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Environmental Protection
Agency

Office of
Solid Waste and
Emergency Response

9285.9-24A
EPA/540/R-95/143
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EPA

EMERGENCY RESPONSE TO HAZARDOUS MATERIAL INCIDENTS

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FOREWORD

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

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

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

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

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

EMERGENCY RESPONSE TO HAZARDOUS MATERIAL INCIDENTS
(165.15)
5 Days

This course provides emergency response personnel, primarily firefighters, police officers, and emergency medical services personnel, with the information and skills needed to recognize, evaluate, and control an incident involving the release or potential release of hazardous materials. It is intended for members of hazardous materials response teams.

The focus of the course is on recognizing and evaluating a hazardous materials incident, organizing the response team, protecting response personnel, identifying and using response resources, implementing basic control measures, refining decision-making skills, and protecting the public. Firefighting techniques are not part of the course.

Topics that are discussed include chemical and physical properties of hazardous materials, toxicology, recognition and identification of hazardous materials, direct-reading instruments, standard operating procedures, personnel protection and safety, and sources of information.

Instructional methods used are lectures, class problem-solving sessions, and exercises. Emphasis is on the hands-on use of equipment to practically apply lecture information. Class members will participate in two simulations designed to apply and test the lessons learned during the week. Participants will wear fully encapsulating suits and chemical splash gear. Individuals who are not participating in a medical surveillance program should consult their physician prior to attending this course.

After completing the course, participants will be able to:

- Select the appropriate personal protective equipment for responding to an incident involving hazardous materials.
- Use combustible gas detectors, oxygen meters, and detector tubes to evaluate the hazards present at a hazardous materials incident.
- Use confinement and containment techniques to control the release of a hazardous material.
- Identify the importance of an incident command system for effectively managing an incident involving hazardous materials.
- Develop procedures for the decontamination of emergency response personnel.
- Use size-up techniques to develop strategies and select the appropriate tactics for mitigating hazardous material incidents.

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ACRONYMS

AAR - Association of American Railroads

ACGIH - American Conference of Governmental Industrial Hygienists

AC - Area Committee

ACP - Area Contingency Plans

AIChE - American Institute of Chemical Engineers

AIHA - American Industrial Hygiene Association

ANSI - American National Standards Institute

API - American Petroleum Institute

APF - Assigned Protection Factor

APR - Air-Purifying Respirator

ARC - American Red Cross

ARES - Amateur Radio Emergency Services

ASCS - Agricultural Stabilization and Conservation Service

ASME - American Society of Mechanical Engineers

ASSE - American Society of Safety Engineers

ASR - Atmosphere Supplying Respirator

ASTM - American Society of Testing and Materials

ATA - American Trucking Association

ATM - Atmosphere

ATSDR - Agency for Toxic Substances and Disease Register, Department of Health and Human Services

ATTIC - Alternative Treatment Technology Information Center

autoign - Autoignition

Avg - Average

aw - Atomic Weight

BAT - Battery

BBS - Bulletin Board System - Dataport

BC & G - Boot Covers and Gloves

BEI(s) - Biological Exposure Indices

BLEVE - Boiling Liquid Expanding Vapor Explosion

BOE - Bureau of Explosives

B of M - Bureau of Mines

BOD - Biological Oxygen Demand

BP - Boiling Point

*C - Degrees Celsius

C - Ceiling

CC - Close Cup Test

cc - Cubic Centimeter

CAA - Clean Air Act of 1977, as Amended

CAG - Carcinogen Assessment Group

CAER - Community Awareness and Emergency Response - Developed By Chemical Manufactures association

CAMEO - Computer Aided Management of Emergency Operations

CAS - Chemical Abstract Service

CCD - Condensed Chemical Dictionary

CCIRS - Chemical Carcinogenesis Research Information System, information on GENETOX with genetic assay studies; ACQUIRE with Aquatic toxicity information; DERMAL with dermal toxicity information.

CDC - Center for Disease Control

CEPP - Chemical Emergency Preparedness Program

CERCLA - Comprehensive Environmental Response Compensation and Liability Act (1980)

CESARS - Chemical Evaluation Search and Retrieval System

CFR - Code of Federal Regulations

CGA - Compress Gas Association

CGI - Combustible Gas Indicator

CHEMNET - A mutual aid network between chemical shippers and for hire contractors that advice and assist at incidents.

CHEMTREC - Chemical Transportation Emergency Center

CHLOREP - Chlorine Emergency Plan

CHRIS - Chemical Hazard Response Information System, by Coast Guard

CIS - Chemical Information System

CL - Ceiling Concentration

cm^2 - Square Centimeter

CMA - Chemical Manufacturers' Association

CNS - Central Nervous System

CO_2 - Carbon Dioxide

COC - Cleveland Open Cup Test

COFC - Container On Flat Car

compd - Compound(s)

conc - Concentration, Concentrated

COR - corrosive

CPC - Chemical Protective Clothing

CPE - Chlorinated Polyethylene (Chloropel)

CPM - Counts Per Minute

CPR - Cardiopulmonary Resuscitation

CRC - Chemical referral center - A publisher of scientific reference books

CRC - Contamination Reduction Corridor

CRGS - Chemical Regulations and Guidelines Systems

CRP - Community Relations Plan

CRZ - Contamination Reduction Zone

CSIN - Micro-Chemical Substances Information Network

CTC - Canadian Transport Commission

cu ft - Cubic Foot

cu m - Cubic Meter

CWA - Clean Water Act

2,4-D - Dichlorophenoxy = acetic acid

d - Density

D - Day

dBA - Decibels-A-weighted

DBCP - Dibromochloropropane

DBIR - Directory of Biotechnology Information Resources

decomp,dec - Decomposition

dil - Dilute

DDT - Dichlorodiphenyltrichloroethane

DEA - U.S. Drug Enforcement Administration

DECON - Decontamination

DEM - Department of Emergency Management

DEP - Division of Environment Protection

DES - Diethylstilbestrol

DES - Department of Emergency Services

DFM - Diesel Fuel Marine

DHHS - Department of Health and Human Services

DIALCOM - EPA's access into E-Mail for technical reports collected information on various hazardous waste treatment technologies.

DNA - Deoxyribonucleic acid

DMSO - Dimethyl sulfoxide

DOC - Department Of Commerce

DOD - Department of Defense

DOE - Department of Energy

DOI - Department of the Interior

DOJ - Department Of Justice

DOL - Department of Labor

DOS - Department Of State

DOT - Department of Transportation

DOT-ERG - Department of Transportation - Emergency Response Guidebook

DRI - Direct-Reading Instruments

E - Excellent

EAG - Emergency Action Guides, ARR and BOE

EBS - Emergency Broadcasting System

EC - Effective Concentration

ECHME - Emergency Care for Hazardous Materials Exposures

EERU - Environmental Emergency Response Unit

EENET - Emergency Education Network, FEMA

EL - Exposure Limit

EMA - Emergency Management Agency

EMI - Emergency Management Institute

EMICBACK - Environmental Mutagen Information Center Backfill

EMS - Emergency Medical Service

EMT - Emergency Medical Technician

EOC - Emergency Operations Center

EOP - Emergency Operation Plan

EOS - Emergency Operations Service

EPA - Environmental Protection Agency

EPA "400 LIST" - 1986 EPA Published list of substances subject to the reporting and emergency planning requirement of the superfund.

ERCS - Emergency Response Cleanup Services, under EPA contract

ERD - Emergency Operation Division, EPA

ERG - Emergency Response Guidebook

EROS - A central computer complex which controls a data base of over 6 million images and photographs of the earth's surfaces, it provides a chronological overview of an area, and includes research and training in the interpretation and application of remotely sensed data. Run by the U.S. Geological Survey.

ERT - Environmental Response Team

ESD - Emergency Service Directors

ETICBACK - Environmental Teratology Information Center Backfill

eV - Electron Volt

EWS - Early Warning System

EXP - Explosive materials

F - Fair

F - False

F - Fast

*F - Degrees Fahrenheit

FAA - Federal Aviation Administration

FCP - Federal Contingency Plan

FEMA - Federal Emergency Management Agency

FES - Fully Encapsulating Suit

FHWA - Federal Highway Administration

FID - Flame Ionization Detector

FIT - Field Investigation Team, under contract to EPA

flam - Flammable

flash p - Flash Point

FM - Factory Mutual

FP - Flashpoint

fp - Freezing Point or Fusion Point

FR - Federal Register

FRERP - Federal Radiological Emergency Response Plan

F.S.O.P. NO. 7 - Field Standard Operations Procedures for Decon by EPA

FWPCA - Federal Water Pollution Control Act of 1972, as Amended

G - Good

GAR - Governor's Authorized Representative

GATX - General American Transportation Company

g/cc - Grams per cubic centimeter

GC - Gas Chromatograph

GC - EC - Gas Chromatography Electron

GC - FID - Gas Chromatography Flame Ionization Dectection

GEMS - Graphical Exposure Modeling System

GFCI - Ground Fault Circuit Interrupter

glc's - Ground Level Concentration

GM - Geiger - Mueller

gm - Grams

gran - Granular, granules

GSA - General Service Administration

gm/mL - Grams per Milliliter

H - Hour(s)

H+ - Hydrogen ions

HACS - Hazard Assessment Computer System

HASP - Site - Specific Health and Safety Plan, by Environmental Protection Agency

HAZARDLINE - For response personnel, it provides information on physical/chemical properties of chemicals and their toxicity.

HazCom - Federal Hazard Communication Standard, 29 CFR 1910.1200

HAZMAT - Hazardous Material

HAZOP - Hazard and Operability Study

HAZWOPER - Hazardous Waste Operation and Emergency Response, 29 CFR 1910.120

HCS - Hazard Communication Standard

HEPA - Common use: "HEPA Filter" High Efficiency Particulate Air filter.

HIT - Hazardous Information Transmission

HLW - High Level Waste

HMIS - Hazardous Materials Identification System

hmn - Human

HMRT - Hazardous Materials Response Team

HMTA - Hazardous Material Transportation Act of 1975

H.hr - Hour(s)

HR - Hazard Rating

HRS - Hazard Rating System

HSDB - Hazardous Substance Data Bank

htd - Heated

htg - Heating

hygr - Hygroscopic

IAEA - International Atomic Energy Agency

IATA - International Air Transport Association

IC - Incident Commander

ICAO - International Civil Aviation Organization

ICC - Interstate Commerce Commission

ICI - Information Consultants, INC's

ICIS - Information Consultants, Inc System

ICS - Incident Command System

ID - Identification

IDLH - Immediately Dangerous to Life or Health

IEMS - Integrated Emergency Management System

IIHS - Insurance Institute for Highway Safety

ihL - Inhalation

IM - Intermodal Tanks

IMDO CODE - International Maritime Dangerous Goods

IME - Institute of Makers of Explosives.

immisc - Immiscible

IMO - International Maritime Organization

incomp - Incompatible

insol - Insoluble

IP - Ionization Potential

IPY - Inch per Year

IR - Infrared Radiation

IRAP - Interagency Radiological Assistance Plan

IRIS - Integrated Risk Information System

IUPAC - International Union of Pure and Applied Chemists

kg - Kilograms (1000 grams)

L,l - Light or Liter

LC - Lethal Concentration

LC_{Lo} - Lethal Concentration Low

LC_{50} - Lethal Concentration, 50%

LD - Lethal Dose

LD_{Lo} - Lethal Dose Low

LD_{50} - Lethal Dose, 50%

LEL - Lower Explosive Limit

LEVEL A - Personal protective equipment to be selected when the HIGHEST LEVEL of SKIN, RESPIRATORY and EYE protection is REQUIRED.

LEVEL B - Personal protective equipment to be selected when the HIGHEST LEVEL of RESPIRATORY protective is NECESSARY but a lesser level of skin protection is needed.

LEVEL C - Personal protective equipment to be selected when concentration(s) type(s) of airborne substance(s) is KNOW and the CRITERIA for using APR's are met.

LEVEL D - A work uniform affording minimal protection: used for nuisance contamination only.

LFL - Lower Flammable Limit

LiOH - Lithium Hydroxide

liq - Liquid

LLW - Low Level Waste

LNG - Liquid Natural Gas

LPG - Liquid Petroleum Gas

LSA - Low Specific Activity

M - Month

M - Meter

m^3 - Cubic Meter

MATC - Maximum Acceptable Toxicant Concentration

MACs - Maximum Allowable Concentration

MAX - Maximum

MC - Motor Carrier

MESA - Mining Enforcement and Safety Administration

mfd - Manufacture

mf - Molecular Formula

mg - Milligram

mg/cm^3 - Milligrams per Cubic Centimeter

mg/cm^2 - Milligrams per Square Centimeter

mg/kg - Milligrams per Kilogram

mg/L - Milligrams per Liter

mg/m^3 - Milligrams per Cubic Meter

mi - Miles

Min - Minute(s) or Minimum

MIRAN - Trade name for series of Foxboro Miniature Infrared Analyzers

misc - Miscible

mL,ml - Milliliter

MLD - Mild or Median Lethal Dose

mm - Millimeter

mmHg - Millimeter of Mercury

mod - Moderate(ly)

MOS - Metal Oxide Semiconductor

MOU - Memorandum of Understanding

MP - Melting Point

MpH - Miles per Hour

mR/hr - Milliroentgens per Hour

MSDS - Materials Safety Data Sheets

MSHA - Mine Safety and Health Administration

MSST -Maximum Safe Storage Temperature

MTB - Materials Transportation Bureau, DOT

MUC - Maximum Use Concentration

MUL - Maximum Use Limits

mw - Molecular Weight

NN, N, nn, n - Ratings in A.D. Little book Guidelines for the Selection of Chemical Protective Clothing, ACGIH, 1985

NA / UN - North American / United Nation = Hazardous Materials four digit Numbers.

