the manufacturing process, the finger crotch area of glove is particularly susceptible to thin coverage.

- Garment closures differ significantly from manufacturer-to-manufacturer and within one manufacturer's product line. Attention should be paid to button and zipper areas, and the number of fabric overlaps in these areas.

Gloves are typically produced by one of two principal processes — latex-dipping and solvent (cement) dipping. Latex gloves predominate the market. Researchers have speculated, however, that the chemical resistance of a solvent dipped glove may be greater than that of a latex dipped glove of the same generic material. The principal reason being that the solvent dipped glove is produced by multiple dip process while the latex process is a single dip operation. In a multiple dip process, imperfections in any one layer are covered by subsequent layers. Since the solvent dip process is more involved, its products are generally more expensive. Consequently, the manufacturers of such gloves typically highlight the fact the gloves are solvent dipped in justifying the cost.

C. APPLICATION

The degree of protection provided by an item of clothing is also a function of the application. For example, a less durable piece of clothing may be more than adequate for a moderate duration, mild activity (e.g., sampling) whereas it would not endure more than five minutes of a vigorous, waste site clean-up activity. Factors such as abrasion, puncture and tear resistance and reaction to perspiration and crumpling should be considered. Temperature and to some extent humidity have significant influences on the performance of elastomeric and plastic CPC. Also with regard to application it is important to recognize that protective clothing can be cumbersome and restrictive and thereby hasten the onset of worker fatigue. A result is that the period of safe and effective worker activity may be reduced.

D. REUSE

Protective clothing decontamination and reuse are controversial and unresolved issues at this time. Often, surface contamination can be removed by scrubbing with soap and water. In other cases, especially with highly viscous liquids, surface decontamination may be practically impossible and the CPC should be discarded. A more subtle problem arises with regard to the detection and removal of a chemical that has been absorbed into the elastomer or plastic. Once absorbed, some of this chemical will continue to diffuse through the material towards the inside surface even after the surface has been decontaminated. For highly resistant clothing the amount of chemical reaching the inside may be insignificant. However, for moderately performing materials significant amounts of chemical may reach the inside. This may not occur during the work shift but can take place while, for example, a glove is stored overnight. The next morning when the worker dons the glove, he may be putting his skin into direct contact with a hazardous chemical. In addition to chemical resistance, which is a function of temperature, both duration and the surface area exposed affect the amount of chemical that may reach the inside surface. Reuse decisions must consider these factors as well as the toxicity of the involved chemical(s). In fact, unless extreme care is taken to ensure decontamination, the reuse of CPC which has been contacted with highly toxic chemicals is not advisable. In summary, the decision to reuse CPC must take into account previous uses; unfortunately there is little or no documented experience for guidance in this task.

E. SUBSTITUTION OF CPC

Particular caution is required when substituting clothing from one manufacturer for that of another manufacturer. Clothing performance is determined by the type of plastic or elastomer, the specific formulation of that plastic or elastomer, and the clothing manufacturing process. For example, materials classified generically as nitrile rubber can differ significantly in composition and therefore chemical resistance. Testing is the only means for identifying the superior products for a particular application.

F. COST

Cost is an important consideration in the selection and utilization of clothing, especially where clothing is likely to be damaged (e.g., tear, puncture, etc.). In some cases it may be more cost-effective to adopt the practice of using multiple changes of less expensive but relatively poorer performing clothing than to attempt to extend the use of better performing, but more expensive clothing.

CHAPTER 3

PERMEATION THEORY

A. INTRODUCTION

This manual addresses the problem of selecting the most appropriate CPC for situations where human exposure to potentially hazardous chemicals is possible. An important concern in such situations is the effectiveness of the CPC as a barrier to the chemicals. Barrier properties may be estimated by simple-immersion tests wherein the CPC or a portion thereof is exposed to the chemical(s) of concern, and the material examined for obvious signs of degradation, swelling, or weight changes. This has been the traditional method for generating the chemical resistance tables which are included in many CPC brochures. It is important to note, however, that permeation may occur with little or no visible or physical effect on clothing materials.

The barrier effectiveness of CPC can be measured by permeation testing. Recently, there has been increasing emphasis placed on the importance of permeation testing of CPC, and a standard method has been promulgated by ASTM Committee F-23.

An overview of permeation theory and associated concepts is presented in this chapter. For more detailed discussion, please refer to Chapter 2 of Volume II of the Guidelines.

B. PERMEATION THEORY CONCEPTS

Permeation of a liquid or vapor through a rubber or plastic material is a three-step process involving:

- the sorption of the chemical at the outside surface of the CPC
- the diffusion of the chemical through the CPC material, and
- the desorption of the chemical from the inside surface (i.e., towards the wearer) of the CPC.

Of principal importance in selecting CPC for protection from chemicals is the rate at which chemicals permeate the clothing materials and the time elapsed between the contact with the chemical and the appearance of the chemical on the inside of the CPC (i.e., breakthrough time).

1. Permeation Rate

Classical permeation theory (Fick's Law) states that the chemical permeation rate through a material is a function of the:

- diffusion coefficient of the permeating chemical in the material (this is a property of the chemical material pair),
- the difference in chemical concentrations between the inside and outside surfaces of the material,
- the thickness of the material, and
- the area of the material contacted with chemical.

Permeation rate is often expressed in terms of the amount of a chemical which passed through a given area of clothing per unit time. (Common units are milligrams per square meter per hour.) Thus, obviously, the total amount of chemical permeating an article of clothing increases as the area exposed to the chemical is increased and also as the duration of exposure is lengthened. For a given material/chemical pair, the permeation rate decreases as the material thickness is increased. The concentration gradient mentioned above pertains to concentrations in clothing material itself. Thus, if no chemical is absorbed by the CPC, then permeation will not occur. This is discussed further in Paragraph C.3. below.

2. Breakthrough Time

Breakthrough time is defined as the elapsed time from initial contact of the outside surface of the CPC with chemical to the first detection of chemical on the inside surface. In some cases (e.g., when handling suspect carcinogens), breakthrough time may be the single most important criterion for CPC selection. Measured breakthrough times are readily determined by permeation testing, and are dependent on the sensitivity of the analytical method used in the test.

C. INFLUENCING FACTORS

1. Temperature

Most CPC permeation data and other chemical resistance information were generated at 20-25°C. Permeation rates increase and breakthrough times decrease with increasing temperatures. The extent of the reduction in barrier performance with increasing temperature is dependent on the chemical/material pair.

2. CPC Thickness

For a given chemical/clothing material pair:

- Permeation is inversely proportional to thickness. Thus, doubling the thickness will theoretically halve the permeation rate.
- Breakthrough time is directly proportional to the square of the thickness. Thus, doubling the thickness will theoretically quadruple the breakthrough time.

3. Solubility Effect

Permeation rate is a direct function of the solubility of the chemical in the CPC material. Solubility is the amount of chemical that can be absorbed by a given amount of CPC material (i.e., grams liquid per gram material); absorption may be accompanied by swelling. In general, chemicals having high solubilities will rapidly permeate the CPC material in question. Thus, simple immersion testing to determine solubility is an expedient means for preliminary evaluation of candidate CPC items. (See Volume II for further discussion of solubility and permeation.)

Caution in interpreting solubility data is required, however, since low solubilities do not necessarily correspond to low permeation rates. It is important to remember that permeation rate is a function of both solubility and diffusion coefficient. Gases, for example, have low solubilities but high diffusion coefficients, and may permeate CPC materials at rates several times greater than a liquid with moderate to high solubility in the material.

4. Multi-component Liquids

Multi-component liquids represent a difficult problem relative to the selection of the most appropriate CPC. Rarely is there any prior CPC experience with the particular solution of concern, and oftentimes the components of the solution are not known. Furthermore, mixtures of chemicals can be significantly more aggressive towards plastics and rubbers than any one of the components alone. Finally, the presence of a small fraction of a rapidly permeating component may provide a pathway that accelerates the permeation of a chemical that would permeate at a slower rate if in pure form.

At the present time, researchers are attempting to develop correlations for the prediction of multi-component permeation. But this work is in its early stages. In the meantime, immersion and permeation testing are recommended as the best means selecting CPC for multi-component solutions.

5. Persistent Permeation

Once a chemical has begun to diffuse into a plastic/rubber material, it will continue to diffuse even after the chemical on the outside surface is removed. This is because a concentration gradient has been established within the material, and there is a natural tendency for the chemical to move towards areas of lower concentration. This phenomenon has significant implications relative to the reuse of CPC. For example, a possible field scenario is:

- chemical contacts and absorbs into a glove,
- a breakthrough does not occur during the workday since the glove has low permeability to the chemical,
- prior to removal, the glove is washed to remove surface chemical, but
- the next morning some fraction of the absorbed chemical has reached the inside surface of the glove due to continued diffusion.

Of course, similar scenarios could occur over both shorter and longer time frames; for example, morning-to-afternoon or over a weekend. The user must take this possibility into account when reuse is considered. Factors influencing persistent permeation were discussed in Chapter 2, Part D.

CHAPTER 5

CPC USE PROCEDURES

A. PURCHASE

Protective clothing is purchased either directly from the manufacturer or through a CPC distributor. Listings of these organizations may be found in, for example, the Thomas Register or Best's Safety Directory. A fairly extensive listing is provided as Appendices C and D. The larger distributors carry several manufacturers' products and a wide variety of products. Virtually every manufacturer has a catalogue of its products which describes each product in detail as to the sizes available, thickness of the rubber or plastic barrier, and the materials of construction. Many of the catalogues also contain chemical resistance ratings charts for the products. The reliability of the ratings varies from vendor to vendor. Some ratings are based on extensive testing, while most would appear to have minimal supporting evidence. Further comments on CPC vendors' literature is presented in Chapter 6.

In making CPC purchase decisions important considerations are:

- the application to which the clothing will be put.
- the recommendations presented in Chapter 7.
- past experience with the particular item of clothing.
- cost and availability.

B. PRE-USE INSPECTION

Each item of clothing should be inspected immediately upon removing it from the package. First determine that the material of construction is that which was ordered or specified for the task at hand. This will involve comparing the item number with the catalogue number. Items of different materials should be kept separated. (See Storage below.)

Visually inspect the items for defects such as imperfect seams, nonuniform coatings, pinholes, malfunctioning closures, and tears. Some flexible materials may stiffen during extended storage periods; flex the product and observe for surface cracks or other signs of shelf life deterioration. Pinholes may be detectable by holding the garment up to a light in a dark room. Gloves with holes can be identified by pressurizing the glove. This can be accomplished by blowing into the glove and then tightly rolling the gauntlet towards the fingers (thereby reducing volume and increasing pressure) while observing that the glove holds pressure. Alternatively, the glove could be inflated and then held under water and examined for the presence of air bubbles. Full-body encapsulating ensembles should be checked for the operation of pressure relief valves and the fittings at the wrists, ankles, and neck.

C. DONNING

Each worker should thoroughly inspect the clothing he is to wear immediately before donning. Of principal concern are cuts, tears, punctures, and discoloration or stiffness which may be indicative of chemical attack resultant from previous use or non-uniformities in the rubber or plastic. The wearer should understand all aspects of the clothing operation and its limitations; this is especially important for full-body encapsulating ensembles where misuse could potentially result in suffocation. Note some materials may have temperature limitations; for example, some PVCs become stiff and may be unusable at low temperatures.

Once the clothing is on, all closures should be secured and checked. Use the "buddy system." Finally, the fit of the clothing should be evaluated. Improperly fitting protective clothing represents a severe potential hazard. Where clothing is too small, worker movement is restricted, likelihood for tear is increased and the potential for accelerated worker fatigue is increased. Where the clothing is too large, the possibility of snag is increased and the dexterity and coordination of the worker may be compromised.

D. IN-USE

During the course of the work task, each worker should periodically inspect his protective clothing. Of principal concern are tears, punctures, seam discontinuities, or closure failure that may have developed while working. Evidence of chemical attack such as discoloration, swelling, stiffening, or softening should also be noted. (Note permeation can occur without any visible effects on the clothing material.) Any item of clothing that has been physically damaged or chemically degraded should be doffed and replaced as soon as safely possible.

E. DOFFING

A principal objective of the doffing process is to restrict the transfer of chemical from the work area. A second objective is to avoid contact of the person doffing the garment as well as others with chemical on the outside of the garment.

Detailed doffing procedures have been developed by the EPA and are contained in the *Interim Standard Operating Safety Procedures* of the Office of Emergency and Remedial Response, Hazardous Response Support Division. Part 7 and pertinent Annexes of the Interim Standard are included herein as Appendix G.

They address:

- doffing site location
- decontamination
- disposal of contaminated garments

F. RE-USE AND STORAGE

Several considerations relative to the storage and re-use of protective clothing were discussed in Chapter 2. They primarily focus on hazards that could potentially develop upon the storage of contaminated clothing. Briefly, in cases where a chemical is absorbed by the clothing, the chemical begins to permeate into the clothing. Short duration washing of the clothing with soap and water removes surface decontamination but not absorbed chemical. After surface decontamination, some of the absorbed chemical will continue to permeate the clothing material and may ultimately appear on the inside surface. This can happen during periods of overnight or weekend storage. Where such potential hazards may develop, clothing can be checked inside and out for discoloration or, if possible, by wipe testing for suspect chemicals prior to re-use. This is particularly important for full-body encapsulating ensembles which are generally subject to extensive re-use due to their cost. Note, however, that negative (i.e., no chemical found) test results do not necessarily preclude the possibility that some absorbed chemical will be released to the inside of the CPC during re-use.

It should be noted that at the present time, there is very little documentation regarding clothing re-use. The use of disposable clothing, of course, obviates the problem. Where reusable CPC is required, however, the type of problem discussed above can best be minimized by selecting the most resistant clothing for the chemical at hand; such clothing will absorb little or no chemical. Furthermore, used clothing should be stored in well ventilated areas. Ideally, there should be good air flow around each item of clothing.

Re-use of face shields and lens is a particularly important issue. Good vision is required for both safety and efficiency on the worksite. All such items should be inspected for crazing, cracks, and fogginess prior to use. See Chapter 3, Part D, in Volume II.

Finally, in storing protective clothing, different types and materials of clothing should not be mixed. For example, gloves which are black in color and virtually indistinguishable from one another may be made from nitrile, neoprene, Viton, polyvinyl chloride, butyl, etc., materials. Each material has unique chemical barrier properties. Mixing the gloves significantly increases the chance that a worker will be wearing the wrong clothing for the chemical of concern. It may be possible to separate mixed gloves by using the manufacturer's product number that is often found in the gauntlet area.

CHAPTER 6

CPC VENDORS' LITERATURE

A. INTRODUCTION

The most widely available sources of information on CPC are the product catalogues of the CPC manufacturers and vendors. These booklets contain descriptions of the types, sizes and varieties of CPC produced by each manufacturer. In most cases the basic materials of construction of the CPC are also included in the product descriptions. Many manufacturers also include information pertinent to the chemical resistance of their products or of the materials from which the products are fabricated. This information is generally in the form of tables of qualitative chemical resistance ratings or use recommendations for the products/materials and particular chemicals. A few vendors also provide information pertinent to abrasion, tear, etc., resistance but in general most catalogues do not address such application-related issues. Since the focus of these Guidelines is the selection of clothing for protection from exposure to chemicals, the vendors' chemical ratings and recommendations tables are the focus in this chapter; they are discussed in more detail in Chapter 4 of Volume II.

B. COMMENTS ON VENDORS' CPC RATINGS AND RECOMMENDATIONS

Of the 120 CPC catalogues which were obtained and reviewed in the preparation of these Guidelines, approximately 30 contained some form of chemical resistance table for the products described therein. The recommendations/ratings typically were on a four-grade scale of "excellent," "good," "fair," and either "poor" or "not recommended." In a small number of cases, five- or six-grade scales were used. With only a few exceptions do the tables include information as to the basis for the recommendations. From the results of interviews with several of the vendors, it would appear that, at present, most do not have (or at least are unwilling to share) performance specifications or quantitative test data for their products. The ratings/recommendations for a particular type of product (for example, nitrile gloves) for a particular chemical may vary from vendor to vendor. Both of these factors – little or no test data and inconsistencies among recommendation tables – make the selection, from vendor literature, of the best CPC for a given application, at best, a difficult and uncertain task.

Given the above facts, the most important consideration to keep in mind when using vendor recommendation tables is that the tables are intended to provide *guidance* in the selection of CPC. That is, the tables are meant as a place to start the CPC selection process. The tables are meant for identifying candidate CPC for further evaluation, and are particularly useful for identifying CPC from which poor performance would be expected and, therefore, which can be dropped from consideration. In no way do the recommendations address the wide variety of uses, challenges, and care to which the CPC may be subjected. Most vendors strongly emphasize this point in the descriptive text which accompanies the tables. Secondly, the vendors' recommendations were not developed by, nor are they sanctioned by, industrial hygienists or other safety professionals. CPC manufacturers are in business to sell clothing and not to set the standards for safety at any given work site. In conclusion, the principal purpose of the catalogues is to provide information about products in terms of the sizes, styles, and materials of construction. The ratings charts should only be used as a starting point for further evaluation if chemical resistance is an issue.

C. VENDORS' TEST METHODS

The quality of the test methods used by vendors to generate data to support their recommendations range from state-of-the-art to essentially non-existent. It would appear that fewer than five vendors have performed any permeation testing. Only two organizations — DuPont and Edmont Division of Becton, Dickinson — have published permeation data.

It would further appear that most purveyors of recommendation tables rely on information provided by the supplier of the raw materials from which the clothing is fabricated. In general, the suppliers' ratings are based on some form of immersion testing, but little or no permeation testing. Two drawbacks of this approach are (1) the supplier may be unaware of the special needs of CPC and (2) the CPC vendor has no firsthand knowledge of the chemical resistance of his products. Potential problems associated with the first drawback are:

- Chemical permeation of a rubber or plastic material can occur with little or no physical effect on the rubber or plastic. This may or may not be detected by an immersion test.

- The information provided by the materials supplier is typically developed for a general elastomer/plastic formulation or type. A result is that the recommendation may not take into account formulation modifications that were required to put the material into a form appropriate for CPC.

A further comment on recommendation tables based on immersion testing is that most are quite old, and based on subjective observation of immersion test specimens rather than quantification of swelling, weight or strength changes. In many cases the details of the testing and the qualitative descriptions for defining "excellent," "good," etc. were not documented. Thus, it becomes impossible to compare results. Another consideration associated with the age of the recommendations is that as time passes and

1. raw materials suppliers change formulations,

2. CPC manufacturers change raw materials suppliers, and

3. CPC manufacturers change production methods,

the performance of the same "nominal" product may also change. There is no indication that recommendations are routinely updated to reflect these changes, except in a few exceptional cases.

Again, the CPC recommendation tables should only be used for guidance.

CHAPTER 7

USERS' MATRICES

In this chapter, CPC recommendations for approximately 300 chemicals are presented. In addition, the chemicals have been grouped into generic families (e.g., acids, amines, etc.) and general recommendations are made for each family which is represented by more than one chemical having CPC performance information for a given material. The recommendations are contained in two so-called Users' Matrices. The matrices are complemented by Appendices B through F which contain information pertinent to the acquisition of CPC such as a directory of vendors' addresses and telephone numbers.

A. SCOPE AND LIMITATIONS

1. Chemicals

Two user matrices have been developed. Matrix A (pp. 37-76) contains CPC recommendations for approximately 300 chemicals and fourteen clothing materials. The chemicals are the liquids included in the Clean Water Act (CWA) Sections 311 and 307a, the Clean Air Act (CAA) Section 112, and the Resource Conservation and Recovery Act (RCRA) Sections P, U, F and K. Also included are any other chemicals (principally liquids but including some gases) for which there were CPC vendors' recommendations or technical reports of permeation test results. Vendors' recommendations or permeation data were not available for all the liquids addressed in the aforementioned Acts. Approximately 40% of the chemicals are included in OSHA directive Subpart 2 — Toxic and Hazardous Substances, 29 CFR 1910.1000. Tables Z-1 and Z-2.

An alphabetical list of the chemicals is presented in Appendix B. The right-hand column of Appendix B contains two pieces of information for each chemical: the chemical abstract number (CAS number) and a numeric "chemical class" code. The code is the "key" to Matrix A since the matrix is organized numerically by chemical class, with the code shown in parentheses following the generic class name. Note, except for the aqueous solutions, all liquids are single component; multi-component organic solutions are not addressed.

In Matrix B (pp. 77-79), CPC recommendations are provided for the same fourteen materials but in this case for generic families of chemicals. The chemicals in each family and on which the Matrix B recommendations are based are readily determined from Matrix A. The chemical classification is based on the system used by the Eastman Kodak Company. This system was selected because it addresses a large fraction of the chemicals of concern herein. Additional categories have been included as appropriate. Note that not all classes in Matrix A are represented in Matrix B; furthermore, recommendations are not given for all materials for all classes. The criterion for being given a recommendation in Matrix B is that the class must contain more than one chemical with CPC recommendation for the material of concern. In many cases there was considerable variability among the recommendations for chemicals within a class; these are indicated by double asterisks (**). In these cases, please refer to Matrix A for specific information.

2. Materials

The fourteen principal materials from which CPC is fabricated are listed across the top of the matrices. Where information on other materials was available, recommendations for these materials are in the right-most column of the matrices. A general characterization of several of the physical properties of the materials is presented in Table 7.1.

The fourteen material categories were reduced from the approximately 100 types and forms of clothing materials listed in Appendix E, and represent the materials of construction for well over 90% of the CPC considered in the Guidelines. By grouping several types and forms of clothing into one category, it is likely that in some cases particularly good or particularly poor items have gone unnoted since there can be significant differences in product quality between vendors. This is a compromise that must be accepted and recognized in summary compilations such as Matrices A and B. In general, however, a given material will exhibit the same performance relative to another material independent of whether the materials are free films or coatings and independent of source. For example, if a butyl rubber glove is more resistant than a nitrile rubber glove to a given chemical, then it is highly likely that butyl rubber gloves and clothing in both supported and unsupported form will be better barriers to that chemical than their nitrile counterparts. In other words, differences in performances between products of a given material will probably be small compared to performance differences between categories of materials. In using the matrices, it must be remembered that their purpose is to provide a starting point for CPC selections. Selections based on the Matrices' recommendations do not guarantee protection since in no way do the Matrices take into account such key issues as the application of the CPC or quality differences between CPC products.

TABLE 7.1

PHYSICAL CHARACTERISTICS OF CPC MATERIALS*

Material (Designation in Matrices)	Abrasion Resistance	Cut Resistance	Flexibility	Heat Resistance	Ozone Resistance	Puncture Resistance	Tear Resistance	Relative Cost
Butyl Rubber (Butyl)	F	G	G	E	E	G	G	High
Natural Rubber (Nat. Rub.)	E	E	E	F	P	E	E	Medium
Neoprene (Neop.)	E	E	G	G	E	G	G	High
Neoprene/Styrene-butadiene Rubber (Neop./SBR)	G	G	G	G	G	G	G	Medium
Neoprene/Natural Rubber (Neop./Nat. Rub.)	E	E	E	G	G	G	G	Medium
Nitrile Rubber (Nitrile)	E	E	E	G	F	E	G	High
Nitrile Rubber/Polyvinyl Chloride (Nitrile/PVC)	G	G	G	F	E	G	G	Medium
Polyethylene (PE)	F	F	G	F	F	P	F	Low
Chlorinated Polyethylene (CPE)	E	G	G	G	E	G	G	Low
Polyurethane (PU)	E	G	E	G	G	G	G	High
Polyvinyl Alcohol (PVA)	F	F	P	G	E	F	G	Medium
Polyvinyl Chloride (PVC)	G	P	G	P	E	G	G	Low
Styrene-butadiene Rubber (SBR)	E	G	G	G	F	F	F	Low
Viton	G	G	F	G	E	G	G	Very High

*Ratings are subject to variation depending on formulation, thickness, and whether the material is supported by fabric.

E-excellent; G-good; F-fair; P-poor

3. Performance Information

The information on which the users' matrices recommendations are based is from three sources:

- CPC vendors' chemical resistance charts that are often included in the product catalogues. The ratings in the charts of approximately 30 vendors (including the five largest manufacturers of CPC) were tabulated and reviewed by chemical and material classes. In total over 6000 individual ratings composed the tabulation.

- CPC raw materials suppliers' chemical resistance charts.

- The technical literature which addresses chemical resistance and permeation testing of CPC materials and products. In all, over 2000 individual test results (such as breakthrough time, permeation rate, and percent weight change) were tabulated.

The vendors use a variety of rating scales; some have three grades, most have four grades, and a few have five or six grades. In order to compare ratings, a normalized four-grade system (i.e., A, B, C, D) was developed. Briefly, products with the highest rating in a four- or three-grade system or the highest two ratings in the case of a six-grade system were given a normalized rating of "A". A normalized rating of "B" was given to the next highest vendor's ranking, which was generally called "good", but in some three-grade systems was called "fair". A normalized rating of "C" was given to the third highest vendor ranking except for the three-grade systems. Typically, vendors called this ranking "fair". Finally, all vendors' rankings of "poor" and "not recommended" were given a normalized rating of "D".

B. RECOMMENDATIONS

The recommendations in the Users' Matrices resulted from a comprehensive analysis of all the available information. Briefly, a computerized database of the information was developed. No attempt was made to validate any of the data before they were input. In a sense, there was a self-validation of the data since the recommendation scale used in the matrices takes into account the number of independent information sources that will in total either substantiate or throw into question individual performance claims. This is discussed in the next paragraph and becomes evident from review of Table 7.2. The database was organized such that any available information for a particular chemical and a particular clothing material could be retrieved in the form of a single printed report. The report was analyzed and a recommendation was developed. No recommendation was made for a chemical/material pair for which there was no information.

There are eight grades of recommendations. Each is designed to represent a particular combination of performance, number of sources substantiating that performance, and the consistency of the information. This is reflected by the number and size of the letters which indicate the recommendation. The criteria and explanations for the recommendations are summarized in Table 7.2. In all cases of inconsistencies between test results and manufacturers' recommendation information, the test results were more influential in forming the recommendation. All recommendations are "conservative" in that they reflect a cautious attitude towards CPC selection.

C. USING THE MATRICES

To make the most effective use of the matrices, reference must be made to the Appendices. Assuming that the chemical(s) for which protection is required is known, the procedure would be as follows:

1. Go to Appendix B, an alphabetical listing of the chemicals listed in Matrix A. Find the chemical and referring to the right-most column, its class code.

2. Return to Matrix A, a numerical listing of the chemicals by class. Locate the class which contains the subject chemical by means of the numbers in the parentheses next to the class names. If the chemical is not listed, go to Step 6.

3. Locate the subject chemical and read across to determine which is(are) the preferred clothing material(s) for the chemical.

4. Go to Appendix C, an alphabetical listing of CPC by material type and by product type. The vendors for the CPC are listed in the right column. Additional information on the products can be found by referring to Appendix E and using the first two digits of the product code from Appendix C.

5. Go to Appendix D, an alphabetical listing of the vendors and their addresses and telephone number. Contact the vendor(s) and initiate procurement procedures.