NACA - National Agricultural and Chemical Association

NACE - National Association of Corrosive Engineers

NaI (T1) - Sodium Iodide Crystals

NBR - Nitrile-Butadiene Rubber (syn. Buna-N)

NCP - National Contingency Plan

NCRIC - National Chemical Response and Information Center

NCRP - National Council on Radiation Protection and Measurement

ND - None Detected

NEC - National Electric Code

NETC - National Emergency Training Center

NFA - National Fire Academy

NFPA - National Fire Protection Association

NFPA 704-M - National Fire Protection Association, hazard identification system

NHTSA - National Highway Traffic Safety Administration

NIEHS - National Institute for Environmental Health Sciences

NIOSH - National Institute for Occupational Safety and Health

NIOSH (P) - National Institute for Occupational Safety and Health, Pocket guide

NMFC - National Motor Freight Classifications

NOAA - National Oceanic and Atmospheric Administration

nonflam - Nonflammable

NOS or n.o.s. - Not Otherwise Specified

NPAC - National Poison Antidote Center

NPIRS - National Pesticide Information Retrieval System

NPL - National Priorities List

NPRM - Notice of Proposed RuleMaking

NR - Not Rated or Not Recommended

NRC - National Response Center

NRC - Nuclear Regulatory Commission

NRR - Noise Reduction Rating

NRS - National Response System

NRT - National Response Team

NSF - National Strike Force, U.S. Coast Guard

NTP - National Toxicology Program

NTSB - National Transportation Safety Board

NWPA - National Waste Policy Act of 1982

O_2 - Oxygen

OBS - Obsolete

OC - Open Cup Test

OSHACIS - Occupational Safety and Health Administration Computerized Information System

OH - Hydroxide ions

OHSMSDS - Occupational Health Services Material Safety Data Sheets

OHMT - Office of Hazardous Materials Transportation Administration, DOT

OHMTADS - Oil and Hazardous Materials Technical Assistance Data System

O.I. - Odor Index

OPA - Oil Pollution Act

OPD - Overpack Drum or Recovery Drum

OPPSD - Organic Peroxide Producers Safety Division

OPS - Operation Officer

org - Organic

or,orl - Oral

ORP - Office of Radiation Program, Environmental Protection Agency

ORM - Other Regulated Material. Various specific classes such as ORM-A,B,C,D,E,.

OSC - On-Scene Coordinator

OSC/RPM - On-Scene Coordinator/Remedial Project Manger

OSHA- Occupational Safety and Health Administration

OSWER - Office of Solid Waste and Emergency Response

OVA - Organic Vapor Analyzer

OTA - U.S. Office of Technology Assessment

OXY - Oxidizer or Oxidizing properties

P - Poor

PA - Public Address System

PA/SI - Preliminary Assessment and Site Investigation

PATRAM - Packaging and Transportation of Radioactive Materials

PCB - Polychlorinated Biphenyl

PDS - Personnel Decontamination Station(s)

PE - Polyethylene

PI - Preliminary Investigation

PEL - Permissible Exposure Limit

petr - Petroleum

PF - Protection Factor

pg - Picogram (trillionth of a gram)

Pg - Page

PH - a unit of measurement for corrosive materials

PHC - Principal Hazardous Constituent

PIAT - Public Information Assist Team, United States Coast Guard

PID - Photoionization Detector

PIO - Public Information Officer

PIRS - Pollution Incident Reporting System

Pk - Peak Concentration

PL - Public Law

p.m. - Particulate Matter or time

PPE - Personal/Personnel Protective Equipment

PMS - Photoionization Mass Spectrometer

ppb - Parts Per Billion

pph - Parts Per Hundred

ppm - Parts Per Million

ppt - Parts Per Trillion

powd - Powder

PROP - Properties

PSIA - Pounds Per Square Inch of Area

PSIG - Pounds Per Square Inch Gauge

PSTM - Pesticide Safety Team Network

PTD - Programmed Thermal Desorber

PVA- Poly Vinyl Alcohol

PVC - Poly Vinyl Chloride

QA/QC - Quality Assurance/Quality Control

RR, R, rr, r - Ratings from A.D. Little, Guidelines for selection of Chemical Protective Clothing ACGIH, 1985

RAT - Radiological Assistance Team, DOE

RAD - Radiation

RBC - Red Blood Count

RCP - Regional Contingency Plan

R.C.R. - Relative Chemical Reactivity

RCRA - Resource Conservation and Recovery Act

RD_{50} - Concentration Associated with 50 % Decrease in Respirtory Rate.

REL - Recommended Exposure Limits

REM - Roentgen Equivalent to Man

REMFIT - Field Investigation Team for remedial actions under contract to EPA

RES - Reset

R/Hr - Roentgen per Hour

RI/FS - Remedial Investigation/Feasibility Study

ROD - Record of Decision

RQ - Reportable Quantity

RRP - Regional Response Plan

RRT - Regional Response Team

RSPA - Research and Special Programs Administration, Dartment Of Transportation - Office of Hazardous Material Tranportation

RTECS - Registry of Toxic Effects of Chemicals

RV - Residual Volume

S - Slow

S,sec - Second(s)

SADT - Self-Accelerating Decomposition Temperature Test

SAR - Supplied Air Respirator

SARA - Superfund Amendments and Reauthorization Act of 1986

Sat. Conc. - Saturation Concentration in Air

Sat. Vap - Saturated Vapor

SAX - Dangerous Properties of Industrial Materials

SBA - Small Business Administration

SBR - Styrene-Butadiene Rubber

SCBA - Self Contained Breathing Apparatus

Sec - Seconds

SERC - State Emergency Response Commission

SEV - SEVERE

SHMED - State Hazardous Materials Enforcement Development Programs, Department Of Transportation

SIC - Standard Industrial Codes

sl,slt,sltly - Slightly

SOL - Solubility

soln - Solution

solv(s) - Solvent(s)

SOPs - Standard Operating Procedures

SOSGs - Standard Operating Safety Guides

SpG - Specific Gravity

SPCC - Spill Prevention Control and Countermeasures

SPHERE - Scientific Parameters for Health and the Environment, Retrieval and Estimation, contains three databases under its umbrella. ACQUIRE deals with data on aquatic organisms, DERMAL contains information on human and test animals via the dermal route, GENETOX contains information on mutagenicity assays have been performed and published.

spont - Spontaneous(ly)

SQG - Small Quantity Generator

SSC - Scientific Support Coordinator

STARA - Studies on Toxicity Applicable to Risk Assessment

STC - Single Trip Container, Department Of Transportation

STCC - Standard Transport Commodity Code, Assoication of Amercian Railroads

STEL - Short Term Exposure Limit

STP - Standard Temperature and Pressure

subl - Sublimes

SWDA - Solid Waste Disposal Act

T - TRUE

$t^{1/2}$ - Half Life

TAC - Tactical

TAT - Technical Assistance Team, under contract to Envornmental Protection Agency

2,3,7,8-TCDD - Tetrachlorodibenzo-p-dioxin

TC - Testing and Certification / Toxic Concentration

TC_{Lo} - Toxic Concentration Low

TC_{HI} - Toxic Concentration HI

TCC - Tag Closed Cup Test

TCDD - Tetrachlorodibenzo-p-dioxin

TCE - Trichloroethylene

TDG - Transportation of Dangerous Goods

TDI - Toluene-2,4,-diisocynate

TD_{Lo} - Toxic Dose Low

TD_{HI} - Toxic Dose Hi

TEAP - Technical Emergency Assistance Plan, Canada

Tech - Technical

TECP - Totally Encapsulated Chemical Protective Suit

TEMP - Temperature

THR - Toxic Hazard Rating

TIER I/II - SARA Title III reporting requirements of hazardous chemicals that facilities must submit for each applicable OSHA category of health and physical hazard of chemicals at each location.

TITLE III - Part of SARA of 1986 known as emergency planning and community right-to-know.

TIP - Total Ionizable Present

TLC - Total Lung Capacity

TLD - Thermoluminescent Dosimeter

TL_m - Median Threshold Limit

TLVs - Threshold Limit Values

TLV/C - Threshold Limit Value - Ceiling

TLV/STEL - Threshold Limit Value - Short Term Exposure Limit

TLV/TWA - Threshold Limit Value - Time Weighted Average

T.O.C. - Threshold Odor Concentration

TNT - Trinitrotoluene

TOC - Tag Open Cup Test or Total Organic Carbon

TOFC - Trailer On Flat Car

T.O.N. - Threshold Odor Number

TOXNET - Toxicology Data Network

TRADE - Training Recourse And Data Exchange

TRI - Toxic Release Inventory

TSCA - Toxic Substances Control Act

TSD - Treatment, Storage, and Disposal

TSDF - Treatment, Storage, and Disposal Facility

TV - Television

TWA - Time Weighted Average

2, 4, 5-T - 2, 4, 5-Trichlorophenoxyacetic acid

U - Uranium

u - Micro

U,unk - Unknown, Unreported

UEL - Upper Explosive Limit

UFL - Upper Flammable Limit

ug - Microgram

ug/cm^2 - Micrograms per square meter

ug/cm - Micrograms per Centimeter

UL - Underwriters Laboratories

UN - United Nations

UP - Union Pacific

uR/Hr - Micro - Roentgen per Hour

USCG - United States Coast Guard

USGS- United States Geological Survey

USN - United States Navy

UST - Underground Storage Tank

UV - Ultraviolet

vac - Vacuum

vap - Vapor

vap d - Vapor Density

VP,vap press - Vapor Pressure

VD - Vapor Density

VG - Very Good

vol - Volume

visc - Viscosity

vsol - Very Soluble

W - Week(s) / Water Reactive

WEEL - Workplace Environmental Exposure Levels

WT - Water Tight

wt/gal - Weight per Gallon

Y - Year(s)

% - Percent(age)

> - Greater Than

< - Less Than

=> - Equal to or Greater Than

<= - Equal to or Less Than

Emergency Response to Hazardous Material Incidents (165.15)

Orientation and Introduction

Student Guide

EMERGENCY RESPONSE TO HAZARDOUS MATERIAL INCIDENTS (165.15)

Presented by:

Halliburton NUS Corporation
EPA Contract No. 68-C2-0121

TP-1

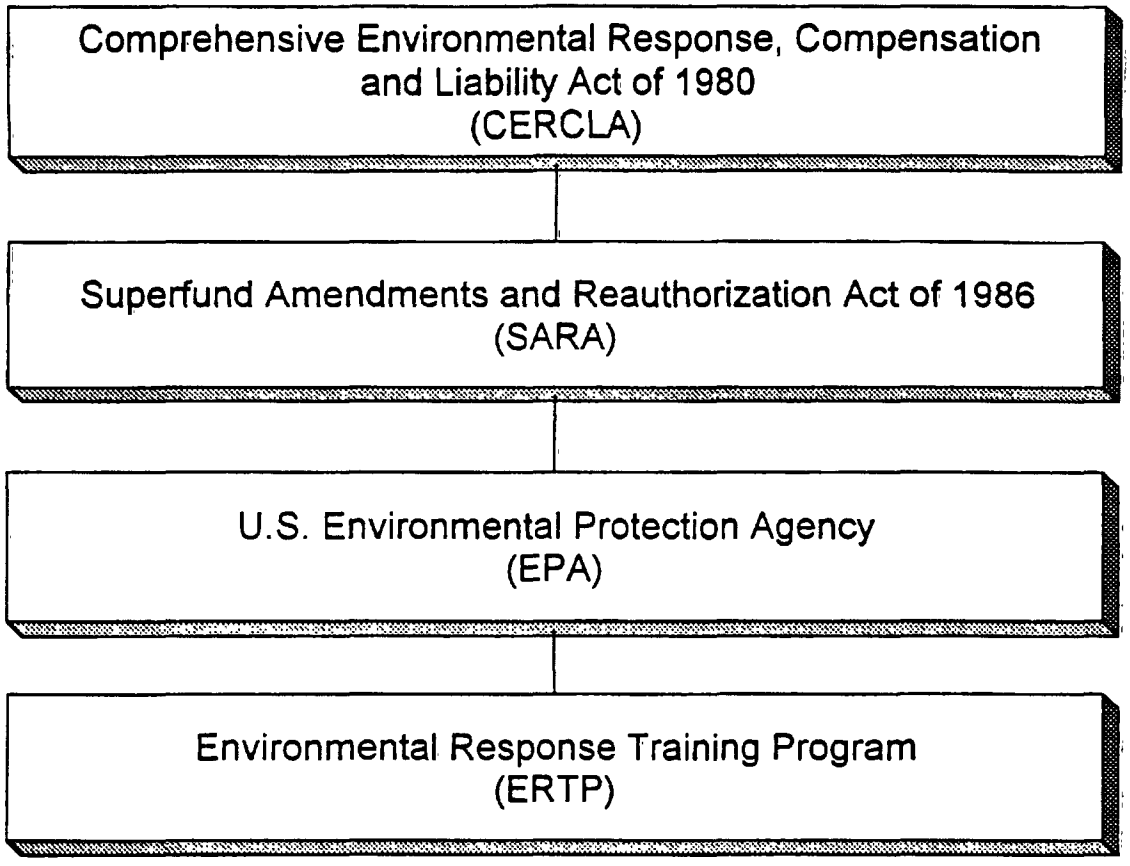
Orientation and Introduction

Agenda:

- Environmental Response Training Program (ERTP) overview
- Synopsis of ERTP courses
- Course layout and agenda
- Course materials
- Facility information

Notes

ERTP OVERVIEW



TP-2

ERTP Overview

In 1980, the U.S. Congress passed the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), also known as Superfund. In 1986, the Superfund Amendments and Reauthorization Act (SARA) was passed. This act reauthorized CERCLA. CERCLA provides for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and for the cleanup of inactive waste disposal sites. The Environmental Protection Agency (EPA) allocated a portion of Superfund money to training. EPA's Environmental Response Team (ERT) developed the Environmental Response Training Program (ERTP) in response to the training needs of individuals involved in Superfund activities.