TABLE 7.2

DESCRIPTION OF CRITERIA FOR RECOMMENDATIONS

Character	Performance Data	Vendor Recommendations
RR	Breakthrough times greater than one hour reported by (normally) two or more testers.	A or B ratings from three or more (apparently independent) vendors.
R	None	Same as RR
rr	Some data suggesting breakthrough times of approximately an hour or more.	A or B ratings from less than three vendors; no C's or D's.* B and C ratings – with B's predominating – from several vendors.
r	None	Same as rr
NN	Breakthrough times less (usually significantly less) than one hour reported by (normally) two or more testers.	C or D ratings from three or more (apparently independent) vendors.
N	None	Same as NN
nn	Some data (usually high solubilities) suggesting breakthrough times of one hour are not likely.	C or D ratings from less than three vendors.* B and C ratings – with C's predominating – from several vendors.
n	None	Same as nn

*Products of some materials (e.g., CPE and Vitron) are manufactured and rated by only one or two vendors.

6. When the specific chemical of interest is not listed in Appendix B, it may be possible to narrow the CPC alternatives through the use of Matrix B. With the help of Matrix B, attempt to classify the chemical; then follow the general recommendations provided in Matrix B. At this point, two options are open: (a) follow Steps 4 and 5 above, or (b) return to Matrix A. In Matrix A, review all the chemicals in the class of interest and identify the one or two that are most similar to the specific chemical in question. Select CPC on the basis of the recommendations for the similar chemicals. *Note* that in Matrix B, asterisks are indicative that the particular material exhibited considerable variability in its resistance to the chemicals of the given class. In these cases reference to Matrix A and caution in CPC selection is highly advised.

During the selection and eventual use of the CPC recommended in Matrices A and B, it is important to remember that:

1. The recommendations are based on the best information available. In some cases, however, this information is very limited.

2. *The recommendations are a guide, not a guarantee.*

3. The recommendations probably do not hold for extreme use conditions (e.g., high and low temperatures, long-term contact, high abrasion, etc.) nor do they consider the problems associated with reuse described in Chapter 5, Part F.

4. There may be certain products in each category that are better or poorer than the norm. Also, the quality of construction of even the "better" products can vary from batch to batch. In their present form, the matrices do not address quality issues. The assessment of quality and uniformity of quality can best be gained through field experience and, therefore, left as a task for the field personnel. It is possible that future Guidelines will be modified to include recommendations for specific products that are based on quality and field performance.

5. The "double" letter recommendations are based primarily on breakthrough time data; permeation rate data were given only secondary consideration.

A final comment pertains to the specific CPC products and vendors referred to in the Appendices. The objective for this first printing of the Guidelines was to include at least one source for any given item of CPC. The listing, therefore, is extensive but is not all-inclusive; it is unlikely that all distributors or all brands/lines of CPC are mentioned. The listings are designed such that they can be readily expanded to cover additional manufacturers or distributors as they become known to the EPA. Furthermore, the recommendations can also be modified as additional performance information becomes available to the EPA.

USERS' MATRIX A – CPC RECOMMENDATIONS BY CHEMICAL

	BUTYL	NAT. RUB	NEOPRENE	NEOP. SBR	NEOP. NAT RUB	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
ACIDS, CARBOXYLIC, ALIPHATIC															
Unsubstituted (102)															
Acetic Acid	R	rr	RR	r		RR	n	RR		R	n	RR	r	rr	NBR (r)
Acrylic Acid									r			n			
Butyric Acid									r			r			
Formic Acid	R	RR	RR	r		rr		r		r	n	RR	r	n	NBR (r)
Lauric Acid, 30-70%	r	rr	RR			RR		N		r	n	nn			
Oleic Acid	r	NN	RR	r		RR	r	rr		R	RR	rr	n	r	NBR (r)
Palmitic Acid	r	nn	RR			RR				r		rr	n	r	
Propionic Acid															
Substituted (103)															
Lactic Acid	R	RR	RR	r		RR	r	r	r	R	rr	RR		r	
Polybasic (104)															
Maleic Acid	n	RR	RR			RR	r	r		r	n	RR		r	
Oxalic Acid	R	RR	RR		RR	r	r	r	rr		n	RR	r	r	NBR (r)

Source: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
ACID HALIDES, CARBOXYLIC															
Aliphatic (111)															
Acetyl Bromide									nn						
Acetyl Chloride	n								nn			n			
Aromatic and Heterocyclic (112)															
Benzoyl Chloride			n						n			n		i	

Ses Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP SBR	NEOP. NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
ALDEHYDES															
Aliphatic and Alicyclic (121)															
Acetaldehyde	R	NN	NN	n		n	n	r	nn	r	n	r	r	n	NBR (r)
Acrolein									nn						
Chloroacetaldehyde															
Crotonaldehyde									NN						
Formaldehyde, <37%	R	rr	RR			RR	rr	r	RR	r	n	RR	r	n	NBR (r)
Paraldehyde															
Trichloroacetaldehyde															
Aromatic and Heterocyclic (122)															
Benzaldehyde	r	NN		n		N	n	r	n	N	rr	N	r	n	NBR (r)
Furfural	r	rr	rr	n		N	n	r	r	n	rr	N		n	NBR (r)
Glycidaldehyde															

...ce: Arthur D. Little, Inc.

AMIDES (132)	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP. NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Dimethylformamide	r	NN	NN			N	n	r		n	NN	N		n	
Hexamethylphosphoramide	n		nn			nn		nn		nn				nn	
Aliphatic and Alicyclic Primary (141)															
Butylamine	n								NN						
α,α-Dimethylphenethylamine															
Ethanolamine	r	n	RR	n		RR	r	r	r	r	n	RR	n	n	NBR (r)
Ethylamine															NBR (r)
Methylamine	r	NN	n			RR	r	r		r	n	n	r		NBR (r)
n-Propylamine	n								NN		n				
Isopropylamine											n				

Source: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP., SBR	NEOP., NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
AMINES (Continued)															
Secondary (142)															
Diethylamine	r	n	n			NN	n	r		r	n	n	r	n	NBR (r)
Dimethylamine															
Dipropylamine	nn								nn						Polycarbonate (r)
Ethylenimine															
2-Methylaziridine															
Morpholine	r	nn	n	n		r	r				r	rr	R	rr	NBR (r)

-rce: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
AMINES (Continued)															
Tertiary (143)															
Triethanolamine	r	rr	RR	r		RR	r	r	r	n	rr	RR		n	
Triethylamine			r						RR						
Trimethylamine									rr						
Polyamines (144)															
Ethylenediamine	r	r	r			r			n						
Aromatic															
Primary (145)															
Aniline	r	RR	RR	n	n	rr	n	rr	r	n	rr	NN	r	R	NBR (nn)
p-Chloroaniline															
α-α-Dimethylphenethylamine															
Polyamine (147)															
Benzidine															
4,4'-Methylenedianiline															

Source: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP. NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
ANHYDRIDES, CARBOXYLIC															
Aliphatic (181)															
Acetic Anhydride	n		f									n		n	
Propionic Anhydride															
ISOCYANATES (210)															
Methyl Isocyanate															
Toluene Diisocyanate	f	ff	N			N	n	f	ff	f	ff	N		n	
CYANIDES (215)															
Cyanogen Bromide									ff						
Cyanogen Chloride									ff						
Ethyl Cyanide															
Hydrocyanic Acid	f		f									f		f	

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
ESTERS, CARBOXYLIC															
Aliphatic															
Chloroformates (221)															
Methyl Chloroformate	rr								nn						
Acetates (222)															
Amyl Acetate	r	N	N	n		nn	n	r	n	r	rr	N		n	NBR (r)
Isoamyl Acetate	r	nn	nn	n		rr	n	r	n	r	RR	N		n	
Butyl Acetate	n	NN	NN	n	nn	NN	n	nn	r	r	rr	NN	r	n	NBR (r)
Ethyl Acetate	RR	nn	NN	n		NN	n	nn	r	r	nn	NN	n	n	NBR (NN)
Propyl Acetate	r	NN	R	n		NN	n	r		r	rr	N		n	NBR (r)
Vinyl Acetate	n								r			n			
Higher Monoesters (223)															
Ethyl Acrylate	r								NN			n			
Ethyl Methacrylate									NN						
Methyl Methacrylate	r	r	r			N	n	r	n	r	RR	N			
Pyrethrins															

Source: Arthur D. Little, Inc.

ESTERS, CARBOXYLIC (Continued)

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP. NAT. RUB	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Polybasic (224)															
Tannic Acid	r	RR	RR	r		rr	r	n	r	r	n	RR		r	NBR (r)
Aromatic Phthalates (226)*															
Bis(2-ethylhexyl) Phthalate	n	rr	RR			RR					NN			r	
Butyl Benzyl Phthalate															
Di-n-butyl Phthalate	r	NN	RR	n		rr	n	r	n	r	rr	N		n	NBR (r)
Di-n-octyl Phthalate															
Diethyl Phthalate															
Diheptyl Phthalate															
Diisobutyl Phthalate															
Diisooctyl Phthalate															
Diisodecyl Phthalate															
Diisononyl Phthalate															
Dimethyl Phthalate															
Dinonyl Phthalate															

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
ESTERS, OTHER THAN CARBOXYLIC															
Sulfonates (232)															
Ethyl Methanesulfonate															

Source: Arthur D. Little, Inc.

ETHERS	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP. NAT RUB	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Aliphatic (241)															
Bis(chloromethyl) Ether															
Bis(2-chloroethoxy) Methane *															
2-Chloroethyl Vinyl Ether															
Chloromethyl Methyl Ether									nn						
2,2'-Dichloroethyl Ether	rr								rr						
Dichloroisopropyl Ether															
Ethyl Ether	r	n	NN	r		rr	n	r	r	R	RR	N		n	NBR (r)
Isopropyl Ether		NN	rr			RR					RR	NN		RR	
Aromatic (242)															
4-Bromophenyl Phenyl Ether															
4-Chlorophenyl Phenyl Ether															

…ce: Arthur D. Little, Inc.

HALOGEN COMPOUNDS

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Aliphatic															
Unsubstituted (261)															
• Allyl Chloride	r								nn		rr	n			
Carbon Tetrachloride •	N	NN	NN	n	NN	RR	r	NN	n	R	RR	NN	n	r	NBR (r)
Chlorodibromomethane															
Chloroethane															
Chloroform	nn	NN	NN	n	NN	NN	n	NN	NN	r	RR	NN		r	NBR (r), Saranex (NN)
1-Chloropropane											rr				
1,4-Dichloro-2-butene	rr	NN	**			NN		rr	NN		RR	**		RR	Saranex (RR)
• Dichlorobromomethane															
Dichloroethane	RR	NN	NN			NN		NN		nn	NR	nn		RR	FEP or TFE (RR)
Dichloroethylene (all isomers)									n			n			
trans, 1,2-Dichloroethylene															
1,2-Dichloroethylene															
Dichloropropanes									NN						

**Materials greater than 0.15 cm thick (RR), materials less than 0.015 cm thick (NN)

Source: Arthur D. Little, Inc

HALOGEN COMPOUNDS (Continued)

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Aliphatic, Unsubstituted (Continued)															
1,2-Dichloropropane															
Dichloropropane-Dichloropropene															
Dichloropropanes	n	n	n			n									
1,3-Dichloropropene															
Ethylene Dibromide	n								NN			n			
Ethylene Dichloride	n	NN	NN		NN	NN	nn	NN	NN	n	RR	NN		r	
Ethylidene Dichloride	n	n	n			n									
Freon TF	n	NN	RR		nn	RR		NN			nn	NN			
Freon TMC		NN	NN			NN					RR				
Freon 11	n	n	r			n						n		r	
Freon 12	n	N	R			n						n		r	
Hexachlorobutadiene															
Hexachloropropene															
Methyl Bromide	n	N	r			n		NN	nn			N		r	

Source: Arthur D. Little, Inc.

HALOGEN COMPOUNDS (Continued)

Aliphatic, Unsubstituted (Continued)

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE-PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Methyl Chloride	n	N	r	n		n		n		n		N			NBR (r)
Methyl Iodide		NN	NN		NN	NN		NN							
Methylene Bromide	r	r	r			n	n	r		r	RR	N			
Methylene Chloride	n	NN	NN		NN	NN	n	NN	n	r	rr	NN		rr	
Pentachloroethane															
1,1,2,2-Tetrachloro-ethane	n	NN	NN		NN	NN		NN	n			NN			
1,1,1,2-Tetrachloro-ethane															
Tetrachloroethylene	NN	NN	NN	N		RR	n	nn	n	r	RR	NN	n	RR	NBR (rr)
Tribromomethane															
1,1,2-Trichloroethane	nn	NN	NN			NN		NN		NN	NN	NN		RR	FEP or TFE (RR), NBR (r)
Trichloroethylene	NN	NN	NN	n	NN	NN		NN	NN	nn	NN	NN	n	RR	Chlorobutyl (r), NBR (r)
Vinyl Chloride	rr									rr			rr	r	
Vinylidene Chloride															

Source: Arthur D. Little, Inc.

HALOGEN COMPOUNDS (Continued)

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP. NAT. RUB	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Substituted (282)															
Bis (2-chloromethyl) Ether															
Bis(2-chloro-ethoxy) Methane															
Bromoacetone															
Chloroacetaldehyde															
2-Chloroethyl Vinyl Ether															
Chloromethyl Methyl Ether									nn						
3-Chloropropionitrile															
1,2-Dibromo-3-chloropropane									n			n			
2,2-Dichloroethyl Ether	rr								rr						
Dichloroisopropyl Ether															
Diisoproply Flourophosphate															
Epichlorohydrin	RR	n	n			nn		nn	n	NN	nn	nn		nn	
Methyl Chloroform	n	NN	NN		NN	nn		NN	n		RR	NN			
Trichloroacetaldehyde															
Trichloromethanethiol															
Trifluoroethanol		RR	RR		RR	NN		rr				NN			

ce: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
HALOGEN COMPOUNDS (Continued)															
Aromatic															
Unsubstituted (263)															
Benzotrichloride															
Benzyl Chloride	n	N	N	n		r			NN	n		n			
Benzyl Dichloride															
Chlorobenzene	N	N	N			n	n	r	n	r	nn	N	n	r	NBR (r)
Dichlorobenzene	n								n			n			
1,2-Dichlorobenzene									NN						
1,3-Dichlorobenzene															
1,4-Dichlorobenzene															
Hexachlorobenzene															
1,2,4,5-Tetrachlorobenzene															Saranex (nn)
1,2,4-Trichlorobenzene															

Source: Arthur D. Little, Inc.

HALOGEN COMPOUNDS (Continued)

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP. NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Substituted (264)															
p-Chloroaniline															
p-Chloro-m-cresol															
2-Chlorophenol															
2,4-Dichlorophenol															
2,6-Dichlorophenol		RR	RR			RR					NN	RR			
Pentachlorophenol		R	RR			rr					NN	rr			
Polynuclear (265)															
4-Bromophenyl Phenyl Ether															
Chloronaphthalenes	n	N	N			n					RR	N			
2-Chloronaphthalene	n	n	n			n									
4-Chlorophenyl Phenyl Ether															
Polychlorinated Biphenyls (undiluted)	RR	NN	RR			RR		RR	rr		RR	n		RR	Saranex (RR), TFE (RR)

Source: Arthur D. Little, Inc

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE-PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
HETEROCYCLIC COMPOUNDS															
Nitrogen															
Pyridines (271)															
2-Picoline														a	
Pyridine	f	NN	NN		NN	NN		f							
Quinolines (272)															
Quinoline															
Others (274)															
Ethylenimine	NN	m	NN												
2-Methylaziridine															

Source: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP. NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
HETEROCYCLIC COMPOUNDS (Continued)															
Oxygen															
Epoxy Compounds (275)															
2,2'-Bioxirane															
Epichlorohydrin	RR	n	rr			nn		nn	n	NN	NN	nn		NN	
Ethylene Oxide	r	n	n			r			rr			n		n	
Glycidaldehyde															
Propylene Oxide		n	n			n	n	r		n	nn	n			
Furan Derivatives (277)															
Furan	n														
Furfural	r	rr	rr	n		N	n	r	r	n	RR	N		n	NBR (r)
Tetrahydrofuran	n	NN	NN		NN	NN	n	NN	NN	n	NN	NN		n	
Others (278)															
Dihydrosafrole															
1,4-Dioxane	r	NN	NN		nn	NN	n	NN	r	n	NN	N		n	
Isosafrole															
Safrole															

Source: Arthur D. Little, Inc.

HETEROCYCLIC COMPOUNDS (Continued)

HYDRAZINES (280)

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
* 1,2-Diethylhydrazine															
1,1-Dimethylhydrazine	RR		NN			nn						NN			
1,2-Dimethylhydrazine	n	n	n			n									
Hydrazine	r	r	n			r			n			r		n	
Hydrazine, 30-70%		rr	rr			rr	r	r		r	n	rr		n	
Methylhydrazine	RR								rr			RR		rr	Chlorobutyl (rr) CR-39 (rr) TFE or FEP (rr)

Source: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP. NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
HYDROCARBONS															
Aliphatic and Alicyclic (291)															
• Butane	n	N	R	r		R				R		N	n	r	NBR (r)
Cyclohexane	NN	NN	nn	n	NN	RR		nn	r	n	RR	NN		RR	NBR (rr)
Ethane	n							nn	r			r			
Gasoline	N	N	R	n		RR			r	R	RR	N	n	r	NBR (r)
Heptane		NN	R			RR					RR	NN		RR	
Hexane	NN	N	RR	n		RR	n	nn	r	R	RR	N		r	NBR (r)
Isobutylene								nn							
Isooctane	N	N	rr			RR			r		nn	nn		r	
Isopentane															
Isoprene															
JP-4, jet fuel			n											r	
Kerosene	n	NN	RR	n		RR	r	r		r	RR	N		r	NBR (r)
Methane	r	r	r			r		nn							
Methylcyclohexane															

Source: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
HYDROCARBONS (Continued)															
Aliphatic and Acyclic (291) (Continued)															
Mineral Spirits		N	R			r						N	r		NBR (r), Saranex (nn)
Naphtha, V.M. & P	NN	NN	rr	n		RR	n	nn	rr	r	RR	NN	r	r	NBR (RR)
Neopentane															
1,3-Pentadiene															
Pentane	r	NN	rr		NN	RR	n	nn		r	RR	NN		r	
Propane	n	N	R	n		R		nn		r		r		r	NBR (r)
Turpentine	N	N	r	n		rr	n	r	r	r	RR	N		r	NBR (r)
Aromatic (292)															
Benzene	NN	NN	NN	n	NN	NN	n	NN	NN	NN	rr	NN	n	rr	FEP or TFE (nn) Chlorinated natural rubber (nn) Saranex (nr) NBR (nn)
p-Chloro-m-cresol															
Creosote	RR	n	RR			R		n				R		RR	
Creosols	n	r	r			n			r			n			Saranex (rr)
m-Cresol		rr	RR		nn	RR		r				NN			
Cumene									rr						

Source: Arthur D. Little, Inc.

HYDROCARBONS (Continued)

Aromatic (292) (Continued)

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP. NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Ethyl benzene															
Gasoline	N	N	R	n		RR			r	R	RR	N	n	r	NBR (r)
JP-4, jet fuel			n											r	
Kerosene	n	NN	RR	n		RR	r	r		r	RR	N		r	NBR (r)
Nitrobenzene	N	NN	N	r		N			nn	n	RR	N		r	NBR (r)
Styrene	N	N	N			n		r	n		RR	N		r	
Toluene	NN	NN	NN	n		nn	NN	NN	n	r	rr	NN	n	RR	Flourine/Chloroprene (RR), Saranex (nn), NBR (rr)
Xylenes	N	NN	NN			rr	n	n	n	r	RR	NN		r	

Source: Arthur D. Little, Inc.

PEROXIDES (300)	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
α-α-Dimethylbenzyl Hydroperoxide															NBR (r)
Hydrogen Peroxide	r	n	r	r		r				r		R		r	
Hydrogen Peroxide, 30-70%	r	RR	RR			RR		rr		r	n	RR		r	
Methyl Ethyl Ketone Peroxide															

HYDROXYL COMPOUNDS

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP. NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Aliphatic and Alicyclic															
Primary (311)															
Allyl Alcohol	RR		NN						RR	r	NN	n	r		
Amyl Alcohol	r	NN	RR	r		RR	r	r		r	RR	RR		r	NBR (r)
n-Butyl Alcohol	R	NN	RR	n		RR		r	r	r	nn	RR	r	r	NBR (r)
Ethanol	RR	RR	RR	r		RR	r	r		r	NN	NN	n	RR	NBR (RR)
Ethanolamine	r	RR	RR	n		RR	r	r	r	r	rr	RR	n	n	NBR (r)
Isobutyl Alcohol	r	NN	RR			RR	r	r		r	n	RR		r	
Methanol	R	rr	rr	r		RR	r	r	r	r	NN	NN	r	RR	NBR (R)
n-Octanol		rr	RR			RR					RR	RR			
Propargyl Alcohol															
Propyl Alcohol	r	nn	RR	r		RR	r	r		r	n	rr	r	r	NBR (r)
Trifluoroethanol		RR	RR		RR	NN		r					NN		

Source: Arthur D. Little, Inc

Source: Arthur D. Little, Inc.

HYDROXYL COMPOUNDS (Continued)

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Aliphatic and Alicyclic (Continued)															
Secondary (312)															
Cyclohexanol	R	rr	RR			RR	r	r	r	r	RR	RR		r	
Isopropyl Alcohol	r	RR	RR			RR		r	r			RR		r	
Lactic Acid	R	RR	RR	r		RR	r	r	r	R	rr	RR		r	
Tertiary (313)															
Citric Acid	r	R	R	r		R	r	r		R	R	R	R	r	NBR (r)
Citric Acid, <30%		RR	RR			RR		rr			RR	RR			
Polyols (314)															
1,3-Butylene Glycol	rr					RR					RR	RR			

HYDROXYL COMPOUNDS (Continued)

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP. NAT. RUB	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Aliphatic and Alicyclic															
Aromatic (316)															
p-Chloro-m-cresol															
2-Chlorophenol															
Creosote	RR	n	RR			R		n				R		RR	
Cresols	n	r	r			n			r			n			Saranex (rr)
m-Cresol		rr	RR		nn	RR		r				NN			
2,4-Dichlorophenol															
Aromatic (Continued)															
2,6-Dichlorophenol		RR	RR			RR					NN	RR			
2,4-Dimethyl phenol															
Pentachlorophenol		rr	rr			rr					NN	rr			
Phenol	R	rr	RR		rr	NN	n	rr	r	nn	NN	NN	n	n	
Phenol, <30%								rr	rr			r			
Picric Acid	r	R	R			R	r	r		r	n	n		r	
Picric Acid, <30%		nn	RR			RR						nn			
Resorcinol															

rce: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
INORGANIC GASES (350)															
Ammonia	r	r	r			r						r		n	
Carbon Oxyfluoride															
Chlorine	n	N	R			n			r			r		r	Saranex (rr)
Cyanogen															
Cyanogen Bromide															
Cyanogen Chloride															
Fluorine	r	n	r			n						r			
Hydrocyanic Acid	r		r									r		r	
Hydrogen Sulfide	r		r	n					r	n		r	r		
Nickel Carbonyl	r								r			r			
Nitric Oxide	r											r			
Nitrogen Dioxide															
Nitrogen Tetroxide	rr							rr	rr			NN		nn	Chlorobutyl (RR) CR-39 (rr)
Phosgene															
Phosphine															

Source: Arthur D. Little, Inc.

INORGANIC ACIDS (370)

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Antimony Pentachloride									rr						
Chlorosulfonic Acid			rr						nn					n	
Chromic Acid	n	N	N			rr	r	r	r	n	n	RR	n	r	
Hydrochloric Acid		r	R	n		R	r		RR	n		R			Polycarbonate (rr), NBR (r)
Hydrochloric Acid, <30%	r	RR	RR			RR	r	r		r	n	RR	r	r	NBR (r)
Hydrochloric Acid, 30-70%	r	RR	RR			rr	n	r		n	n	rr		rr	Saranex (rr)
Hydrofluoric Acid	nn	r	r	n		r			r	n		R		r	Polycarbonate (rr), NBR (r)
Hydrofluoric Acid, <30%		r	r			r						R			
Hydrofluoric Acid, 30-70%		rr	rr			rr	n	n		n	n	nn	n	r	NBR (r)
Nitric Acid	n	N	N	n		N			n			N	n	r	
Nitric Acid, <30%	r	RR	RR			RR		r	r			RR	r	r	NBR (r)
Nitric Acid, 30-70%		r	RR			r	r	r		r	n	RR		r	Saranex (rr)
Nitric Acid, >70%	n	rr	rr			rr	n	r	r	n	n	rr		rr	NBR (r), Saranex (rr)

rce: Arthur D. Little, Inc.

INORGANIC ACIDS (Continued)

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Perchloric Acid	r	N	R	n		n				n		N		r	NBR (r)
Perchloric Acid, 30-70%		RR	RR			RR	r	r		n	n	RR			
Phosphoric Acid	r	RR	RR	n		RR	n	r		n	n	RR			NBR (r)
Phosphoric Acid, <30%	r	r							r			r		r	
Phosphoric Acid, 30-70%			r											r	
Phosphoric Acid, >70%	r		r						r			r		r	
Phosphorous Oxychloride			rr						nn		nn	NN		NN	Saranex (nn)
Phosphorous Trichloride									nn						
Sulfur Monochloride									nn						
Sulfuric Acid	r	r	RR	n		n			rr	n		RR	r		NBR (r)
Sulfuric Acid, <30%	r	R	R			R		rr	r			R	r		Saranex (rr)
Sulfuric Acid, 30-70%	r		r					rr	rr			r	r		Saranex (rr)
Sulfuric Acid, >70%	r		rr			rr	n	n	r	n	n	rr	rr	rr	NBR (r)

Source: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP. NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
INORGANIC BASES (380)															
Ammonium Hydroxide	R	rr	RR	r		RR		r	r	r	n	RR	r	r	NBR (r)
Ammonium Hydroxide, <30%		rr	rr			rr						nn			
Ammonium Hydroxide, 30-70%		rr	rr			rr	r	r		r		R		RR	
Potassium Hydroxide	R	R	R	r		R		r		n		R	r	n	NBR (r)
Potassium Hydroxide, 30-70%	r	RR	RR			RR	r	r	r	r	n	RR	r		NBR (r)
Sodium Hydroxide	r	R	R	r		R		r	r	r		R			
Sodium Hydroxide, <30%			r					rr							
Sodium Hydroxide, 30-70%	r	RR	RR			RR	r	r	r	r	n	RR	r	rr	NBR (r), Saranex (rr)

Source: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
KETONES															
Aliphatic and Alicyclic (301)															
Acetone	RR	NN	NN	n	NN	NN	n	rr	r	n	NN	NN	r	NN	NBR (NN)
Bromoacetone															
Cyclohexanone	n	r	n			n			n	n		n			
Diisobutyl Ketone	r	N	n			rr	n	r	n	r	RR	N			
Isophorone												r			
Methyl Ethyl Ketone	RR	NN	NN	n	NN	NN	n	NN	n	n	NN	NN	n	NN	NBR (NN)
Methyl Isobutyl Ketone	R	NN	n			N	n	r	n	r	RR	N	r	n	NBR (r)
Alkyl-Aryl (302)															
Acetophenone															

Source: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP.,NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
LACTONES (400)															
2-Methyllactonitrile															
beta-Propiolactone	rr	NN	nn			nn		NN			NN	nn		nn	

Source: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
NITRILES															
Aliphatic and Alicyclic (431)															
Acetonitrile		r	r												
Acrylonitrile	r	n	R	n		N		r	NN	n		R		n	NBR (r)
3-Chloropropionitrile															
Malonitrile															
Methacrylonitrile															
2-Methyllactonitrile															
Aromatic (432)															
Benzonitrile															

Source: Arthur D. Little, Inc.