Notes

ERTP OVERVIEW

U.S. Environmental Protection Agency
(EPA)

Office of Solid Waste and Emergency Response
(OSWER)

Environmental Response Team
(ERT)

Environmental Response Training Program
(ERTP)

TP-3

ERTP Overview

ERTP is administered by ERT, which is part of OSWER. ERT offices and training facilities are located in Cincinnati, Ohio, and Edison, New Jersey. ERT has contracted the development of ERTP courses to Halliburton NUS Corporation (EPA Contract No. 68-C2-0121). ERTP provides education and training for environmental employees at the federal, state, and local levels in all regions of the United States. Training courses cover areas such as basic health and safety and more specialized topics such as air sampling and treatment technologies.

Notes

Types of Credit Available

CEU

Continuing Education Units
(3.6 CEUs)

CEU Requirements

- 100% attendance at this course.
- ≥70% on the exam.

ABIH

American Board of Industrial Hygiene
(4.5 Certification Maintenance [CM] points, ABIH approval #9629)

Notes

TP-4

Health and Safety Courses

- *Hazardous Materials Incident Response Operations (165.5)*
- *Safety and Health Decision-Making for Managers (165.8)*
- *Emergency Response to Hazardous Material Incidents (165.15)*

TP-5

Technical Courses

- *Treatment Technologies for Superfund (165.3)*
- *Air Monitoring for Hazardous Materials (165.4)*
- *Risk Assessment Guidance for Superfund (165.6)*
- *Introduction to Groundwater Investigations (165.7)*
- *Sampling for Hazardous Materials (165.9)*
- *Radiation Safety at Superfund Sites (165.11)*

TP-6

Special Courses

- *Health and Safety Plan Workshop (165.12)*
- *Design of Air Impact Assessments at Hazardous Waste Sites (165.16)*
- *Removal Cost Management System (165.17)*
- *Inland Oil Spills (165.18)*

TP-7

Courses Offered in Conjunction with Other EPA Offices

✓ *Chemical Emergency Preparedness and Prevention Office (CEPPO)*
- *Chemical Safety Audits (165.19)*

TP-8

✓ *Site Assessment Branch*
- *Preliminary Assessment*
- *Site Investigation*
- *Federal Facilities Preliminary Assessment/Site Investigation*
- *Hazard Ranking System*
- *Hazard Ranking System Documentation Record*

Notes

Course Goals

TP-9

- Identify the importance of an incident command system for effectively managing an incident involving hazardous materials.
- Use size-up techniques to develop strategies and select the appropriate tactics for mitigating hazardous materials incidents.

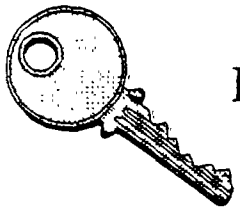
TP-10

- Select the appropriate personal protective equipment for responding to an incident involving hazardous materials.
- Use confinement and containment techniques to control the release of a hazardous material.

TP-11

- Use combustible gas detectors, oxygen meters, and detector tubes to evaluate the hazards present at a hazardous materials incident.
- Develop procedures for the decontamination of emergency response personnel.

Notes



Key Points:

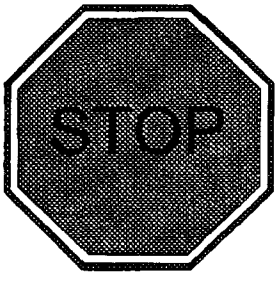
- Agenda times are only approximate. Every effort is made to complete units, and to finish the day, at the specified time.
- Classes begin promptly at 8:00 am. Please arrive on time to minimize distractions to fellow students.
- Breaks are given between units.
- Lunch is 1 hour.
- Each student must take the examination given on Thursday at 1:00 pm.
- Direct participation in field or lab exercises is optional. Roles are randomly assigned to ensure fairness.
- Attendance at each lecture and exercise is required in order to receive a certificate.
- Attire all week should be comfortable, and cool or warm as weather dictates.
- Write your name in all your books for identification purposes.

Notes

CHEMICALS USED IN THIS COURSE

- Acetone
- Alcohol
- Ammonia
- Propane
- Rosco Smoke Oil (vegetable oil)

TP-12



For your safety, please speak with the Course Director regarding any health concerns that may prohibit your direct participation in exercises or labs involving use or close proximity to these chemicals. Material Safety Data Sheets (MSDS) are available for review.

Chemical Use and Health-Related Considerations

	Chemical	"Health Hazard"
Direct Reading Instruments (workbook)	Ammonia	Skin contact can cause burns to skin and eyes. Irritating to mucous membranes, can cause eye damage in contact with contact lens.
	Propane	If inhaled will cause dizziness, difficulty breathing, or loss of consciousness. Liquid can cause frostbite.
Field & Radiation Survey Instruments (workbook)	Acetone	May cause irritation to nose and throat. If inhaled may cause difficulty in breathing or loss of consciousness in large concentration.
	Alcohol	May be poisonous if inhaled or absorbed through skin. Vapors may burn or irritatie skin and eyes. Fire may produce irritating or poisonous gases. Can cause water pollution.
	1 mR/hr Radiation Sources	

Notes

Training Evaluation

- The *Training Evaluation* is a tool to collect valuable feedback from YOU about this course.

- We value YOUR comments!! Important modifications have been made to this course based on comments of previous students.

DO

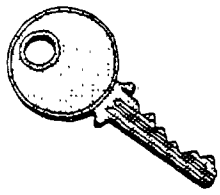
- Write in your comments at the end of each unit!
- Tell us if you feel the content of the course manual (and workbook) is clear and complete!
- Tell us if you feel the activities and exercises were useful and helpful!
- Tell us if you feel the course will help you perform related duties back on the job!
- Complete the first page at the end of the course before you leave!
- Write comments in ink.

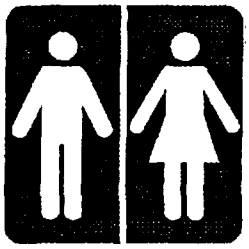
DON'T

- Hold back!
- Focus exclusively on the presentation skills of the instructors.
- Write your name on the evaluation, if it will inhibit you from being direct and honest.

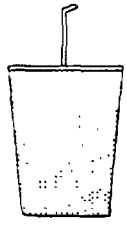
Notes

Facility Information





Please put beepers in the vibrate mode and turn off radios. Be courteous to fellow students and minimize distractions.



Emergency Telephone Numbers

Emergency Exits

Alarms

Sirens

Notes

EMERGENCY RESPONSE OVERVIEW

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. Identify the four major components of an effective response organization

2. Identify at least three components of U.S. Environmental Protection Agency's (EPA) incident response model

3. Describe EPA's purpose in providing this training

4. Identify the regulation under which this training program falls.

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

NOTES

EMERGENCY RESPONSE OVERVIEW

TP-1

COMPONENTS OF AN EFFECTIVE RESPONSE ORGANIZATION

- Response organization
- Personnel
- Training
- Equipment

TP-2

THE U.S. EPA INCIDENT RESPONSE MODEL

- Recognition
- Evaluation
- Control
- Information
- Safety

TP-3

EMERGENCY RESPONSE OVERVIEW

TOPIC		PAGE NO.
I.	INTRODUCTION	1
II.	RECOGNITION	2
III.	EVALUATION	3
IV.	CONTROL	4
V.	INFORMATION	4
VI.	SAFETY	5
VII.	RELATIONSHIP OF ELEMENTS	5

EMERGENCY RESPONSE OVERVIEW

I. INTRODUCTION

A hazardous material incident is a situation in which a hazardous material is or may be released into the environment. Hundreds of thousands of different chemicals are produced, stored, transported, and used annually. Because of the hazardous nature of many of these chemicals, safeguards are established to prevent them from causing harm. If these safeguards are accidentally or purposefully disregarded, the material is no longer under effective control and a situation is established that can have dangerous effects. Hazardous material incidents vary considerably by chemicals and quantities involved, types of hazard, response efforts required, number of responders needed, and effects produced. They may require immediate control measures (emergency) or long-term cleanup activities (remedial action) to restore acceptable conditions.

All activities that are required when responding to incidents can be divided into five broad, interacting elements.

- Recognition: identification of the substance involved and the characteristics that determine its degree of hazard.
- Evaluation: impact or risk the substance poses to public health and the environment.
- Control: methods to eliminate or reduce the impact of the incident.
- Information: knowledge acquired concerning the conditions or circumstances relative to an incident. Information is often called intelligence. In a response, intelligence is gathered and disseminated.
- Safety: protection of responders from harm.

These elements comprise a system — an orderly arrangement of components that interact to accomplish a task (**Figure 1**). In response work, the task is to prevent or reduce the impact of the incident on people, property, and the environment, and to restore conditions to as near normal as possible. To achieve this goal, response personnel undertake a variety of activities; for example, firefighting, sampling, developing safety plans, erecting fences, installing a physical treatment system, recordkeeping, and evaluation. These activities are all related; what occurs in one affects or is affected by the others.

These five elements can be used to classify all response activities. Recognition, evaluation, and control describe performance-oriented elements. In each, there is an outcome; a sample is collected, a treatment system is installed, a chemical is identified, or a risk is determined. Information and safety are supportive elements. They are inputs to and/or outcomes from recognizing, evaluating, and controlling.

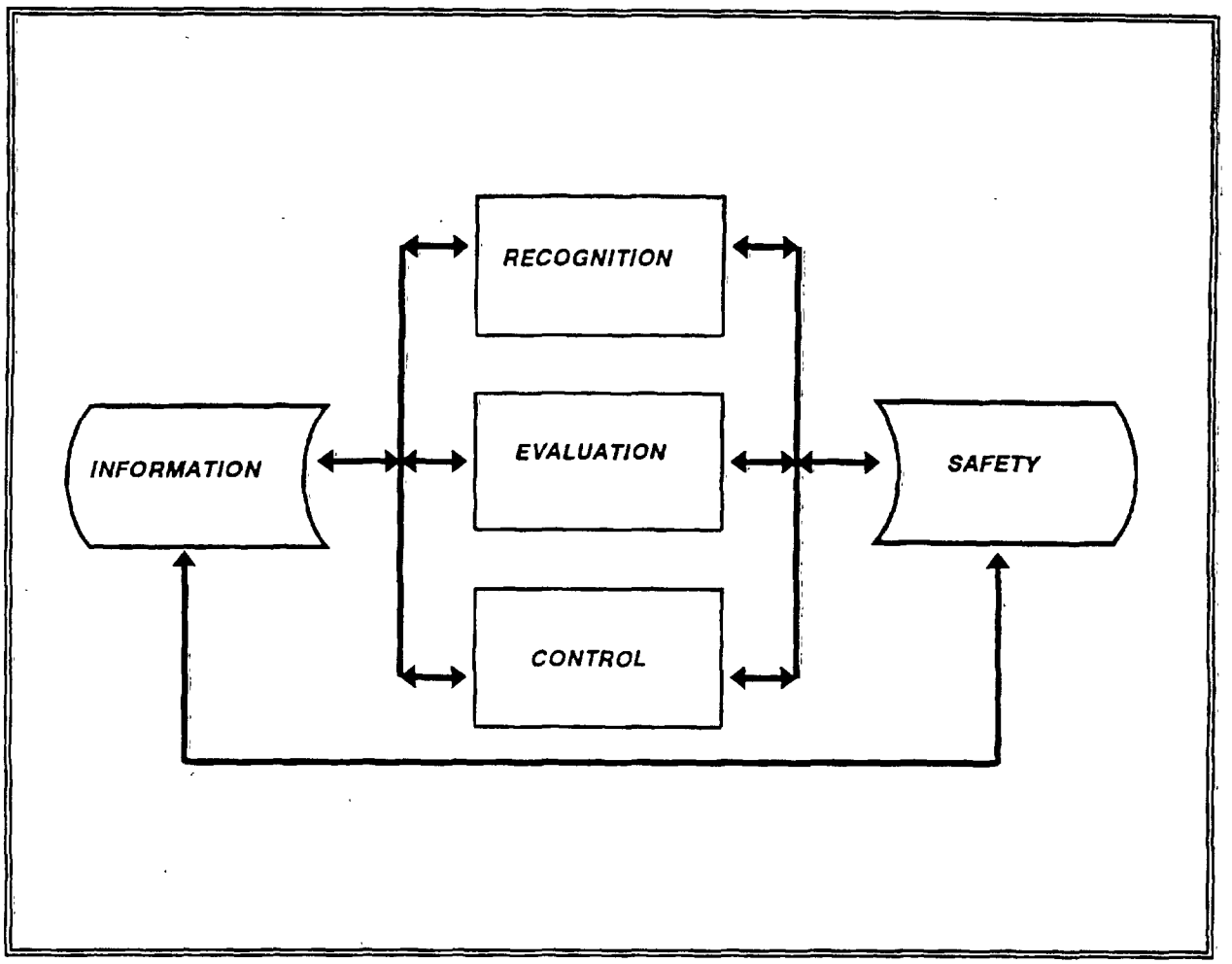


FIGURE 1
THE INCIDENT RESPONSE SYSTEM

Understanding the system provides some insight into how response activities relate to each other. It helps explain, in broad terms, the processes involved in responding to a hazardous material incident.