NITRO COMPOUNDS

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Unsubstituted (441)															
Nitrobenzene	nn	NN	N	n		N			nn	n	RR	N		r	NBR (r)
Nitroglycerine	r								r						
Nitromethane	n	NN	rr			NN					RR	n		n	
Nitropropane	rr	NN	NN			NN				nn	rr	nn		nn	
Nitrotoluene	nn								nn						
Tetranitromethane															
Substituted (442)															
Diethyl-p-nitrophenyl Phosphate															
Picric acid	r	R	R			R	r	r		r	n	n		r	
Picric acid, <30%		nn	RR			RR						nn			

Source: Arthur D. Little, Inc.

ORGANO PHOSPHOROUS COMPOUNDS

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
(400)															
O,O-diethyl S-Methyl Dithiophosphate															
Diethyl-p-nitrophenyl Phosphate															
Diisopropyl Fluorophosphate															
Hexethyltetraphosphate															
Hexamethylphosphoramide	rr		nn			rr		NN		nn				nn	
Tetraethyl-dithiopyrophosphate															NBR (r)
Tricresyl Phospate	r	nn	rr	n	r	rr	r		r	r	rr	rr	n	r	
Tris(2,3-dibromopropyl) Phosphate															

Source: Arthur D. Little, Inc.

ORGANO-METALLIC COMPOUNDS	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP./NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
(461)															
Dichlorophenylarsine															
Diethylarsine															
Tetraethyllead															

...: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
QUINONES (490)															
p-Benzoquinone															
Hydroquinone	n	R	R			N	r	r		r	n	n		r	
Hydroquinone, <30%		RR	RR			RR						RR			

Source: Arthur D. Little, Inc.

SULFUR COMPOUNDS	BUTYL	NAT. RUB.	NEOPRENE	NEOP. SBR	NEOP./NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Thiols ([illegible])															
Methylmercaptan															
Thiophenol															
Trichloromethanethiol															
Sulfides and Disulfides ([illegible])															
Carbon Disulfide	nn	N	N	n		NN	n	nn	NN	r	RR	N	n	r	
Thiophene															

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
SULFUR COMPOUNDS (Continued)															
Sulfoxides (503)															
Dimethylsulfoxide		rr	RR			RR						rr			
Sulfonic Acids (504)															
Chlorosulfonic Acid		n							nn					n	
Sulfonyl Chlorides (505)															
Benzenesulfonyl Chloride															
Others (507)															
Dimethylsulfate														r	
VINYL HALIDES (530)															
Vinyl Chloride	nr								rr			nr		r	
Vinylidene Chloride									nn						

Source: Arthur D. Little, Inc.

USERS' MATRIX B – CPC RECOMMENDATIONS BY CHEMICAL CLASS

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Acids, Carboxylic															
• Aliphatic and Alicyclic *															
— Unsubstituted	R	**	RR	r	r	RR		rr	r	r	n	RR	**	r	NBR (r)
— Polybasic	**	RR	RR			RR	r	r			n	RR		r	
Aldehydes															
• Aliphatic	R	**	**			**	**	r	**	r	n	rr	r	n	NBR (r)
• Aromatic and Heterocyclic	r	**	**	n	**	N	n	r	**	n	rr	N		n	NBR (r)
Amides, Carboxylic															
• Aliphatic	rr		NN			NN		**		nn				nn	
Amines															
• Aliphatic and Alicyclic															
— Primary	r	**	rr			RR	r	r	NN	r	rr	rr	**		NBR (r)
— Secondary	*	n	n			**	**	**	nn	r	**	**	**	**	NBR (r)
— Tertiary	r	rr	R	r	r	RR			rr	r	rr	RR		rr	
Ester, Carboxylic															
• Aliphatic															
— Acetates	**	NN	NN	n	**	NN	n	**	**	r	RR	NN	n	n	NBR (*)
— Higher Monobasic	r								NN			N			
• Aromatic															
— Phthalates	**	**	RR		r	RR					**	**		**	
Ethers, Aliphatic	rr	nn	**		**	RR					RR	NN		**	

* Class recommendations only for chemical classes in which two or more chemicals have recommendations for a given material. Double asterisks (**) indicate a wide variation in ratings within the class for the giv material. In these cases refer to Matrix A.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Halogen Compounds															
• Aliphatic															
— Unsubstituted	nn	NN	NN	n	NN	NN	n	NN	NN	nn	**	NN	n	RR	FEP or TFE (RR)
— Substituted	**	**	**		**	NN		nn	nn		**	NN			
• Aromatic															
— Unsubstituted	n	N	N			**		r	NN	**		N			
— Substituted		rr	RR			rr					NN	rr			
— Polynuclear	**	N	**		**						RR	N			
Heterocyclic Compounds															
— Epoxy Compounds	rr	n	**			**		**	**	nn	NN	n		n	
— Furan Derivatives	n	**	**		nn	NN	n	nn	nn	n	**	NN		n	
Hydrazines	**	**	**			**			**			**		**	
Hydrocarbons															
• Aliphatic and Alicyclic	NN	NN	RR	n	NN	RR	n	nn	r	R	RR	NN	n	RR	NBR (r)
• Aromatic	NN	NN	*	n	NN	*	n	nn	*	*	RR	NN	*	RR	NBR (r)
Hydroxyl Compounds															
• Aliphatic and Alicyclic															
— Primary	RR	**	RR	**		RR	r	r	r	r	**	**	**	rr	NBR (r)
— Secondary	**	RR	RR			RR	r	r	r	r	RR	RR		r	
— Polyols	rr					RR					RR	**			
• Aromatic	rr	**	RR		**	**	**	**	r	**	NN	**		**	

Note: Class recommendations only for chemical classes in which two or more chemicals have recommendations for a given material. Double asterisks (**) indicate a wide variation in ratings within the class for the given material. In these cases refer to Matrix A.

Source: Arthur D. Little, Inc.

	BUTYL	NAT. RUB.	NEOPRENE	NEOP./SBR	NEOP./NAT. RUB.	NITRILE	NITRILE/PVC	PE	CPE	PU	PVA	PVC	SBR	VITON	OTHERS
Inorganic Gas	r	n	R			n			rr			**		**	
Inorganic Salts									rr						
Inorganic Acids	**	**	**	n	**	**	**	rr	**	nr	nr	**	**	rr	NBR (r), Saranex (rr)
Inorganic Base	R	RR	RR	r		RR	r	r	r	r	nr	RR	r	**	NBR (r)
Ketones, Aliphatic	rr	NN	NN	n		NN	n	**	n	**	**	NN	r	NN	
Nitriles, Aliphatic	**	r													
Nitro — Unsubstituted	**	NN	**			NN			nn	nn	RR	nn		nn	
Organo-Phosphorous Compounds	rr		**			rr				**				**	
Peroxides	r	**	RR			RR				r		RR		r	
Vinyl Halides									**						

Note: Class recommendations only for chemical classes in which two or more chemicals have recommendations for a given material. Double asterisks (**) indicate a wide variation in ratings within the class for the given material. In these cases refer to Matrix A.

Source: Arthur D. Little, Inc.

APPENDIX A

GLOSSARY

GLOSSARY

Acetate — Polymer of cellulose acetate; a clear, relatively inexpensive material used for face and eye protection.

Acrylic — Polymer of methyl methacrylate; clear plastic used for face and eye protection.

Breakthrough Time — The time elapsed between initial contact of a chemical with the outside surface of a protective clothing material and the time at which the chemical can be detected at the inside surface of the material. Measured breakthrough times are dependent on the sensitivity of the analytical methods used to detect the chemical.

Baypren — See Neoprene.

Butyl Rubber — Copolymer of isobutylene and a small amount of isoprene. Material has good resistance to weathering and a wide variety of chemicals. Both supported and unsupported forms of butyl rubber are used as protective clothing.

Cellulose Propionate — Polymer; clear plastic used for face and eye protection.

Chlorobutyl Rubber — A chlorinated form of butyl rubber. Generally has better heat and chemical resistance than butyl rubber.

Chlorinated Polyethylene — CPE, Chloropel®. A polyethylene elastomer with a chlorine content of 36 to 45%. The material generally has better chemical resistance and physical properties than polyethylene.

CPE — See Chlorinated Polyethylene.

CR-39 — Polymer of allyl diglycol carbonate. A clear, impact resistant plastic used for face and eye protection.

Degradation — The loss in physical properties of an item of protective clothing due to exposure to chemicals, use, or ambient conditions (e.g., sunlight).

FEP — Polymer of fluorinated ethylene propylene. Polymer with exceptionally good chemical resistance with protective clothing applications in both film and coating form.

Flock-lined or Flocked — A layer of fibers, typically cotton, adhered to the inside of rubber gloves. The lining absorbs perspiration and provides some insulating effect.

Gore-Tex — A proprietary fabric in which microporous PTFE is laminated between nylon or polyester fabrics. The fabric allows the transmittance of heat and moisture vapor but not liquid water.

Latex — A stable dispersion of polymer or rubber particles in water. Latex gloves and coated fabrics are prepared by coagulating and cross-linking the particles on a form or cloth substrate. Most natural rubber, neoprene, and nitrile gloves are prepared from latices.

Latex Dipped — A glove prepared by dipping a glove form or a fabric glove into a rubber latex bath. In one dip, the entire amount of rubber that will form the glove is deposited.

Natural Rubber — Polyisoprene obtained from rubber plants. A highly flexible and conforming material used principally for gloves. High elasticity.

NBR (Nitrile-butadiene rubber) — Butadiene rubbers that typically contain 30-40% acrylonitrile. Chemigum®, Hycar®, Krynac®, and Paracril® are common brand names.

Neoprene — Polychloroprene. A synthetic rubber having chemical and wear resistance properties that are generally superior to those of natural rubber.

Nitrile Rubber — Copolymer of acrylonitrile and butadiene. Also known as acrylonitrile rubber, acrylonitrile-butadiene rubber, Buna-N, and nitrile-butadiene rubber (NBR). Trademarked names include Hycar®, Kyrnac®, and Paracril®. Used for supported and unsupported gloves, and coated fabric. Nitrile rubbers are available in a wide range of acrylonitrile concentrations. In general, the higher the acrylonitrile concentration the better the chemical resistance. However, stiffness also increases at higher acrylonitrile concentrations.

PE — See Polyethylene.

Penetration — The movement of chemical through zippers, stitched seams or imperfections (e.g., pinholed) in a protective clothing material.

Permeation — The process by which a chemical dissolves in and moves through a protective clothing material on a molecular level.

Permeation Rate — The rate at which the chemical moves through the clothing material. This is expressed in terms of amount per unit area per unit time.

Polyethylene — A fairly chemically resistant material that is used as a freestanding film (e.g., apron) or a fabric coating. Low density polyethylene is the most common form used in protective clothing.

Polycarbonate — A hard, transparent plastic used for face and eye protection. It has exceptional impact resistance and good chemical resistance, and is commonly used as the lens of safety glasses.

Polyester — A family of polymers that finds application in fiber form as clothing and in film form as a clear material for face and eye protection.

Polyurethane — An extensive and multi-branched family of polymers based on isocyanates. As used in protective clothing, polyurethanes are rubbery polymers that are either coated onto fabrics or formed into boots.

Polyvinyl Alcohol — A water-soluble polymer that, as long as it is dry, exhibits exceptional resistance to many organic solvents that rapidly permeate most rubbers. The material is somewhat stiff, thus limiting dexterity.

PU — See Polyurethane.

PVA — See Polyvinyl Alcohol.

PVC — See Polyvinyl Chloride.

Polyvinyl Chloride — A stiff polymer that is made suitable for protective clothing applications by the addition of plasticizers. Used as a freestanding material for gloves, aprons, etc. as well as coatings for fabrics. Clear forms are also available as flexible face shields.

Safeguard CPF — A proprietary, nonwoven fabric for limited-use (i.e., disposable) clothing.

Saranex — Multilayer laminate of polyethylene and Saran®.

Sontara — A proprietary spun-laced, limited use fabric.

SBR (Styrene-butadiene Rubber) — Also known as Buna-S. Trademark names include Solprene®, Plioflex®, and Stereon®. Used for fabric coatings and boots.

Solvent Dipped — A glove prepared by repeatedly dipping a glove form or glove substrate into a solution of the rubber in a solvent. The rubber is subsequently cured.

Supported — Materials containing a substrate such as cotton, polyester or nylon fabric or scrim which is coated, laminated or impregnated with a polymer or rubber.

TFE (PTFE) — Polytetrafluoroethylene. An example is Teflon®.

Tyvek — A proprietary, nonwoven fabric for limited use (e.g., disposable) clothing.

Viton — A proprietary fluoroelastomer. Highly chemically resistant, but expensive synthetic elastomer.