II. RECOGNITION

Recognizing the type and degree of the hazard present is usually one of the first steps in responding to an incident. The substance involved must be identified. Then the physical and chemical properties that may make it hazardous — capable of causing harm — can be determined. These inherent properties can be used, on a preliminary basis, to predict the behavior and anticipated problems associated with a material.

Recognition may be easy; for example, the placard on a railroad tank car carrying a hazardous material can be used to quickly identify its contents. At a hazardous waste site that may contain hundreds of different chemicals, complete identification is more difficult.

The element of recognition involves using all available information, sampling results, historical data, visual observation, instruments, package labels, shipping manifests, existing documentation, witnesses, and other sources to identify the substance(s).

An incident involves more than just the presence of a hazardous material. It is a situation in which the normal safeguards associated with the materials are compromised, creating the possibility of undesirable effects. Gasoline can do harm because its vapors can ignite and explode, but the usual safety techniques for handling gasoline prevent this from happening. Problems caused by the release of gasoline into the environment can be anticipated based on its chemical and physical properties. The harm that gasoline will do if released, however, depends on site-specific conditions.

Thousands of substances exhibit one or more characteristics of flammability, radioactivity, corrosiveness, toxicity, or other properties which classify them as hazardous. For any particular hazardous category, the degree of hazard varies depending on the substance. The degree of hazard is a relative measure of how hazardous a substance is. For instance, the immediately dangerous to life or health (IDLH) concentration of butyl acetate in air is 10,000 parts per million (ppm); the IDLH for sulfur dioxide is 100 ppm. Sulfur dioxide is therefore much more acutely toxic (has a higher degree of hazard) when inhaled at IDLH concentrations than butyl acetate. Vapors from butyl acetate, however, have a higher degree of explosive hazard than tetrachloroethane vapors, which are not explosive.

Once the substance(s) has been identified, its hazardous properties and its degree of hazard can be determined using reference material. Although appropriate references give information about the substance's physical/chemical properties and may give indications of its environmental behavior, additional data are required. Most frequently, monitoring and sampling are needed to identify substances, determine concentrations, confirm dispersion patterns, and verify the presence of material.

III. EVALUATION

Recognition provides basic data concerning the substance. Evaluation is determining its effects or potential impact on public health, property, and the environment. A hazardous substance is a threat because of its physical and chemical characteristics. Its actual impact, however, depends on the location of the release, on weather, and on other site-specific conditions. One measure of impact is the adverse effects that have occurred. Another is the potential impact if the substance is released. Risk is the probability of harm being done, a measure of the potential impact or effect. The presence of a hazardous substance constitutes a risk, but if the material is under control, the risk is low; if uncontrolled, the risk increases. For harm to be done, a critical receptor must be exposed to the uncontrolled material. For example, when people live in the area, property may be impacted or a sensitive ecological habitat may be affected. Chlorine gas, for instance, is highly toxic and represents a risk. If chlorine gas is released in a densely populated area, the risk to people is very great, whereas the human risk associated with a release of chlorine gas in an unpopulated area is very low. If the substance were carbon dioxide rather than chlorine, the human risk in both situations would be substantially less, because carbon dioxide is much less toxic than chlorine.

Evaluating risk in these two examples is relatively simple. Much more complex are those episodes where many compounds are involved and a higher degree of uncertainty exists regarding their behavior in the environment and their contact with and effects on receptors.

The completeness of information must also be assessed. Is additional sampling and monitoring of air, water, and soil necessary to provide more comprehensive information on what the material is, where it is, how it moves through the environment, what it will contact, and what the associated risk is? To completely evaluate the effects of a hazardous materials incident, all substances must be identified, their dispersion pathways established, and for toxic chemicals, concentrations determined. Risk is then assessed based on exposure (or potential exposure) of the public or other critical receptors.

Identifying the materials involved in an incident and evaluating the impact the incident may have is frequently termed site characterization. Site characterization may be easy and rapid, or, as in the case of an abandoned waste site, a process that may take a long time to completely accomplish.

IV. CONTROL

Control is those methods which prevent or reduce the impact of the incident. Preliminary control actions are generally instituted as rapidly as possible in emergency situations. As additional information is developed through recognition and evaluation, initial control actions are modified or others instituted. Releases that do not require immediate action allow more time for planning and instituting remedial measures. Control measures include physical, chemical, and biological treatment and cleanup techniques for restoring the area to prerelease conditions. It also includes public health countermeasures, for example, evacuation or the shutdown of a drinking water supply to prevent the public from coming in contact with the substance.

V. INFORMATION

An integral component of response is information. All response activities are based on having information that is readily available or subsequently obtained. Information is a support element to recognition, evaluation, and control. It is an input to these performance elements, providing data for decision-making. It is also an outcome of these elements. A sample is collected and analyzed. The results provide an input to determine treatment options, which is an outcome. Information comes from three sources:

- Intelligence: Information obtained from existing records or documentation, placards, labels, signs, special configuration of containers, visual observations, technical reports, and other sources.

- Direct-reading instruments: Information relatively quickly obtained from instruments.

- Sampling: Information obtained from collecting representative portions of appropriate media or material and subsequent laboratory analysis.

Information acquisition, analysis, and decision-making are iterative processes that define the extent of the problem and the array of possible response actions. For incident response to be effective, an information base must be established which is accurate, valid, and timely. Throughout the lifetime of the incident, a continuous stream of information is collected, processed, and applied. Sound decisions are predicated on having good information and developing a knowledge base concerning the situation.

VI. SAFETY

All hazardous material responses pose varying dangers to responders. An important consideration in all response activities is to protect the health and safety of the responders. To do this requires that the chemical and physical hazards associated with each operation be assessed and methods implemented to prevent or reduce harm to responders. Safety considerations are an input to every activity that is undertaken and are an outcome of each response activity. For example, an outcome of identifying a specific chemical may be changes in safety requirements. Each response organization must have an effective health and safety program, including medical surveillance and health monitoring, appropriate safety equipment, standardized safety procedures, and an active training program.

VII. RELATIONSHIP OF ELEMENTS

Recognition, evaluation, control, information, and safety describe the five elements of response. Each includes a variety of activities or operations. Elements are not necessarily sequential steps for responding. In some situations, control measures may be started before the substances are completely identified. In others, a more thorough evaluation of the material's dispersion is needed before effective control actions can be determined. Likewise, safety measures for responders may be instituted before the materials are identified or all the hazardous conditions are fully known.

Each element and activity is interrelated. For example, a dike (control) is built to contain the runoff water from fighting a fire at a warehouse suspected of containing pesticides. Once it has been determined that the runoff contains no hazardous chemicals (recognition), or that concentrations in the runoff are below acceptable values (evaluation), no treatment is necessary and the dike can be removed. This knowledge (information) also changes the safety requirements for responders (safety).

A constant flow of information is needed to characterize the incident and make decisions. For example, an option to use carbon absorption for water treatment may require additional sample collection and analysis to completely identify the substances involved. In turn, this would require reevaluating the effectiveness of carbon absorption for the identified chemicals. Additional information regarding where and how the substance is migrating may change the requirements for sampling.

The response system is a concept explaining, in general terms, the processes involved in incident response. All responses require the performance elements of recognizing, evaluating, and controlling. To support these elements, information is needed and responder safety must be considered.

The material in this training manual and the lectures given in the course are directed toward a more thorough treatment of selected elements and activities in the response system. The course provides basic information upon which students can build their expertise and competence through additional training, study, and experience.

SAFETY PLANS AND STANDARD OPERATING PROCEDURES

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, participants will be able to:

1. Identify the components of an effective safety program

2. Identify the items included in a set of safety plans and standard operating procedures

3. Identify the regulation governing the necessity for a scene safety plan

4. Discuss the importance of a safety briefing prior to taking action.

Safety plans and standard operating procedures are located in the U.S. EPA's Standard Operating and Safety Guides

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

NOTES

SAFETY PLANS AND SOPs

TP-1

KEYS TO A SAFE RESPONSE

- Safety program
- Standard operating procedures
- Development of a scene safety plan

TP-2

SAFETY PROGRAM PERSONNEL

- Medical surveillance
- Physical fitness
- Training and education

TP-3

NOTES

SAFETY PROGRAM EQUIPMENT

- Equipment selection and maintenance
- Operator training
- Protective clothing program

TP-4

STANDARD OPERATING PROCEDURES

- Organizational directives that establish a standard course of action
- Should address the major aspects of a hazardous material response

TP-5

STANDARD OPERATING PROCEDURES (cont.)

- Command
- Delegation of authority
- Scene safety officer
- Communications

TP-6

NOTES

STANDARD OPERATING PROCEDURES (cont.)

- Tactical priorities
- Support functions
- Scene safety plan

TP-7

STANDARD OPERATING PROCEDURES (cont.)

- Written
- Official
- Applied to all situations
- Enforced

TP-8

SCENE SAFETY PLANS

- Detailed plan that addresses all safety issues
- Must resemble the SOPs
- Must describe the known and unknown hazards present
- Must identify incident-specific variations in the SOPs

TP-9

NOTES

ADVANTAGES OF A SAFETY PLAN

- Hazardous conditions are less likely to be overlooked
- Personnel will be trained to perform hazardous tasks safely
- Response groups will function more efficiently and consistently

TP-10

INCIDENT COMMAND SYSTEM

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. List three reasons for using an Incident Command System (ICS)

2. Identify the law that requires the use of an ICS at a hazardous material incident

3. State the different components of an ICS

4. Explain the differences between single and unified command

5. Explain when a consolidated action plan (CAP) is needed

6. Explain the term span of control

7. State the different levels of the ICS and the associated job function

8. Describe the different types of contingency plans an Incident Commander (IC) may have to follow at any hazardous material incident

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

STUDENT PERFORMANCE OBJECTIVES (cont.)

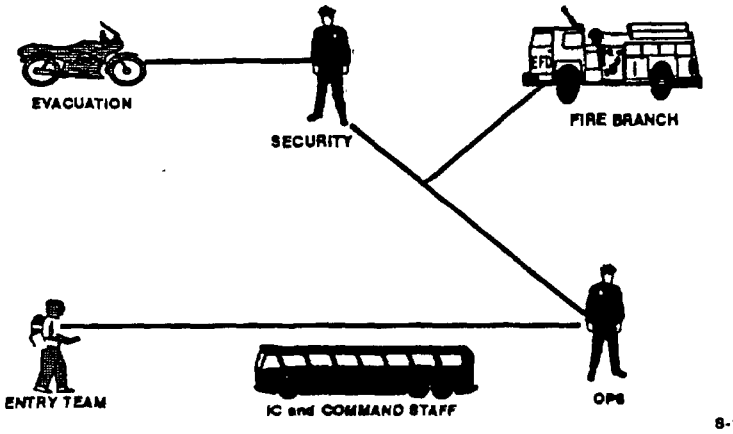
9. Relate how the ICS interfaces with the Federal Contingency Plan

10. Explain how the Federal On-Scene Coordinator (FOSC) functions within the ICS.

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

NOTES

INCIDENT COMMAND SYSTEM



S-1

WHEN IS AN INCIDENT COMMAND SYSTEM (ICS) NEEDED?

- Any emergency, small or large
- Any number of responders
- To organize the response

Without it, effectiveness is reduced

S-2

REASONS FOR ICS

- Special hazards present
- Large number of personnel
- Multiple agency involvement
- Large number of civilians affected
- Legal requirement

S-3

NOTES

REGULATIONS REQUIRING ICS

- Superfund Amendments and Reauthorization Act of 1986 (SARA), Title I, Section 126
  - Requires establishment of an ICS
- Occupational Safety and Health Administration (OSHA) 29 CFR 1910.120(q)
  - Requires the use of an ICS beyond the Awareness Level response

S-4

REGULATIONS REQUIRING ICS (cont.)