APPENDIX B

CHEMICAL INDEX

CHEMICAL NAMES AND SYNONYMS

NAME:	SYN:	CASNO:	CLASS:
Acetaldehyde		00075070	121
Acetic Acid		00064197	102
Acetic Anhydride		00108247	161
Acetone		00067641	391
Acetone Cyanohydrin	(See 2-Methyllactonitrile)		
Acetonitrile		00075058	431
Acetophenone		00098862	393
Acetyl Bromide		00506967	111
Acetyl Chloride		00075365	111
Acrolein		00107028	121
Acrylic Acid		00079107	102
Acrylonitrile		00107131	431
Allyl Alcohol		00107186	311
Allyl Chloride	3-Chloroprene	00107051	261
2-Aminoethanol	(See Ethanolamine)		
Ammonia		07664417	350
Ammonium Hydroxide		01336216	380

CHEMICAL NAMES AND SYNONYMS

NAME:	Ammonium Hydroxide, <30%	CASNO:	01336216
SYN:		CLASS:	380
NAME:	Ammonium Hydroxide, 30-70%	CASNO:	01336216
SYN:		CLASS:	380
NAME:	Amyl Acetate	CASNO:	00628637
SYN:		CLASS:	222
NAME:	Amyl Alcohol	CASNO:	00071410
SYN:		CLASS:	311
NAME:	Aniline	CASNO:	00062533
SYN:	Benzamine	CLASS:	145
NAME:	Antimony Pentachloride	CASNO:	07647189
SYN:		CLASS:	370
NAME:	Aroclor	CASNO:	
SYN:	(See Polychlorinated Biphenyls)	CLASS:	
NAME:	Aziridine	CASNO:	
SYN:	(See Ethylenimine)	CLASS:	
NAME:	Benzal Chloride	CASNO:	
SYN:	(See Benzyl Dichloride)	CLASS:	
NAME:	Benzaldehyde	CASNO:	00100527
SYN:		CLASS:	122
NAME:	Benzamine	CASNO:	
SYN:	(See Aniline)	CLASS:	
NAME:	1,3-Benzendiol	CASNO:	
SYN:	(See Resorcinol)	CLASS:	
NAME:	Benzene	CASNO:	00071432
SYN:		CLASS:	292
NAME:	Benzenesulfonyl Chloride	CASNO:	00098099
SYN:		CLASS:	505
NAME:	Benzenethiol	CASNO:	
SYN:	(See Thiophenol)	CLASS:	
NAME:	Benzidine	CASNO:	00092875
SYN:		CLASS:	147
NAME:	Benzonitrile	CASNO:	00100470
SYN:		CLASS:	432

CHEMICAL NAMES AND SYNONYMS

NAME: p-Benzoquinone
SYN:

NAME: Benzotrichloride
SYN: (Trichloromethyl)benzene

NAME: Benzoyl Chloride
SYN:

NAME: Benzyl Chloride
SYN: Chloromethyl Benzene

NAME: Benzyl Dichloride
SYN: Benzal Chloride

NAME: 2,2'-Bioxirane
SYN: Erythritol Anhydride

NAME: Bis(2-chloroethoxy) Methane
SYN: Dichloroethyl Formal

NAME: Bis(2-chloroisopropyl) Ether
SYN: (See Dichloroisopropyl Ether)

NAME: Bis(chloromethyl) Ether
SYN: sym-Dichloromethyl Ether

NAME: Bis(2-ethylhexyl) Phthalate
SYN: Di(2-ethylhexyl) Phthalate

NAME: Bromine Cyanide
SYN: (See Cyanogen Bromide)

NAME: Bromoacetone
SYN:

NAME: Bromoform
SYN: (See Tribromomethane)

NAME: Bromomethane
SYN: (See Methyl Bromide)

NAME: 4-Bromophenyl Phenyl Ether
SYN:

NAME: Butane
SYN:

NAME: 1,3-Butanediol
SYN: (See 1,3-Butylene Glycol)

CHEMICAL NAMES AND SYNONYMS

NAME: 1-Butanol — CASNO:
SYN: (See n-Butyl Alcohol) — CLASS:

NAME: 2-Butanone — CASNO:
SYN: (See Methyl Ethyl Ketone) — CLASS:

NAME: 2-Butenal — CASNO:
SYN: (See Crotonaldehyde) — CLASS:

NAME: Butyl Acetate — CASNO: 00123864
SYN: — CLASS: 222

NAME: n-Butyl Alcohol — CASNO: 00071363
SYN: 1-Butanol — CLASS: 311

NAME: Butylamine — CASNO: 00109739
SYN: — CLASS: 141

NAME: Butyl Benzyl Phthalate — CASNO: 00085687
SYN: — CLASS: 226

NAME: 1,3-Butylene Glycol — CASNO: 00107880
SYN: 1,3-Butanediol — CLASS: 316

NAME: n-Butyl Phthalate — CASNO:
SYN: (See Di-n-butyl Phthalate) — CLASS:

NAME: Butyric Acid — CASNO: 00107926
SYN: — CLASS: 102

NAME: Carbolic Acid — CASNO:
SYN: (See Phenol) — CLASS:

NAME: Carbon Bisulfide — CASNO:
SYN: (See Carbon Disulfide) — CLASS:

NAME: Carbon Disulfide — CASNO: 00075150
SYN: Carbon Bisulfide — CLASS: 502

NAME: Carbon Oxyfluoride — CASNO: 00353504
SYN: — CLASS: 350

NAME: Carbon Tetrachloride — CASNO: 00056235
SYN: Tetrachloromethane — CLASS: 261

NAME: Carbonyl Chloride — CASNO:
SYN: (See Phosgene) — CLASS:

NAME: Chloral — CASNO:
SYN: (See Trichloroacetaldehyde) — CLASS:

CHEMICAL NAMES AND SYNONYMS

NAME:	Chlorine	CASNO:	07782505
SYN:		CLASS:	350
NAME:	Chlorine Cyanide	CASNO:	
SYN:	(See Cyanogen Chloride)	CLASS:	
NAME:	Chloroacetaldehyde	CASNO:	00107200
SYN:		CLASS:	121 262
NAME:	p-Chloroaniline	CASNO:	00106478
SYN:	4-Chlorobenzamine	CLASS:	145 264
NAME:	4-Chlorobenzamine	CASNO:	
SYN:	(See p-Chloroaniline)	CLASS:	
NAME:	Chlorobenzene	CASNO:	00108907
SYN:		CLASS:	263
NAME:	p-Chloro-m-cresol	CASNO:	00059507
SYN:		CLASS:	292 316 264
NAME:	Chlorodibromomethane	CASNO:	00124481
SYN:		CLASS:	261
NAME:	1-Chloro-2,3-epoxy Propane	CASNO:	
SYN:	(See Epichlorohydrin)	CLASS:	
NAME:	Chloroethane	CASNO:	00075003
SYN:		CLASS:	261
NAME:	Chloroethene	CASNO:	
SYN:	(See Vinyl Chloride)	CLASS:	
NAME:	2-Chloroethyl Vinyl Ether	CASNO:	00110758
SYN:		CLASS:	241 262
NAME:	Chloroform	CASNO:	00067663
SYN:	Trichloromethane	CLASS:	261
NAME:	Chloromethane	CASNO:	
SYN:	(See Methyl Chloride)	CLASS:	
NAME:	Chloromethyl Benzene	CASNO:	
SYN:	(See Benzyl Chloride)	CLASS:	
NAME:	Chloromethyl Methyl Ether	CASNO:	00107302
SYN:		CLASS:	241 262
NAME:	2-Chloronaphthalene	CASNO:	00091587
SYN:		CLASS:	265

NAME: Chloronaphthalenes (all isomers) CASNO: 25586430
SYN: CLASS: 265

NAME: 2-Chlorophenol CASNO: 00095578
SYN: CLASS: 316 264

NAME: 4-Chlorophenyl Phenyl Ether CASNO: 07005723
SYN: CLASS: 265 242

NAME: 3-Chloroprene CASNO:
SYN: (See Allyl Chloride) CLASS:

NAME: 1-Chloropropane CASNO: 00540545
SYN: Propyl Chloride CLASS: 261

NAME: 3-Chloropropionitrile CASNO: 00542767
SYN: CLASS: 262 431

NAME: Chlorosulfonic Acid CASNO: 07790945
SYN: CLASS: 370 504

NAME: Chromic Acid CASNO: 11115745
SYN: CLASS: 370

NAME: Citric Acid CASNO: 00077929
SYN: CLASS: 313

NAME: Citric Acid, <30% CASNO: 00077929
SYN: CLASS: 313

NAME: Creosote CASNO: 08001589
SYN: CLASS: 292 316

NAME: m-Cresol CASNO: 00108394
SYN: CLASS: 292 316

NAME: Cresols CASNO: 01319773
SYN: CLASS: 292 316

NAME: Crotonaldehyde CASNO: 04170303
SYN: 2-Butenal CLASS: 121

NAME: Cumene CASNO: 00098828
SYN: 1-Methyl Ethyl Benzene CLASS: 292

NAME: Cyanogen CASNO: 00460195
SYN: CLASS: 350

NAME: Cyanogen Bromide CASNO: 00506683
SYN: Bromine Cyanide CLASS: 215 350

CHEMICAL NAMES AND SYNONYMS

NAME: Cyanogen Chloride — CASNO: 00506774
SYN: Chlorine Cyanide — CLASS: 215 350

NAME: Cyclohexane — CASNO: 00110827
SYN: — CLASS: 291

NAME: Cyclohexanol — CASNO: 00108930
SYN: — CLASS: 312

NAME: Cyclohexanone — CASNO: 00108941
SYN: — CLASS: 391

NAME: Diamine — CASNO:
SYN: (See Hydrazine) — CLASS:

NAME: 1,2-Diaminoethane — CASNO:
SYN: (See Ethylenediamine) — CLASS:

NAME: 1,2-Dibromo-3-chloropropane — CASNO: 00096128
SYN: — CLASS: 262

NAME: 1,2-Dibromoethane — CASNO:
SYN: (See Ethylene Dibromide) — CLASS:

NAME: Dibromomethane — CASNO:
SYN: (See Methylene Bromide) — CLASS:

NAME: Di-n-butyl Phthalate — CASNO: 00084742
SYN: n-Butyl Phthalate — CLASS: 226

NAME: Dichlorobenzene — CASNO: 25321226
SYN: — CLASS: 263

NAME: 1,2-Dichlorobenzene — CASNO: 00095501
SYN: — CLASS: 263

NAME: 1,3-Dichlorobenzene — CASNO: 00541731
SYN: — CLASS: 263

NAME: 1,4-Dichlorobenzene — CASNO: 00106467
SYN: — CLASS: 263

NAME: Dichlorobromomethane — CASNO: 00075274
SYN: — CLASS: 261

NAME: 1,4-Dichloro-2-butene — CASNO: 00110576
SYN: — CLASS: 261

NAME: Dichlorodifluoromethane — CASNO:
SYN: (See Freon 12) — CLASS:

CHEMICAL NAMES AND SYNONYMS

NAME:	Dichloroethane	CASNO:	01300216
SYN:		CLASS:	261
NAME:	1,2-Dichloroethane	CASNO:	
SYN:	(See Ethylene Dichloride)	CLASS:	
NAME:	1,1-Dichloroethane	CASNO:	
SYN:	(See Ethylidene Dichloride)	CLASS:	
NAME:	Dichloroethene	CASNO:	—
SYN:	(See Dichloroethylene (all isomers))	CLASS:	
NAME:	Dichloroethylene (all isomers)	CASNO:	25323302
SYN:	Dichloroethene	CLASS:	261
NAME:	trans-1,2-Dichloroethylene	CASNO:	00156605
SYN:		CLASS:	261
NAME:	1,1-Dichloroethylene	CASNO:	
SYN:	(See Vinylidene Chloride)	CLASS:	
NAME:	1,2-Dichloroethylene	CASNO:	00540590
SYN:		CLASS:	261
NAME:	2,2'-Dichloroethyl Ether	CASNO:	00111444
SYN:		CLASS:	241 262
NAME:	Dichloroethyl Formal	CASNO:	
SYN:	(See Bis(2-chloroethoxy) Methane)	CLASS:	
NAME:	Dichloroisopropyl Ether	CASNO:	00108601
SYN:	Bis(2-chloroisopropyl) Ether	CLASS:	241 262
NAME:	Dichloromethane	CASNO:	
SYN:	(See Methylene Chloride)	CLASS:	
NAME:	sym-Dichloromethyl Ether	CASNO:	
SYN:	(See Bis(chloromethyl) Ether)	CLASS:	
NAME:	2,4-Dichlorophenol	CASNO:	00120832
SYN:		CLASS:	264 316
NAME:	2,6-Dichlorophenol	CASNO:	00087650
SYN:		CLASS:	264 316
NAME:	Dichlorophenylarsine	CASNO:	00696286
SYN:	Phenyl Dichloroarsine	CLASS:	461
NAME:	1,2-Dichloropropane	CASNO:	00078875
SYN:	Propylene Dichloride	CLASS:	261