- U.S. Environmental Protection Agency (EPA) 40 CFR 311
  - Applies 29 CFR 1910.120 requirements to non-OSHA states
- National Contingency Plan (NCP) 40 CFR 300.135
  - Requires the use of a Unified Command System

S-5

DEFINITION OF ICS

A system for organizing a response in a manner that is systematic and easily expandable to meet incident requirements

S-6

NOTES

HISTORY OF ICS

- Developed in the 1970s in the western United States
- Established to handle large brush fires and other large-scale operations
- Addresses difficult problems encountered at multiagency responses

S-7

COMPONENTS OF ICS

- Common terminology
  - Standard terms
  - Consistent
- Modular organization
  - Top-down structure
  - Used at any incident
- Integrated communication
  - Common terminology
  - Clear text

S-8

COMPONENTS OF ICS (cont.)

- Unified Command Structure
  - Shared responsibility
  - One person in charge
- Manageable Span of Control
  - Ranges from 3 to 7
  - Optimum is 5
- Consolidated Action Plan (CAP)
  - Needed at every incident
  - Has to be written

S-9

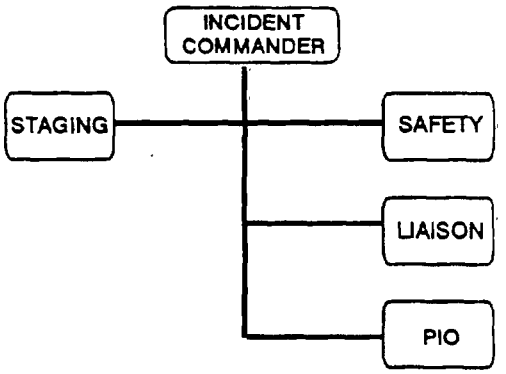
NOTES

COMPONENTS OF ICS (cont.)

- Comprehensive resource management
  - Depends on incident needs
  - Must be performed effectively
  - Should maximize resources

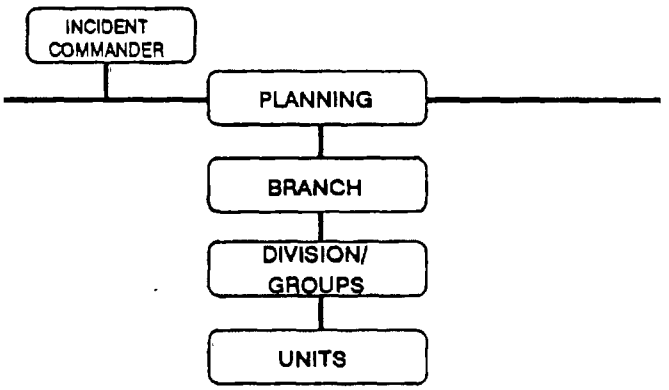
S-10

ICS CHART
Incident Commander (IC) and Command Staff



S-11

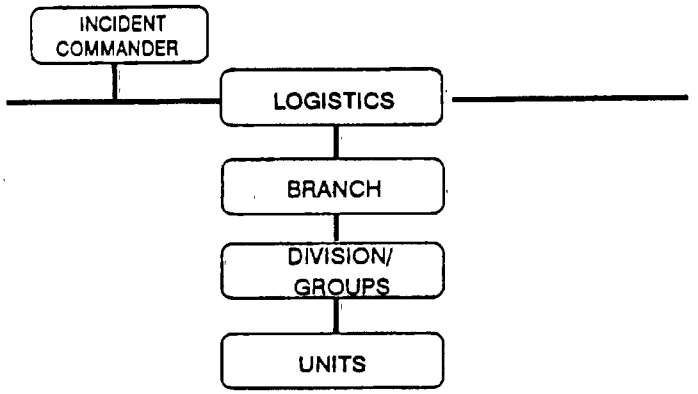
ICS CHART
IC and Planning



S-12

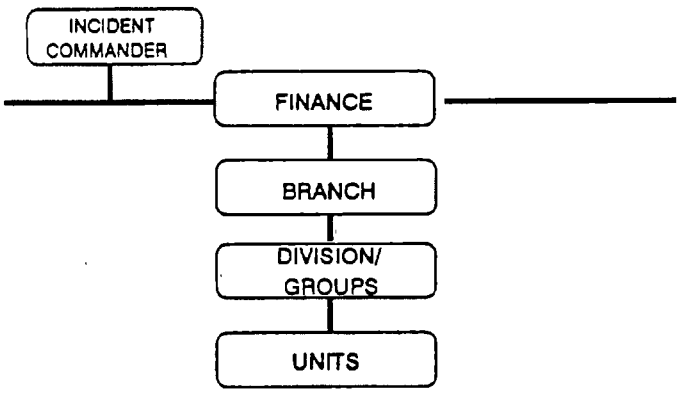
NOTES

ICS CHART
IC and Logistics



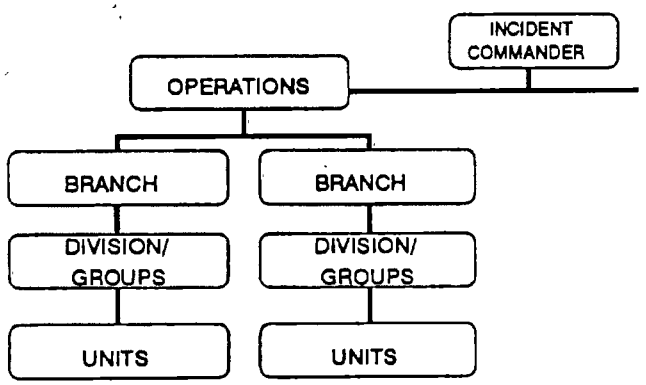
S-13

ICS CHART
IC and Finance



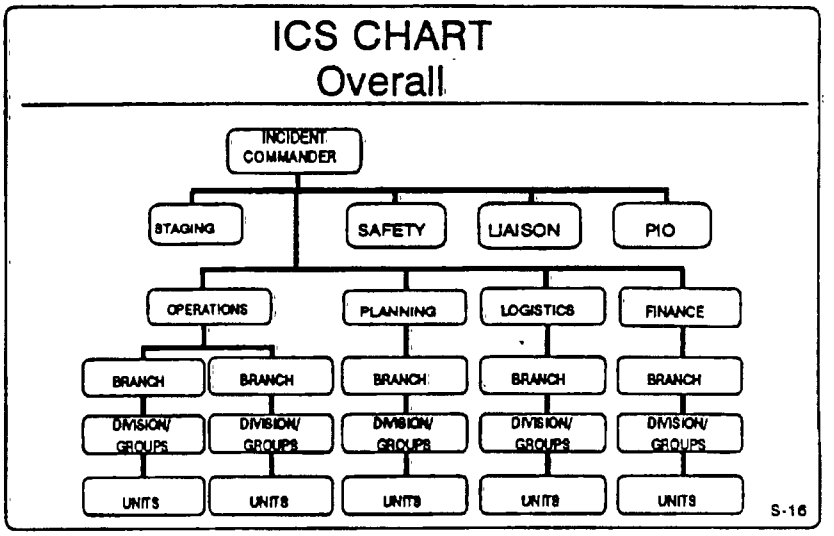
S-14

ICS CHART
IC and Operations



S-15

NOTES


ICS CHART
Overall
INCIDENT COMMANDER
STAGING
SAFETY
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PIO
OPERATIONS
PLANNING
LOGISTICS
FINANCE
BRANCH
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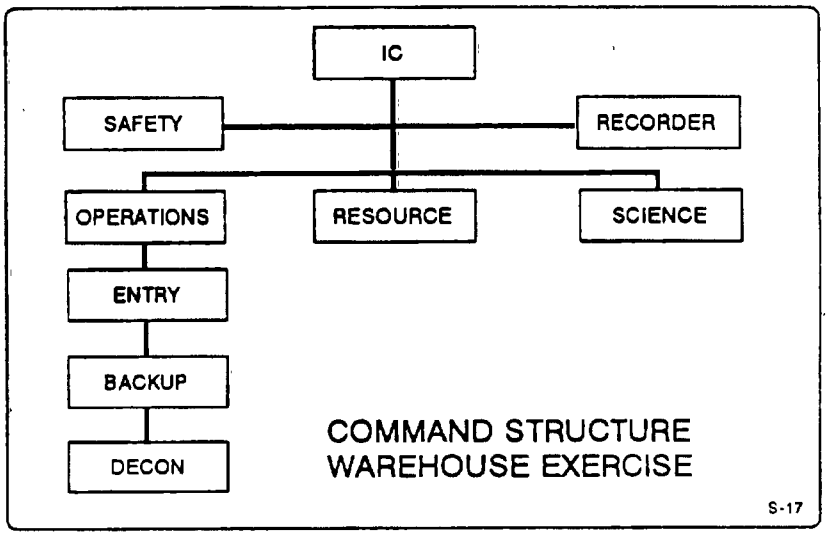
S-16


IC
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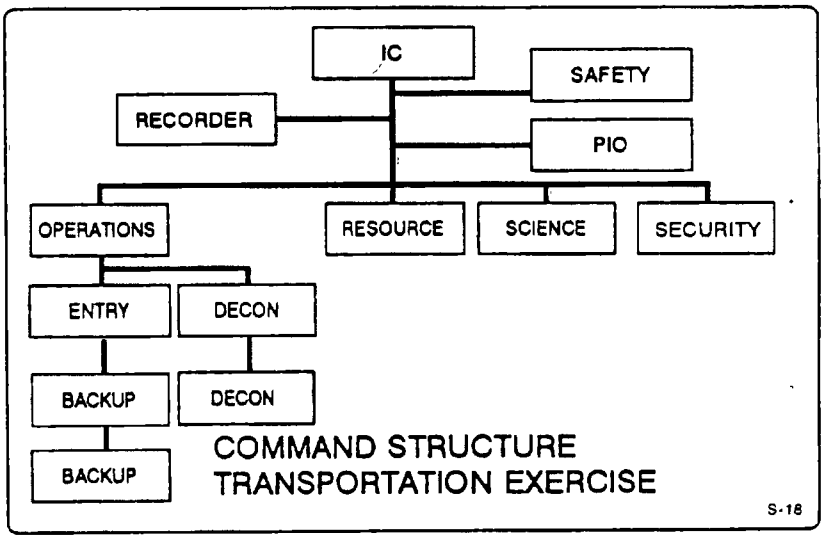
RESOURCE
SCIENCE
ENTRY
BACKUP
DECON
COMMAND STRUCTURE
WAREHOUSE EXERCISE
S-17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SAFETY
RECORDER
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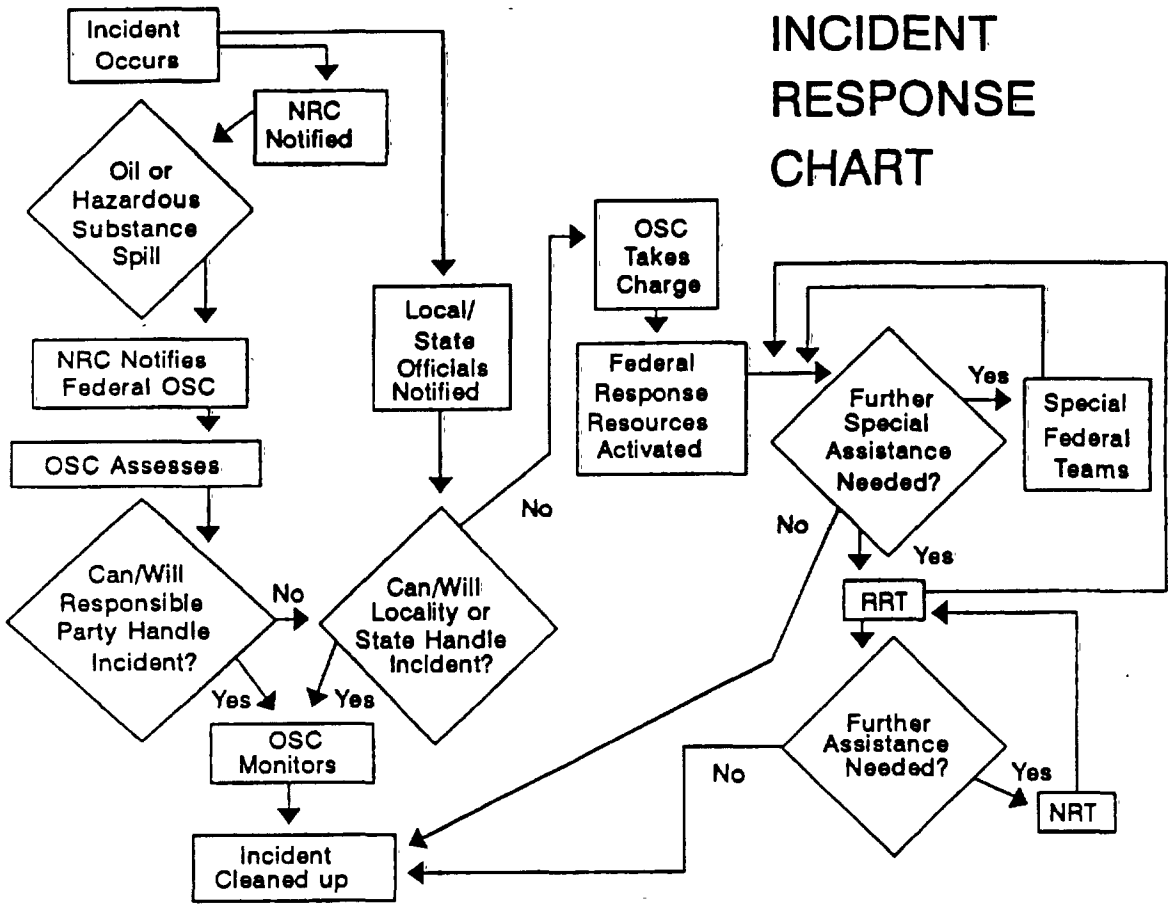
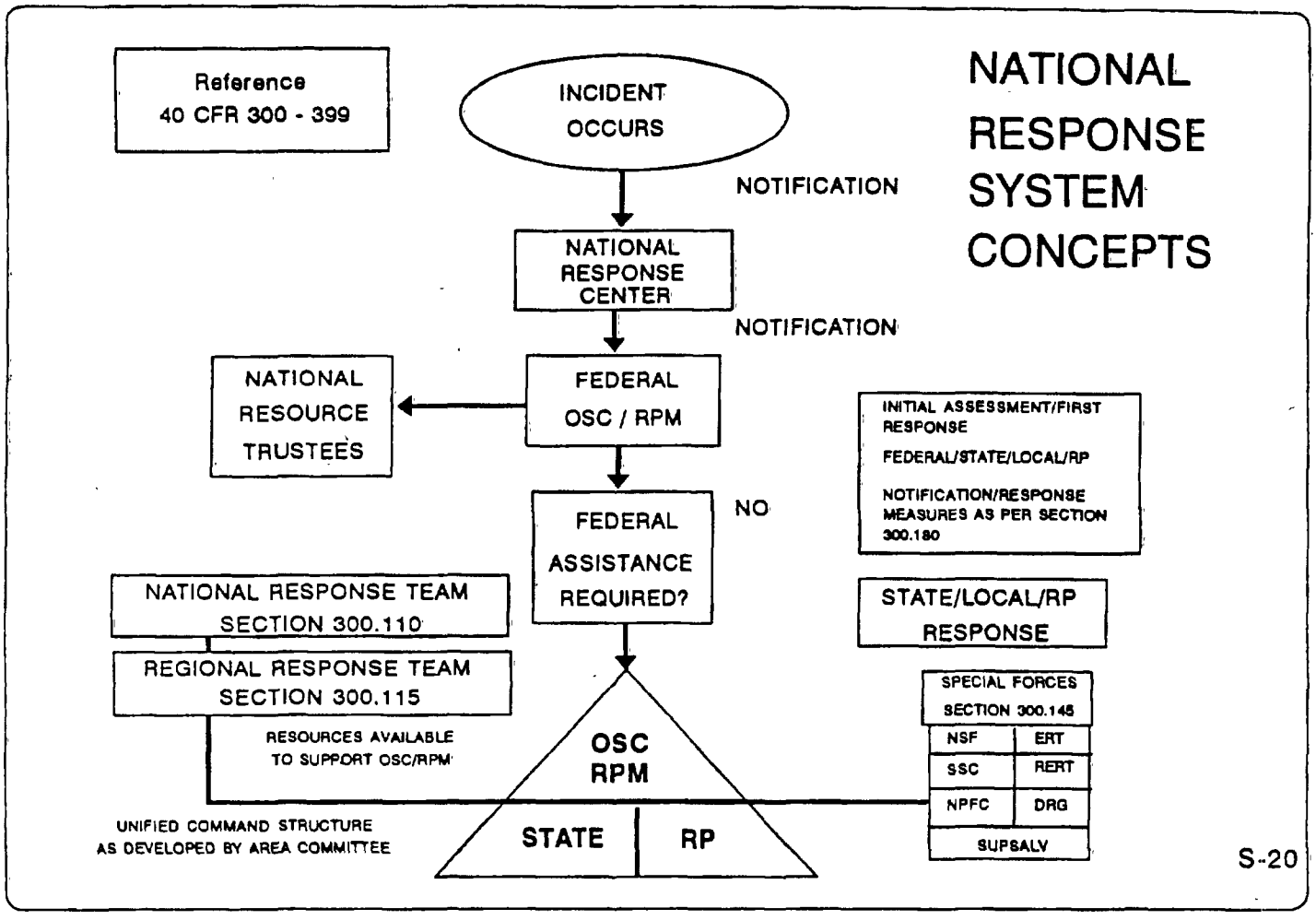
SCIENCE
SECURITY
ENTRY
DECON
BACKUP
DECON
BACKUP
COMMAND STRUCTURE
TRANSPORTATION EXERCISE
S-18


INCIDENT RESPONSE CHART
Incident Occurs
NRC Notified
Oil or Hazardous Substance Spill
NRC Notifies Federal OSC
OSC Assesses
Can/Will Responsible Party Handle Incident?
No
Yes
Local/ State Officials Notified
Can/Will Locality or State Handle Incident?
No
Yes
OSC Monitors
Incident Cleaned up
OSC Takes Charge
Federal Response Resources Activated
Further Special Assistance Needed?
Yes
Special Federal Teams
No
Yes
RRT
Further Assistance Needed?
No
Yes
NRT

S-19

NOTES


NATIONAL RESPONSE SYSTEM CONCEPTS
Reference
40 CFR 300 - 399
INCIDENT OCCURS
NOTIFICATION
NATIONAL RESPONSE CENTER
NOTIFICATION
NATIONAL RESOURCE TRUSTEES
FEDERAL OSC / RPM
INITIAL ASSESSMENT/FIRST RESPONSE
FEDERAL/STATE/LOCAL/RP
NOTIFICATION/RESPONSE MEASURES AS PER SECTION 300.180
FEDERAL ASSISTANCE REQUIRED?
NO
NATIONAL RESPONSE TEAM SECTION 300.110
STATE/LOCAL/RP RESPONSE
REGIONAL RESPONSE TEAM SECTION 300.115
RESOURCES AVAILABLE TO SUPPORT OSC/RPM
OSC RPM
SPECIAL FORCES SECTION 300.145
NSF
ERT
SSC
RERT
NPFC
DRG
SUPSALV
UNIFIED COMMAND STRUCTURE AS DEVELOPED BY AREA COMMITTEE
STATE
RP
S-20

NOTES

NOTES

FEDERAL ON-SCENE COORDINATOR General Guidelines

- Investigate, report, and determine potential outcome
- Monitor situation, making sure removal is being done properly
- Assess the situation and assist the IC

S-21

FEDERAL ON-SCENE COORDINATOR General Guidelines (cont.)

- May take over the incident if necessary
- May activate the RRT or any other federal agency as needed

S-22

CONTINGENCY PLANS

S-23

INCIDENT COMMAND SYSTEM

TOPIC		PAGE NO.
I.	THE NEED FOR AN ICS	1
II.	LAWS THAT REQUIRE AN ICS	1
III.	HISTORY OF ICS	1
IV.	ELEMENTS OF AN EFFECTIVE ICS	1
V.	BUSINESS MANAGEMENT TECHNIQUES APPLIED TO ICS	2
VI.	FACTORS THAT AFFECT ICS	3
VII.	COMPONENTS OF AN ICS	3
VIII.	ICS POSITIONS AND RESPONSIBILITIES	4
	ICS CHARTS FOR BOTH SCENARIOS	10
IX.	INTERFACING THE ICS WITH THE FEDERAL HAZARDOUS MATERIAL CONTINGENCY PLAN (NCP)	12
X.	SUMMARY	17

I. THE NEED FOR AN ICS

At any emergency, small or large, involving emergency responders, one person must be in command. This person, the Incident Commander (IC), must assess the situation and available resources, determine an appropriate action plan, monitor the plan's effectiveness, and continually modify the plan to meet the realities of the situation.

Without an ICS to coordinate the procedures for effective control and communication throughout all the responding resources, chaos would result. If response personnel are not functioning as part of an emergency management system, effectiveness is reduced, as is potential communication and coordination with other agencies that may respond to the scene.

Many systems exist throughout the nation for the command and control of resources at emergency incidents.

II. LAWS THAT REQUIRE AN ICS

All agencies must have an ICS to handle the operations at any incident. There are several laws that require a system to manage emergencies. For example

- The Superfund Amendments and Reauthorization Act of 1986 (SARA) requires organizations that handle hazardous material incidents to operate with an ICS

- The Occupational Safety and Health Administration (OSHA) (29 CFR 1910.120) rules and regulations state: "ICS shall be established by those employers for the incident that will be under their control and shall be interfaced with the other organizations or agencies who may respond to such an incident."

- Non-OSHA states are required under U.S. Environmental Protective Agency (EPA) rules to use an ICS at hazardous material incidents (40 CFR 311).

III. HISTORY OF ICS

The ICS was developed as a consequence of fires that consumed large portions of wildland, including structures, in Southern California in 1970. Difficulties in fighting these fires included ineffective communications, lack of accountability, and lack of a well-defined command structure. Fire response agencies' efforts were to address these difficulties. Although originally developed for a wildland setting, the system ultimately evolved into an "all-risk" system, appropriate for all types of emergency responses.

IV. ELEMENTS OF AN EFFECTIVE ICS

To be effective, an ICS must be suitable for use regardless of the type of jurisdiction or agency involvement. This may include single jurisdiction/single agency, single jurisdiction/multiagency, and multijurisdiction/multiagency involvement. The organizational structure must be adaptable,

applicable and acceptable to users throughout a community or region, readily adaptable to new technology, and capable of logical expansion from the initial scope to the complexities of a major emergency.

Common elements in organization, terminology, and procedures are necessary for maximum application of a system and should use existing qualifications and standards. These same elements ensure the ability to quickly and effectively move resources committed to the incident with the least disruption. Fulfillment of these requirements combined with simplicity will help ensure low operational maintenance costs.

V. BUSINESS MANAGEMENT TECHNIQUES APPLIED TO ICS

Tasks that business managers and leaders perform include planning, directing, organizing, coordinating, communicating, delegating, and evaluating.

Responsibilities of the Incident Commander (IC) include gathering and evaluating information relative to preplanning and sizeup, as well as development and communication of an Incident Action Plan. The IC must be involved with directing available resources to accomplish incident goals through operational and command responsibilities. To ensure proper incident management by coordination of overall operations, tactical operations, and support functions, a responsive organization must be developed.

The IC must be able to communicate effectively within the organization and assess feedback from an incident. Using terms that are understood by all resources is critical to his or her ability to manage the incident. Gathering and assigning resources functionally and geographically are also included in the IC's responsibilities. Continual evaluation of the overall effectiveness of the Incident Action Plan must be based on the results of previous operational decisions. As conditions change, the Incident Action Plan must be modified to achieve the goal and objective.

Although the IC may delegate functional authority, he or she always retains ultimate responsibility for the incident. If the IC chooses not to delegate one or more functions, he or she must perform that function(s) as required by the incident.

CONTROL THE SITUATION OR IT WILL CONTROL YOU!

Emergency response personnel must consider the physical environment, command structure, and proper ICS procedures during preplanning. Positive incident outcomes may be forecast with adequate preplanning and constant monitoring during an incident.

Command activities during preplanning may include strategic goal-setting, which may include 1) developing and implementing Incident Action Plans, 2) controlling/coordinating incident operations, 3) using all available resources, 4) considering safety in decision-making, 5) providing logistical support, and 6) evaluating the Incident Action Plan. The IC is responsible for managing or delegating medical consideration, liaison with other agencies, safety of personnel, media requests, property conservation, and advising the cleanup contractor of the nature of the incident.

VI. FACTORS THAT AFFECT ICS

Although many similarities exist between business and emergency management, several factors make emergency management more difficult. One unique factor to emergency management is danger. Emergency response is performed in a constantly changing environment. Although the situation may get better or worse, it seldom stays the same. The dynamics of a constantly changing environment present additional challenges to the IC. For example, it may be difficult to assess or confirm content in the building just by looking at the building construction. Risk increases due to flashover, backdraft, or the presence of hazardous contents. Combined dynamics of the incident may create difficulty in gathering accurate and current information.

Changing situations may require frequent shifts from offensive to defensive modes. The offensive mode is an aggressive approach that quickly stabilizes the incident, but puts personnel at a higher risk of exposures to toxic environments. The defensive mode includes exposure protection and resource gathering, but reduces risk of toxic exposure to personnel. The transition from defensive to offensive operations may cause changes in priority concerning life safety, incident stabilization, and property conservation.

Emergency responders should be ready for any type of incident. Because there are no guarantees that adequate resources will be available, preparation to handle each incident, regardless of size or complexity, is needed.

VII. COMPONENTS OF AN ICS

The ICS has a number of components. Together, these components provide the basis for an effective ICS concept of operation:

Common terminology	Incident action plans
Modular organization	Manageable span of control
Integrated communication	Designated incident facilities
Unified command structure	Comprehensive resource management

Common terminology in any ICS is essential. Major organizational functions and units are predesignated and titled in the ICS, and the system's terminology is standard and consistent. This will prevent confusion during multiple incidents, either within the same jurisdiction or on the same radio frequency.

Modular organization develops a structure from the top down at any incident. The command function must always be established, and the five functional areas: command, operations, logistics, planning and finance, must be implemented as the incident develops.