CHEMICAL NAMES AND SYNONYMS

NAME:	Dichloropropane (all isomers)	CASNO:	26638197
SYN:		CLASS:	261
NAME:	Dichloropropane-Dichloropropene	CASNO:	08003198
SYN:		CLASS:	261
NAME:	Dichloropropane(s)	CASNO:	26952238
SYN:		CLASS:	261
NAME:	1,3-Dichloropropene	CASNO:	00542756
SYN:		CLASS:	261
NAME:	Di(2-ethylhexyl) Phthalate	CASNO:	
SYN:	(See Bis(2-ethylhexyl) Phthalate)	CLASS:	
NAME:	Diethylamine	CASNO:	00109897
SYN:		CLASS:	142
NAME:	Diethylarsine	CASNO:	00692422
SYN:		CLASS:	461
NAME:	1,4-Diethylene Dioxide	CASNO:	
SYN:	(See 1,4-Dioxane)	CLASS:	
NAME:	1,2-Diethylhydrazine	CASNO:	01615801
SYN:		CLASS:	280
NAME:	O,O-Diethyl S-Methyl Dithiophosphate	CASNO:	03288582
SYN:		CLASS:	460
NAME:	Diethyl-p-nitrophenyl Phosphate	CASNO:	00311455
SYN:		CLASS:	460 442
NAME:	Diethyl Phthalate	CASNO:	00084662
SYN:		CLASS:	226
NAME:	Diheptyl Phthalate	CASNO:	03648213
SYN:		CLASS:	226
NAME:	Dihydrosafrole	CASNO:	00094586
SYN:		CLASS:	278
NAME:	Diisobutyl Ketone	CASNO:	00108838
SYN:	2,6-Dimethyl-4-heptanone	CLASS:	391
NAME:	Diisobutyl Phthalate	CASNO:	00084695
SYN:		CLASS:	226
NAME:	Diisooctyl Phthalate	CASNO:	27554263
SYN:		CLASS:	226

NAME:	Diisodecyl Phthalate	CASNO:	26761400
SYN:		CLASS:	226
NAME:	Diisononyl Phthalate	CASNO:	28553120
SYN:		CLASS:	226
NAME:	Diisopropyl Ether	CASNO:	
SYN:	(See Isopropyl Ether)	CLASS:	
NAME:	Diisopropyl Fluorophosphate	CASNO:	00055914
SYN:		CLASS:	460 262
NAME:	Dimethylamine	CASNO:	00124403
SYN:		CLASS:	142
NAME:	alpha,alpha-Dimethylbenzyl Hydroperoxide	CASNO:	00080159
SYN:		CLASS:	300
NAME:	Dimethylformamide	CASNO:	00068122
SYN:		CLASS:	132
NAME:	2,6-Dimethyl-4-heptanone	CASNO:	
SYN:	(See Diisobutyl Ketone)	CLASS:	
NAME:	1,1-Dimethylhydrazine	CASNO:	00057147
SYN:	unsymmetrical-Dimethylhydrazine	CLASS:	280
NAME:	sym-Dimethylhydrazine	CASNO:	
SYN:	(See 1,2-Dimethylhydrazine)	CLASS:	
NAME:	unsymmetrical-Dimethylhydrazine	CASNO:	
SYN:	(See 1,1-Dimethylhydrazine)	CLASS:	
NAME:	1,2-Dimethylhydrazine	CASNO:	00540738
SYN:	sym-Dimethylhydrazine	CLASS:	280
NAME:	alpha,alpha-Dimethylphenethylamine	CASNO:	00122098
SYN:		CLASS:	141 145
NAME:	2,4-Dimethylphenol	CASNO:	00105679
SYN:		CLASS:	316
NAME:	Dimethyl Phthalate	CASNO:	00131113
SYN:		CLASS:	226
NAME:	Dimethyl Sulfate	CASNO:	00077781
SYN:		CLASS:	507
NAME:	Dimethyl Sulfoxide	CASNO:	00067685
SYN:		CLASS:	503

NAME:	Dinonyl Phthalate	CASNO:	00084764
SYN:		CLASS:	226
NAME:	Di-n-octyl Phthalate	CASNO:	00117840
SYN:		CLASS:	226
NAME:	1,4-Dioxane	CASNO:	00123911
SYN:	1,4-Diethylene Dioxide	CLASS:	278
NAME:	Dipropylamine	CASNO:	00142847
SYN:		CLASS:	142
NAME:	Dithiophosphoric Acid	CASNO:	
SYN:	(See Tetraethyldithiopyrophosphate)	CLASS:	
NAME:	Diundecyl Phthalate	CASNO:	03648202
SYN:		CLASS:	226
NAME:	Epichlorohydrin	CASNO:	00106898
SYN:	1-Chloro-2,3-epoxy Propane	CLASS:	275 262
NAME:	Erythritol Anhydride	CASNO:	
SYN:	(See 2,2'-Bioxirane)	CLASS:	
NAME:	Ethane	CASNO:	00074840
SYN:		CLASS:	291
NAME:	Ethanol	CASNO:	00064175
SYN:	Ethyl alcohol	CLASS:	311
NAME:	Ethanol, 30-70%	CASNO:	00064175
SYN:	Ethyl Alcohol	CLASS:	311
NAME:	Ethanol, >70%	CASNO:	00064175
SYN:	Ethyl Alcohol	CLASS:	311
NAME:	Ethanolamine	CASNO:	00141435
SYN:	2-Aminoethanol	CLASS:	141 311
NAME:	Ethyl Acetate	CASNO:	00141786
SYN:		CLASS:	222
NAME:	Ethyl Acrylate	CASNO:	00140885
SYN:		CLASS:	223
NAME:	Ethyl Alcohol	CASNO:	
SYN:	(See Ethanol)	CLASS:	
NAME:	Ethylamine	CASNO:	00075047
SYN:	Monoethylamine	CLASS:	141

CHEMICAL NAMES AND SYNONYMS

NAME:	Ethyl Benzene	CASNO:	00100414
SYN:		CLASS:	292
NAME:	Ethyl Cyanide	CASNO:	00107120
SYN:		CLASS:	215
NAME:	Ethyldimethylmethane	CASNO:	
SYN:	(See Isopentane)	CLASS:	
NAME:	Ethylene Bromide	CASNO:	
SYN:	(See Ethylene Dibromide)	CLASS:	
NAME:	Ethylene Chloride	CASNO:	
SYN:	(See Ethylene Dichloride)	CLASS:	
NAME:	Ethylenediamine	CASNO:	00107153
SYN:	1,2-Diaminoethane	CLASS:	144
NAME:	Ethylene Dibromide	CASNO:	00106934
SYN:	1,2-Dibromoethane, Ethylene Bromide	CLASS:	261
NAME:	Ethylene Dichloride	CASNO:	00107062
SYN:	1,2-Dichloroethane, Ethylene Chloride	CLASS:	261
NAME:	Ethylene Glycol	CASNO:	00107211
SYN:		CLASS:	314
NAME:	Ethylene Oxide	CASNO:	00075218
SYN:	Oxirane	CLASS:	275
NAME:	Ethylenimine	CASNO:	00151564
SYN:	Aziridine	CLASS:	274 142
NAME:	Ethyl Ether	CASNO:	00060297
SYN:		CLASS:	261
NAME:	Ethylidene Dichloride	CASNO:	00075343
SYN:	1,1-Dichloroethane	CLASS:	261
NAME:	Ethyl Methacrylate	CASNO:	00097632
SYN:		CLASS:	223
NAME:	Ethyl Methanesulfonate	CASNO:	00062500
SYN:		CLASS:	232
NAME:	Fluorine	CASNO:	07782414
SYN:		CLASS:	350
NAME:	Formaldehyde, <37%	CASNO:	00050000
SYN:	Formalin	CLASS:	121

CHEMICAL NAMES AND SYNONYMS

NAME:	Formalin	CASNO:	
SYN:	(See Formaldehyde, <30%)	CLASS:	
NAME:	Formic Acid	CASNO:	00064186
SYN:	Methanoic Acid	CLASS:	102
NAME:	Freon TF	CASNO:	00076131
SYN:	Trichlorotrifluoroethane	CLASS:	261
NAME:	Freon TMC	CASNO:	57762319
SYN:	1,1,2-Trichloro-1,2,2-trifluoroethane	CLASS:	261
NAME:	Freon 11	CASNO:	00075694
SYN:	Trichloromonofluoromethane	CLASS:	261
NAME:	Freon 12	CASNO:	00075718
SYN:	Dichlorodifluoromethane	CLASS:	261
NAME:	Furan	CASNO:	00110009
SYN:	Furfuran	CLASS:	277
NAME:	Furfural	CASNO:	00098011
SYN:		CLASS:	277 122
NAME:	Furfuran	CASNO:	
SYN:	(See Furan)	CLASS:	
NAME:	Gasoline	CASNO:	08006619
SYN:		CLASS:	291 292
NAME:	Glycidaldehyde	CASNO:	00765344
SYN:		CLASS:	275 122
NAME:	Heptane	CASNO:	00142825
SYN:		CLASS:	291
NAME:	Hexachlorobenzene	CASNO:	00118741
SYN:		CLASS:	263
NAME:	Hexachlorobutadiene	CASNO:	00087683
SYN:		CLASS:	261
NAME:	Hexachloropropene	CASNO:	01888717
SYN:		CLASS:	261
NAME:	Hexaethyltetraphosphate	CASNO:	00757584
SYN:		CLASS:	460
NAME:	Hexamethylphosphoamide	CASNO:	00680319
SYN:		CLASS:	132 460

CHEMICAL NAMES AND SYNONYMS

NAME:	Hexane	CASNO:	00110543
SYN:		CLASS:	291
NAME:	Hydrazine	CASNO:	00302012
SYN:	Diamine	CLASS:	280
NAME:	Hydrazine, 30-70%	CASNO:	00302012
SYN:	Diamine	CLASS:	280
NAME:	Hydrochloric Acid	CASNO:	07647010
SYN:		CLASS:	370
NAME:	Hydrochloric Acid, <30%	CASNO:	07647010
SYN:		CLASS:	370
NAME:	Hydrocloric Acid, 30-70%	CASNO:	07647010
SYN:		CLASS:	370
NAME:	Hydrocyanic Acid	CASNO:	00074908
SYN:		CLASS:	215 350
NAME:	Hydrofluoric Acid	CASNO:	07664393
SYN:		CLASS:	370
NAME:	Hydrofluoric Acid; <30%	CASNO:	07664393
SYN:		CLASS:	370
NAME:	Hydrofluoric Acid, 30-70%	CASNO:	07664393
SYN:		CLASS:	370
NAME:	Hydrogen Peroxide	CASNO:	07722841
SYN:		CLASS:	300
NAME:	Hydrogen Peroxide, 30-70%	CASNO:	07722841
SYN:		CLASS:	300
NAME:	Hydrogen Phosphide	CASNO:	
SYN:	(See Phosphine)	CLASS:	
NAME:	Hydrogen Sulfide	CASNO:	07783064
SYN:		CLASS:	350
NAME:	Hydroquinone	CASNO:	00123319
SYN:		CLASS:	490
NAME:	Hydroquinone, <30%	CASNO:	00123319
SYN:		CLASS:	490
NAME:	Isoamyl Acetate	CASNO:	00123922
SYN:		CLASS:	222

NAME:	Isobutane	CASNO:	
SYN:	(See Isobutylene)	CLASS:	
NAME:	Isobutyl Alcohol	CASNO:	00078831
SYN:		CLASS:	311
NAME:	Isobutylene	CASNO:	00115117
SYN:	Isobutane	CLASS:	291
NAME:	Isooctane	CASNO:	26635643
SYN:		CLASS:	291
NAME:	Isopentane	CASNO:	00078784
SYN:	2-Methylbutane, Ethyldimethylmethane	CLASS:	291
NAME:	Isophorone	CASNO:	00078591
SYN:		CLASS:	391
NAME:	Isoprene	CASNO:	00078795
SYN:		CLASS:	291
NAME:	Isopropyl Alcohol	CASNO:	00067630
SYN:		CLASS:	312
NAME:	Isopropylamine	CASNO:	00075310
SYN:		CLASS:	141
NAME:	Isopropyl Ether	CASNO:	00108203
SYN:	Diisopropyl Ether	CLASS:	241
NAME:	Isosafrole	CASNO:	00120581
SYN:		CLASS:	278
NAME:	JP-4, Jet Fuel	CASNO:	99901291
SYN:		CLASS:	291 292
NAME:	Kerosene	CASNO:	08008206
SYN:		CLASS:	291 292
NAME:	Lactic Acid	CASNO:	00079334
SYN:		CLASS:	103 312
NAME:	Lauric Acid	CASNO:	00143077
SYN:		CLASS:	102
NAME:	Ligroine	CASNO:	
SYN:	(See Naphtha, V.M.& P)	CLASS:	
NAME:	Maleic Acid	CASNO:	00110167
SYN:		CLASS:	104

CHEMICAL NAMES AND SYNONYMS

NAME:	Malonitrile	CASNO:	00109773
SYN:	Propane Dinitrile	CLASS:	431
NAME:	Methacrylonitrile	CASNO:	00126987
SYN:		CLASS:	431
NAME:	Methane	CASNO:	00074828
SYN:		CLASS:	291
NAME:	Methanethiol	CASNO:	
SYN:	(See Methylmercaptan)	CLASS:	
NAME:	Methanoic Acid	CASNO:	
SYN:	(See Formic Acid)	CLASS:	
NAME:	Methanol	CASNO:	00067561
SYN:	Methyl Alcohol	CLASS:	311
NAME:	Methanol, <30%	CASNO:	00067561
SYN:	Methyl Alcohol	CLASS:	311
NAME:	Methanol, >70%	CASNO:	00067561
SYN:	Methyl Alcohol	CLASS:	311
NAME:	Methyl Alcohol	CASNO:	
SYN:	(See Methanol)	CLASS:	
NAME:	Methylamine	CASNO:	00074895
SYN:	Monomethylamine	CLASS:	141
NAME:	2-Methylaziridine	CASNO:	00075558
SYN:	1,2-Propyleneimine	CLASS:	274 142
NAME:	Methyl Bromide	CASNO:	00074839
SYN:	Bromomethane	CLASS:	261
NAME:	1-Methylbutadine	CASNO:	
SYN:	(See 1,3-Pentadiene)	CLASS:	
NAME:	2-Methylbutane	CASNO:	
SYN:	(See Isopentane)	CLASS:	
NAME:	Methyl Chloride	CASNO:	00074873
SYN:	Chloromethane	CLASS:	261
NAME:	Methyl Chloroform	CASNO:	00071556
SYN:	1,1,1-Trichloroethane	CLASS:	262
NAME:	Methyl Chloroformate	CASNO:	00079221
SYN:		CLASS:	221