Integrated communications involves managing communications at all incidents through the use of a common communications plan. Standard operating procedures containing common terminology and clear text should be established. It is important that messages are not only received, but that they are also acknowledged and understood.

The command structure can be formed in two general ways, single command and unified command. Single command may be used when there is no overlap of jurisdictional boundaries or when a single IC is designated by the agency with overall management responsibility for the incident. Unified command may be applied when the incident is within one jurisdictional boundary, but more than one agency shares management responsibility. When the incident is multijurisdictional in nature, or when more than one individual is designated by their jurisdiction or agency, they may share overall management responsibility. Unified command should not be confused with unity of command. Unified command is shared responsibility for overall incident management as a result of a multijurisdictional or multiagency incident. Unity of command indicates that one individual reports to only one supervisor.

An Incident Action Plan (IAP) is needed at every incident and is implemented under the unified command under responsibility of the Incident Commander and can be assigned to the Command Staff. The IC usually represents the agency with the greatest jurisdictional involvement. Written IAP is required when resources from multiple agencies are used, when several jurisdictions are involved, or when changes in personnel or equipment are required. The IAP should cover all strategic goals, all tactical objectives, and all support activities needed during the entire operational period.

Manageable span of control is an important component of an effective ICS. Effective management is difficult if too many people are reporting to one supervisor. Span of control is defined as the number of subordinates one supervisor can manage effectively. Guidelines for the desirable range are from three to seven persons; the optimum number is five subordinates per supervisor. The Incident Commander must anticipate span-of-control problems and prepare for them, especially during rapid buildup of incident organization.

Designated incident facilities, such as Command Post or Staging Area (SA), may be established depending on the requirements of the incident. The IC determines when establishment of these facilities is necessary.

Comprehensive resource management may be accomplished using three different methods: single resources, task force, and strike team. The method chosen depends on the needs of the incident. When performed effectively, comprehensive resource management should maximize resources, consolidate control of large numbers of single resources, and reduce the communications load.

There are many reasons to implement and use an ICS. The primary reason is to provide for the safety of operating forces. ICS is an "all risk" system, based on the application of business management techniques in emergency management.

VIII. ICS POSITIONS AND RESPONSIBILITIES

In most day-to-day incidents, approximately 90–95% could be managed with a simple ICS structure. Various companies may be assigned various positions based on incident situations. By law, the two basic positions and responsibilities that must be included in any ICS are the Incident Commander and the Safety Officer. All of the other positions are on and as-needed basis.

INCIDENT COMMANDER (IC) = The IC is responsible for overall management of the incident. Some of these responsibilities include:

- Establish command of the incident
- Establish Command Post (CP) and Staging Area (SA)
- Assess the incident priorities
- Develop an incident command system appropriate for the incident
- Assign an incident Safety Officer
- Develop or approve and implement the Incident Action Plan and scene safety plan
- Determine the strategic goals and tactical objectives for the incident
- Authorize information release to the media.

COMMAND STAFF (CS) = At large-scale or complex incidents, consideration may have to be given to safety, liaison, and information. If the CS cannot effectively handle any of these three functions, he or she must appoint a Safety Officer (SO) and may appoint a Public Information Officer (PIO) and a Liaison Officer (LO).

SAFETY OFFICER (SO) = Must monitor and assess the safety hazards and unsafe situations to develop measures for ensuring personnel safety. This person has the authority to bypass the chain of command when it is necessary to correct unsafe acts immediately then inform the IC of the situation and establish corrective actions. The SO is responsible for the scene safety plan.

LIAISON OFFICER (LO) = The contact point for assisting or coordinating agencies. The LO is essential to avoid the duplication of effort and to increase the control necessary to give strong direction to agencies involved in the response. The agency representatives with whom the LO interacts need to have decision-making authority, and the LO needs to establish a specific area for agencies to report to, work in, and communicate with each other.

PUBLIC INFORMATION OFFICER (PIO) = Responsible for interfacing with the media and other appropriate agencies. The PIO gets his or her information from the IC and relays it to the media, thereby relieving the IC of this responsibility. To provide accurate and consistent information to the media, the PIO establishes a press area away from the CP and all incident activities. The PIO acts as a central clearing point for the dissemination of information, reducing the risk of forwarding conflicting information from multiple sources.

STAGING AREA MANAGER (SAM) = As the incident escalates and the IC requests additional resources, the additional responding units need to report to a given location for assignments. A staging area has to be established as the IC may not know immediately which unit to assign to what task. If an Operations Officer is not staffed, SAM would report directly to the IC. An incident may have more than one staging area. The SAM should establish a check-in procedure, respond to requests for resources, and keep the IC or Operations Officer informed of the status of resources in the staging area. Staging provides significant advantages, including: Personnel accountability, eliminates premature deployment of units, minimizes communication, reinforces unity of command, prevents freelancing, and buys IC time to properly assign and deploy resources.

PLANNING OFFICER (PO) = Proactive incident-management is highly dependent on the PO making an accurate assessment of the incident's potential and prediction of likely outcomes. It is critical that the PO maintain information about resources committed to the incident and projected

resource requirements. Development of an effective Incident Action Plan, or modification of an existing plan, must be based on knowledge of what has happened and a prediction made of probable future outcomes.

Some of these responsibilities include:

- Collect information regarding the incident and resources
- Evaluate information received from a variety of sources
- Disseminate information to the IC, Operations, and incident personnel, as necessary
- Use information in preparation of the Incident Action Plan
- Modify the Incident Action Plan to meet changing needs
- Anticipate changing resource needs
- Prepare alternate strategies and tactical options based on incident potential.

LOGISTICS OFFICER = Manages service and support resources required for the incident. Logistics should establish functional units when needed to maintain an acceptable workload and span of control. Responsible for all logistics needs for the incident.

Some of these responsibilities include:

- Establish service branches for all incident activities, communications, emergency medical service, fire, rescue, and provisions for feeding operating forces
- Provide personnel, equipment, and supplies to support incident operations
- Provision for fixed incident facilities, and ground support such as fuel and equipment maintenance.

FINANCE = Must provide the documentation of all incident cost, and the guidance to the IC on financial issues that may have an impact on incident operations. Financial considerations are not a major factor during most incidents operations. The financial considerations can be extensive however, when an agency is involved in any incident that requires the use of private sector resources or any incidents where agencies involved in the response will be seeking reimbursement.

Some of these responsibilities include:

- Pay future costs and budget
- Pay personnel costs
- Cost recovery
- Purchase replacement equipments.

OPERATIONS OFFICER (OPS) = Is assigned when the IC is faced with a complex incident having major demands in one or more areas in a rapidly escalating incident or when there is a significant need to evaluate strategy and to develop alternative tactical options. When the IC is faced with a major functional tactical responsibility the OPS Officer may be assigned to maintain span-of-control or sector control. The OPS Officer is responsible for the direction and coordination of all tactical operations.

Some of these responsibilities include:

- Assist the IC in planning and developing strategic goals and tactical objectives for the incident
- Develop operation plans
- Request or release resources through the IC, unless SAM is assigned to OPS
- Consult with Command Staff about the overall Incident Action Plan
- Keep the IC informed of the tactical situation and resource status within operations.

BRANCHES = At large scale or complex incidents, which may create a significant span-of-control problem, consideration should be given to the implementation of Branches. Branches are of great value also when large numbers of resources are committed to a specific functional activity. A Branch is an organizational level between divisions/groups and OPS, Logistics and the IC. A Branch is responsible for performing the portion of the Incident Action Plan appropriate for that particular Branch. Branches are managed by a Branch Director. They are used most commonly in the Operations or Logistics sections.

Some of the responsibilities are:

- Implement the portion of the Incident Action Plan appropriate to the Branch function
- Coordinate the activities of the units within the Branch
- Evaluate goals and objectives and requests additional resources, if needed
- Keep his or her supervisor, either the Operation Officer or the Incident Commander informed of the status in the Branch's area of responsibility
- Assign specific tasks to Divisions or Groups within the Branch
- Resolve logistical problems associated within the units deployed in the Branch.

DIVISION/GROUPS = An organizational level responsible for operations in a specified functional assignment at an incident. It is essential to understand that Division/Group operates at the same command level; one does not work for the other, but may cross established boundaries. Each function assignment does not need to be commanded by a Division/Group supervisor. In fact, any activity that only requires one unit to effectively handle the situation would not necessitate the implementation of a Division/Group. Such situations include when there is not a coordination problem, when the assignment obviously does not cover a large area, or when it does not require deployment of several single resources.

Division/Groups affect the following three significant management principles:

- Reduce/solve span-of-control problems at an incident
- Provide essential coordination at a designated area or for a specific function
- Fix personnel accountability.

Some of these responsibilities include:

- Provide accountability and coordination of the unit
- Ensure maximum safety and survival of response personnel
- Implement of their assigned portion of the overall Incident Action Plan

- Coordinate activities within their assignment
- Inform the next-higher-level of command of the status of resources within their area
- Evaluate the resource needs and make adjustments as needed.

The functional positions that are staffed depend on the needs of the incident. As a general rule, the larger or more complex the incident, the more need to delegate functional responsibilities. Functional responsibilities for any position that are not staffed remain with the IC. Some functional assignments must not be combined, due to their critical impact on safety or incident control. There are functions, however, that can be combined on smaller incidents.

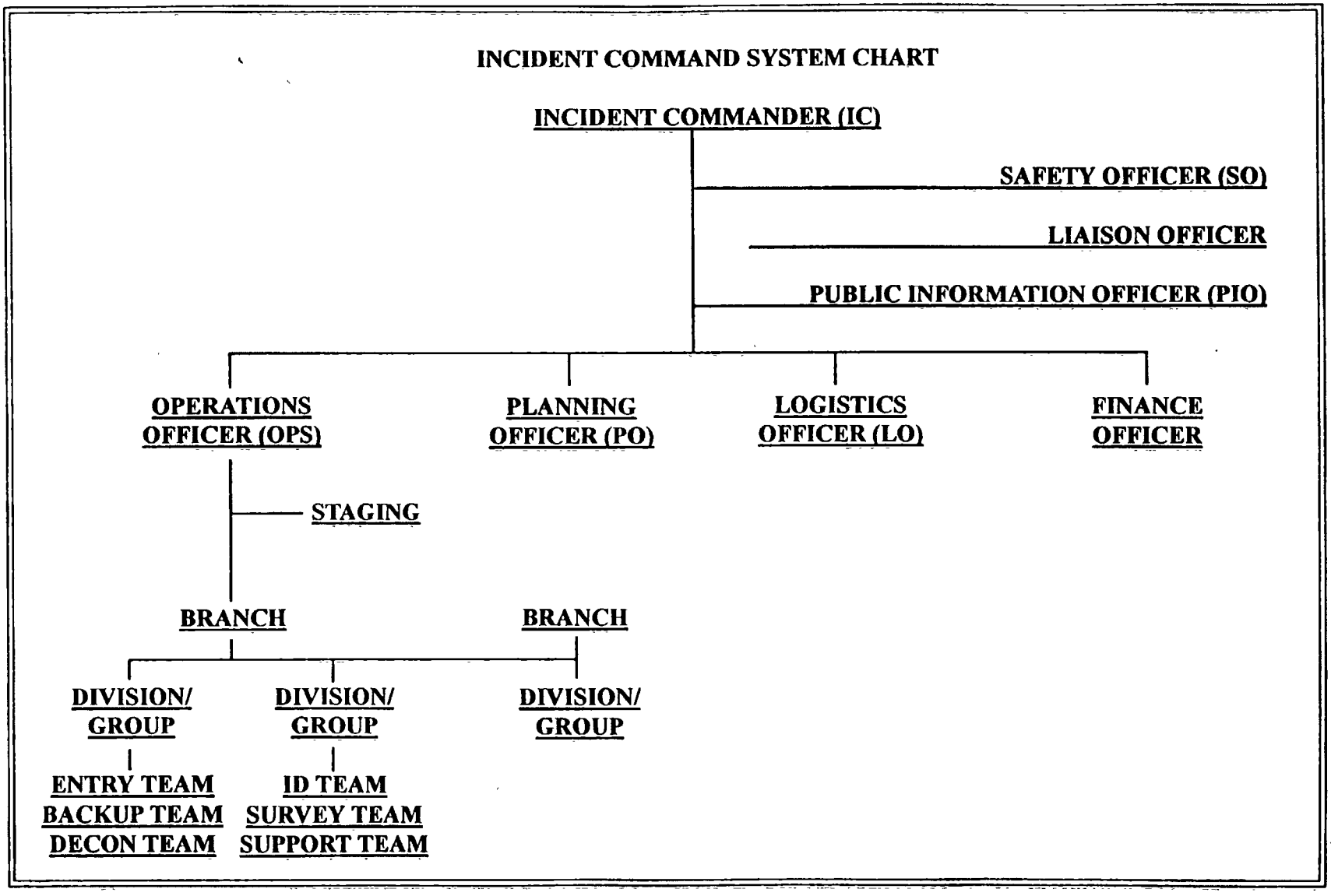

INCIDENT COMMAND SYSTEM CHART
INCIDENT COMMANDER (IC)
SAFETY OFFICER (SO)
LIAISON OFFICER
PUBLIC INFORMATION OFFICER (PIO)
OPERATIONS OFFICER (OPS)
PLANNING OFFICER (PO)
LOGISTICS OFFICER (LO)
FINANCE OFFICER
STAGING
BRANCH
BRANCH
DIVISION/ GROUP
DIVISION/ GROUP
DIVISION/ GROUP
ENTRY TEAM
BACKUP TEAM
DECON TEAM
ID TEAM
SURVEY TEAM
SUPPORT TEAM