CHEMICAL NAMES AND SYNONYMS

NAME:	Methylcyclohexane	CASNO:	00108872
SYN:		CLASS:	291
NAME:	Methylene Bromide	CASNO:	00074953
SYN:	Dibromomethane	CLASS:	261
NAME:	Methylene Chloride	CASNO:	00075092
SYN:	Dichloromethane	CLASS:	261
NAME:	4,4'-Methylenedianiline	CASNO:	00101779
SYN:		CLASS:	147
NAME:	1-Methyl Ethyl Benzene	CASNO:	
SYN:	(See Cumene)	CLASS:	
NAME:	Methyl Ethyl Ketone	CASNO:	00078933
SYN:	2-Butanone	CLASS:	391
NAME:	Methyl Ethyl Ketone Peroxide	CASNO:	01338234
SYN:		CLASS:	300
NAME:	Methylhydrazine	CASNO:	00060344
SYN:		CLASS:	280
NAME:	Methyl Iodide	CASNO:	00074884
SYN:		CLASS:	261
NAME:	Methyl Isobutyl Ketone	CASNO:	00108101
SYN:		CLASS:	391
NAME:	Methyl Isocyanate	CASNO:	00624839
SYN:		CLASS:	210
NAME:	2-Methyllactonitrile	CASNO:	00075865
SYN:	Acetone Cyanohydrin	CLASS:	431 400
NAME:	Methylmercaptan	CASNO:	00074931
SYN:	Methanethiol, Thiomethanol	CLASS:	501
NAME:	Methyl Methacrylate	CASNO:	00080626
SYN:		CLASS:	223
NAME:	2-Methyl Pyridine	CASNO:	
SYN:	(See 2-Picoline)	CLASS:	
NAME:	Mineral Spirits	CASNO:	08052413
SYN:		CLASS:	291
NAME:	Monoethylamine	CASNO:	
SYN:	(See Ethylamine)	CLASS:	

CHEMICAL NAMES AND SYNONYMS

NAME:	Monomethylamine	CASNO:	
SYN:	(See Methylamine)	CLASS:	
NAME:	Morpholine	CASNO:	00110918
SYN:		CLASS:	142
NAME:	Naphtha, V.M.& P	CASNO:	08032324
SYN:	Ligroine	CLASS:	291
NAME:	Neopentane	CASNO:	00463821
SYN:		CLASS:	291
NAME:	Nickel Carbonyl	CASNO:	13463393
SYN:		CLASS:	350
NAME:	Nitric Acid, <30%	CASNO:	07697372
SYN:		CLASS:	370
NAME:	Nitric Acid, 30-70%	CASNO:	07697372
SYN:		CLASS:	370
NAME:	Nitric Acid, >70%	CASNO:	07697372
SYN:		CLASS:	370
NAME:	Nitric Oxide	CASNO:	10102439
SYN:		CLASS:	350
NAME:	Nitrobenzene	CASNO:	00098953
SYN:		CLASS:	441 292
NAME:	Nitrogen Dioxide	CASNO:	10102440
SYN:		CLASS:	350
NAME:	Nitrogen Tetroxide	CASNO:	10544726
SYN:		CLASS:	350
NAME:	Nitroglycerine	CASNO:	00055630
SYN:		CLASS:	441
NAME:	Nitromethane	CASNO:	00075525
SYN:		CLASS:	441
NAME:	Nitropropane	CASNO:	25322014
SYN:		CLASS:	441
NAME:	Nitrotoluene	CASNO:	01321126
SYN:		CLASS:	441
NAME:	n-Octanol	CASNO:	29063283
SYN:		CLASS:	311

CHEMICAL NAMES AND SYNONYMS

NAME	SYN	CASNO	CLASS
Oleic Acid		00112801	102
Oxalic Acid		00144627	104
Oxirane	(See Ethylene Oxide)		
Palmitic Acid		00057103	102
Paraldehyde		00123637	121
Pentachloroethane		00076017	261
Pentachlorophenol		00087865	264 316
1,3-Pentadiene	1-Methylbutadiene	00504609	291
Pentane		00109660	291
Perchloric Acid		07601903	370
Perchloroethylene	(See Tetrachloroethylene)		
Perchloric Acid, 30-70%		07601903	370
Phenol	Carbolic Acid	00108952	316
Phenol, <30%	Carbolic Acid	00108952	316
Phenyl Dichloroarsine	(See Dichlorophenylarsine)		
Phosgene	Carbonyl Chloride	00075445	350
Phosphine	Hydrogen Phosphide	07803512	350

CHEMICAL NAMES AND SYNONYMS

NAME:	Phosphoric Acid	CASNO:	07664382
SYN:		CLASS:	370
NAME:	Phosphoric Acid, <30%	CASNO:	07664382
SYN:		CLASS:	370
NAME:	Phosphoric Acid, 30-70%	CASNO:	07664382
SYN:		CLASS:	370
NAME:	Phosphoric Acid, >70%	CASNO:	07664382
SYN:		CLASS:	370
NAME:	Phosphorus Oxychloride	CASNO:	10025873
SYN:		CLASS:	370
NAME:	Phospherus Trichloride	CASNO:	07719122
SYN:		CLASS:	370
NAME:	2-Picoline	CASNO:	00109068
SYN:	2-Methyl Pyridine	CLASS:	271
NAME:	Picric Acid	CASNO:	00088891
SYN:	2,4,6-Trinitrophenol	CLASS:	316 442
NAME:	Picric Acid, <30%	CASNO:	00088891
SYN:	2,4,6-Trinitrophenol	CLASS:	316 442
NAME:	Polychlorinated Biphenyls (PCBs)	CASNO:	01336363
SYN:	Aroclor	CLASS:	265
NAME:	Potassium Hydroxide	CASNO:	01310583
SYN:		CLASS:	380
NAME:	Potassium Hydroxide, <30%	CASNO:	01310583
SYN:		CLASS:	380
NAME:	Potassium Hydroxide, 30-70%	CASNO:	01310583
SYN:		CLASS:	380
NAME:	Propane Dinitrile	CASNO:	
SYN:	(See Malonirtile)	CLASS:	
NAME:	Propane	CASNO:	00074986
SYN:		CLASS:	291
NAME:	Propanol	CASNO:	
SYN:	(See Propyl Alcohol)	CLASS:	
NAME:	Propargyl Alcohol	CASNO:	00107197
SYN:		CLASS:	311

CHEMICAL NAMES AND SYNONYMS

NAME: Beta-Propiolactone — CASNO: 00057578
SYN: — CLASS: 400

NAME: Propionic Acid — CASNO: 00079094
SYN: — CLASS: 102

NAME: Propionic Anhydride — CASNO: 00123626
SYN: — CLASS: 161

NAME: Propyl Acetate — CASNO: 00109604
SYN: — CLASS: 222

NAME: Propyl Alcohol — CASNO: 00071238
SYN: Propanol — CLASS: 311

NAME: n-Propylamine — CASNO: 00107108
SYN: — CLASS: 141

NAME: Propyl Chloride — CASNO:
SYN: (see 1-Chloropropane) — CLASS:

NAME: Propylene Dichloride — CASNO:
SYN: (See 1,2-Dichloropropane) — CLASS:

NAME: Propylene Oxide — CASNO: 00075569
SYN: — CLASS: 275

NAME: 1,2-Propylenimine — CASNO:
SYN: (See 2-Methylaziridine) — CLASS:

NAME: Pyrethrins — CASNO: 00121299
SYN: — CLASS: 223

NAME: Pyridine — CASNO: 00110861
SYN: — CLASS: 271

NAME: Quinoline — CASNO: 00091225
SYN: — CLASS: 272

NAME: Resorcinol — CASNO: 00108463
SYN: 1,3-Benzendiol — CLASS: 316

NAME: Safrole — CASNO: 00094597
SYN: — CLASS: 278

NAME: Sodium Hydroxide — CASNO: 01310732
SYN: — CLASS: 380

NAME: Sodium Hydroxide, <30% — CASNO: 01310732
SYN: — CLASS: 380

CHEMICAL NAMES AND SYNONYMS

NAME:	Sodium Hydroxide, 30-70%	CASNO:	01310732
SYN:		CLASS:	380
NAME:	Styrene	CASNO:	00100425
SYN:		CLASS:	292
NAME:	Sulfuric Acid	CASNO:	07664939
SYN:		CLASS:	370
NAME:	Sulfuric Acid, <30%	CASNO:	07664939
SYN:		CLASS:	370
NAME:	Sulfuric Acid, 30-70%	CASNO:	07664939
SYN:		CLASS:	370
NAME:	Sulfuric Acid, >70%	CASNO:	07664939
SYN:		CLASS:	370
NAME:	Sulfur Monochloride	CASNO:	12771083
SYN:		CLASS:	370
NAME:	Tannic Acid	CASNO:	01401554
SYN:		CLASS:	224
NAME:	1,2,4,5-Tetrachlorobenzene	CASNO:	00095943
SYN:		CLASS:	263
NAME:	1,1,2,2-Tetrachloroethane	CASNO:	00079345
SYN:		CLASS:	261
NAME:	1,1,1,2-Tetrachloroethane	CASNO:	00630206
SYN:		CLASS:	261
NAME:	Tetrachloroethene	CASNO:	
SYN:	(See Tetrachloroethylene)	CLASS:	
NAME:	Tetrachloroethylene	CASNO:	00127184
SYN:	Perchloroethylene, Tetrachloroethene	CLASS:	261
NAME:	Tetrachloromethane	CASNO:	
SYN:	(See Carbon Tetrachloride)	CLASS:	
NAME:	Tetraethyldithiopyrophosphate	CASNO:	03689245
SYN:	Dithiophosphoric Acid	CLASS:	460
NAME:	Tetraethyllead	CASNO:	00078002
SYN:		CLASS:	460
NAME:	Tetrahydrofuran	CASNO:	00109999
SYN:		CLASS:	277

NAME:	Tetranitomethane	CASNO:	00509148
SYN:		CLASS:	441
NAME:	Thiomethanol	CASNO:	
SYN:	(See Methylmercaptan)	CLASS:	
NAME:	Thiophene	CASNO:	00110021
SYN:		CLASS:	502
NAME:	Thiophenol	CASNO:	00108985
SYN:	Benzenethiol	CLASS:	501
NAME:	Toluene	CASNO:	00108883
SYN:		CLASS:	292
NAME:	Toluene Diisocyanate	CASNO:	00584849
SYN:		CLASS:	210
NAME:	Tribromomethane	CASNO:	00075252
SYN:	Bromoform	CLASS:	261
NAME:	Trichloroacetaldehyde	CASNO:	00075876
SYN:	Chloral	CLASS:	121 262
NAME:	1,2,4-Trichlorobenzene	CASNO:	00120821
SYN:		CLASS:	263
NAME:	1,1,2-Trichloroethane	CASNO:	00079005
SYN:		CLASS:	261
NAME:	1,1,1-Trichloroethane	CASNO:	
SYN:	(See Methyl Chloroform)	CLASS:	
NAME:	Trichloroethene	CASNO:	
SYN:	(See Trichloroethylene)	CLASS:	
NAME:	Trichloroethylene	CASNO:	00079016
SYN:	Trichloroethene	CLASS:	261
NAME:	Trichloromethane	CASNO:	
SYN:	(See Chloroform)	CLASS:	
NAME:	Trichloromethanethiol	CASNO:	00075707
SYN:		CLASS:	262 501
NAME:	(Trichloromethyl)benzene	CASNO:	
SYN:	(See Benzotrichloride)	CLASS:	
NAME:	Trichloromonofluoromethane	CASNO:	
SYN:	(See Freon 11)	CLASS:	

CHEMICAL NAMES AND SYNONYMS

NAME: Trichlorotrifluoroethane
SYN: (See Freon TF)
CASNO:
CLASS:

NAME: Tricresyl Phosphate
SYN:
CASNO: 01330785
CLASS: 460

NAME: Triethanolamine
SYN:
CASNO: 00102716
CLASS: 143

NAME: Triethylamine
SYN:
CASNO: 00121448
CLASS: 143

NAME: Trifluoroethanol
SYN:
CASNO: 00075898
CLASS: 311 262

NAME: Trimethylamine
SYN:
CASNO: 00075503
CLASS: 143

NAME: 2,4,6-Trinitrophenol
SYN: (See Picric Acid)
CASNO:
CLASS:

NAME: Tris(2,3-dibromopropyl) Phosphate
SYN:
CASNO: 00126727
CLASS: 460

NAME: Turpentine
SYN:
CASNO: 08006642
CLASS: 291

NAME: Vinyl Acetate
SYN:
CASNO: 00108054
CLASS: 222

NAME: Vinyl Chloride
SYN: Chloroethene
CASNO: 00075014
CLASS: 530 261

NAME: Vinylidene Chloride
SYN: 1,1-Dichloroethylene
CASNO: 00075354
CLASS: 261 530

NAME: Xylene
SYN:
CASNO: 00133207
CLASS: 292

NAME: o-Xylene
SYN:
CASNO: 00095476
CLASS: 292

NAME: p-Xylene
SYN:
CASNO: 00106423
CLASS: 292