FIGURE 1

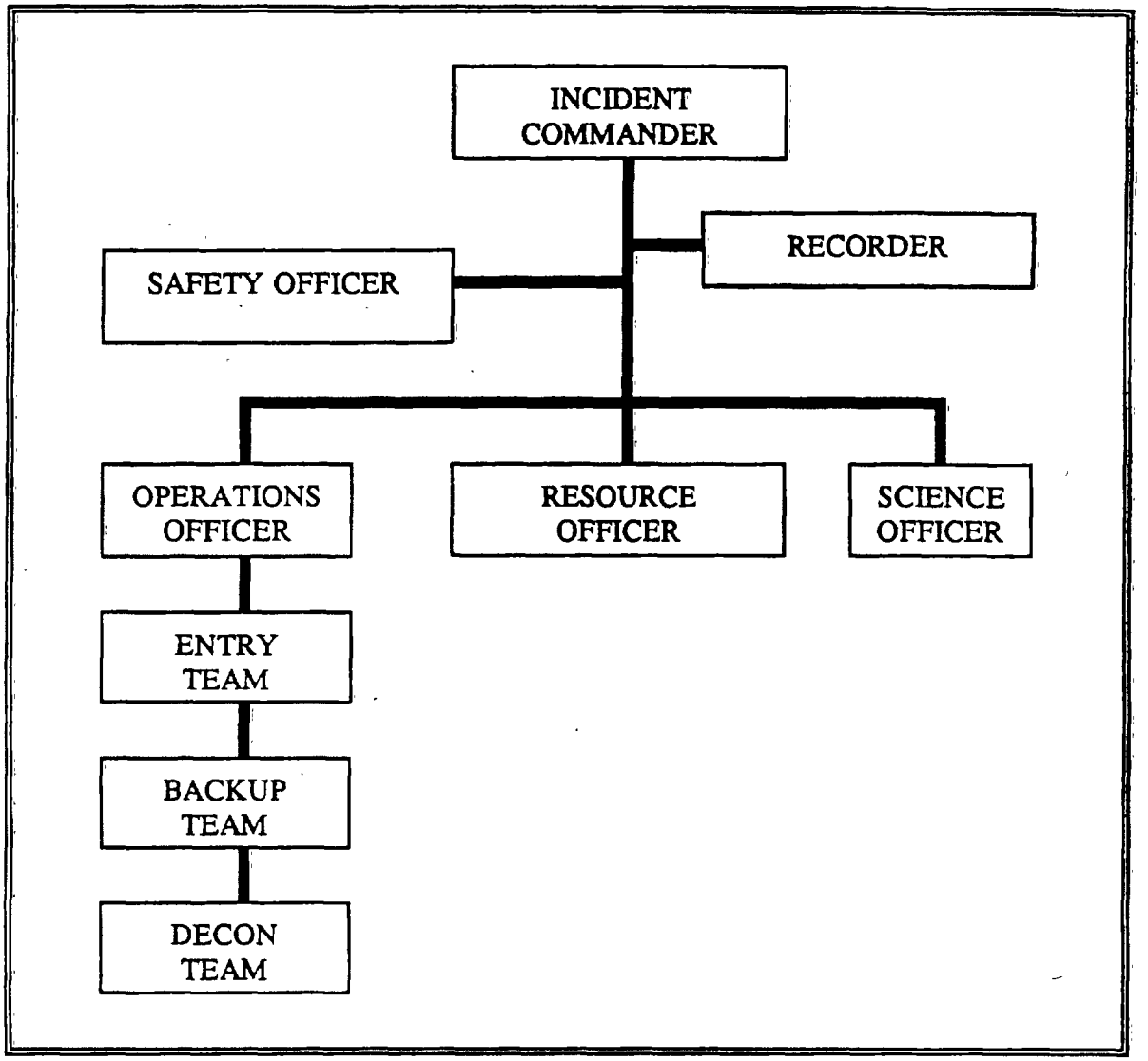


FIGURE 2
COMMAND STRUCTURE FOR SMALL INCIDENT

This is the command structure we will use in the course for the warehouse incident on Thursday.

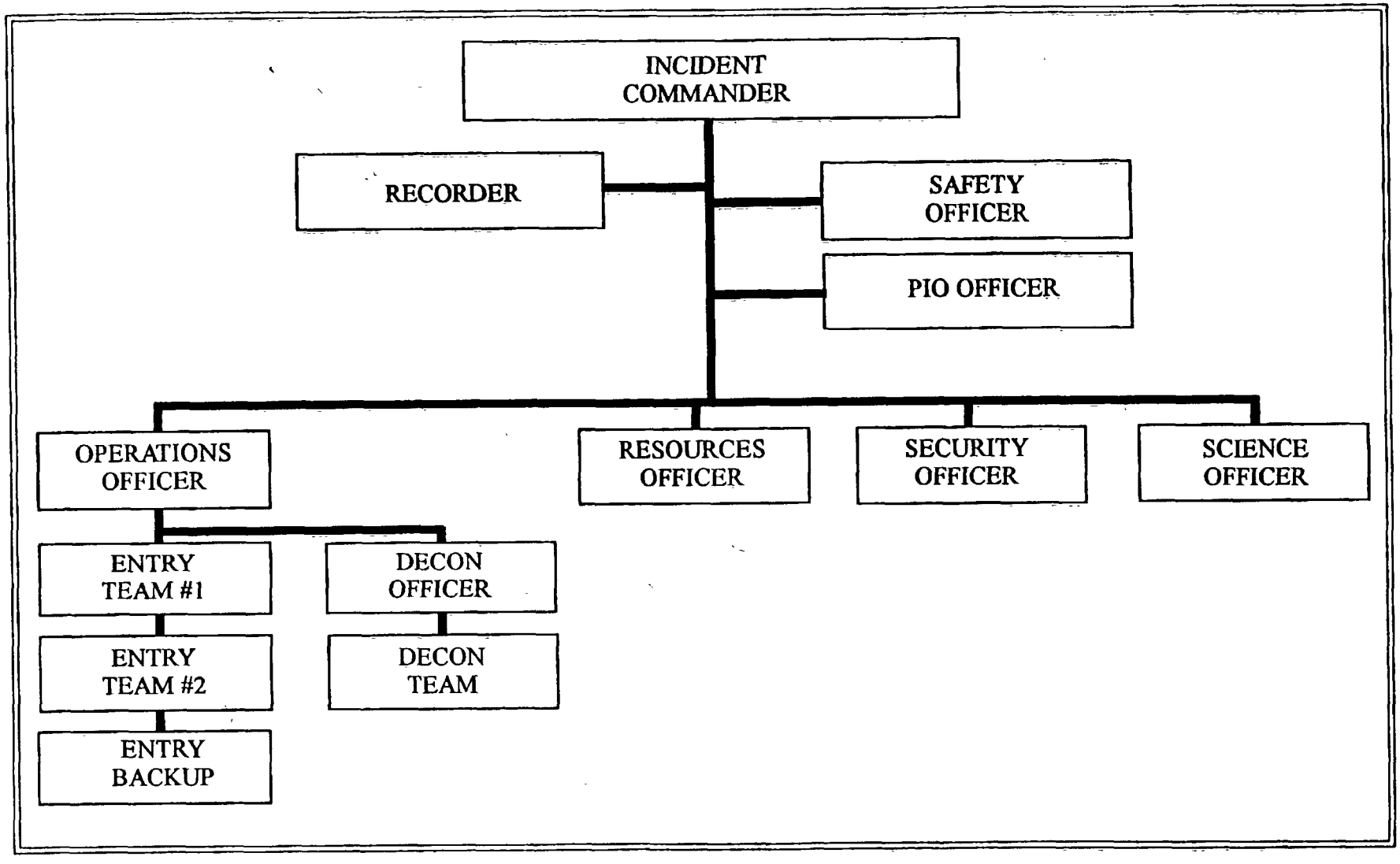


FIGURE 3
COMMAND STRUCTURE FOR A MAJOR INCIDENT

This is the command structure we will use in the course for the Transportation incident on Friday.

IX. THE INCIDENT COMMAND SYSTEM INTERFACED WITH THE FEDERAL HAZARDOUS MATERIAL CONTINGENCY PLAN (NCP)

A. If the incident exceeds the training and/or the equipment of the local jurisdiction, or the incident is more than the jurisdiction can handle, the incident commander should then use the local and state contingency plans for assistance.

Once passed, the Superfund Amendments and Reauthorization Act of 1986 (SARA) or public law 99-499, required all states to establish State Emergency Response Commissions (SERC) and Local Emergency Planning Committees (LEPC). The SERCs are responsible for designating an official to serve as coordinator of all SERC and LEPC actives in the respective state. The SERCs are required to establish procedures for receiving and processing the facilities Tier I and II reports. The Tier I and II reports are used to help establish contingency plans that can be used for emergency responses and for information on public access to the facility. The SERCs must review all plans to ensure these plans follow the National Contingency Plan (NCP). This information should be part of the Local Emergency Response standard operation procedures so it may be used at any emergency.

Some incidents are so serious that local authorities must call in additional help. State agencies can provide expertise and management over a wider area. If additional help is still needed, or if several states are involved, a single call to the National Response Center (NRC) will activate the National Response System (NRS).

The National Response System (NRS) is the mechanism for coordinating response actions by all levels of government in support of the Federal On-Scene Coordinator/Remedial Project Manger (OSC/RPM). The NRS is composed of the National Response Team (NRT), Regional Response Team (RRT), Federal OSC/RPM Area Committees (AC), and special teams and related support entities. During oil spill response or a hazardous substance removal action, the NRS functions as an Incident Command System (ICS) under the direction of the Federal OSC, typical of an ICS, the NRS is capable of expanding or contracting to accommodate the response effort required by the size or complexity of the discharge or release.

Notification of an oil discharge, or of a release of a hazardous substance in an amount equal to or greater than the Reportable Quantity (RQ), must be made immediately to the NRC in accordance, respectively, with 33 CFR part 153, subpart b, and 40 CFR part 302.

The NRC acts as the single point-of-contact for all pollution-incident reporting and as the National Response Team (NRT) communications center.
The NRC receives and immediately relays telephone notices of discharges or releases to

1. The appropriate predesignated Federal OSC and/or RPM, and

2. Advises Federal Emergency Management Agency (FEMA) of a potential major disaster or evacuation situation.

The first federal official affiliated with an NRT member agency to arrive at the scene of a discharge or release should coordinate activities under the National Contingency Plan (NCP). The federal official is authorized to initiate, in consultation with the predesignated OSC, any necessary action normally carried out by the federal OSC/RPM until the arrival of the predesignated federal OSC/RPM.

B. There are three levels of the Federal Contingency Plans (FCP) that an Incident Commander must beware of. A federal EPA OSC/RPM, depending on incident status, may act as a resource, or may take charge of the incident and activate federal response resources as needed.

1. The National Contingency Plan (NCP) is officially called the National Oil and Hazardous Substance Pollution Contingency Plan. It provides the organizational structure and procedures for preparing for and responding to discharges of oil and releases of hazardous substances, pollutants, and contaminants. The NCP is a guidance document for EPA and other federal agencies with response authority and responsibility under the Comprehensive Environmental Response, Compensation, and Liability act of 1980 (CERCLA), and certain portions of the Clean Water Act (CWA). This plan is comprehensive in relating how these agencies are involved in a spectrum of pre-event plans for the on-scene response, the study, analysis and remediation, the financing, and the accountability.

2. The Regional Contingency Plans (RCP) are developed by the RRT, working with the states. RCPs were developed for each RCP standard federal region, Alaska, Oceanic in the Pacific, and the Caribbean to coordinate timely, effective response by various federal agencies and other organizations to discharges of oil or releases of hazardous substances, pollutants, or contaminants. RCPs shall, as appropriate, include information on all useful facilities and resources in the region, such as government, commercial, academic, and many other sources. To the greatest extent possible, RCPs shall follow the format of the NCP, the Area Contingency Plans (ACP) and coordinate with SERP, and SARA Title III LERPs. RCPs shall contain lines of demarcation between the inland and coastal zones, as mutually agreed upon by USCG and EPA.

3. The ACP, under the direction of an OSC and subject to approval by the lead agency, each Area Committee, in consultation with the appropriate RRTs, Coast Guard DRGs, NSFCC, SSCs, SERCs, and LEPCs, shall develop an ACP for its designated area. This plan, when implemented in conjunction with other provisions of the NCP, shall remove a worst-case discharge under 40 CFR 300.324, and to mitigate or prevent a substantial threat of such a discharge from a vessel, offshore facility, or onshore facility operating in or near the area.

   The areas responsible may include several Title III Local Planning Districts, or parts of such districts. In developing the ACP, the OSC shall coordinate with affected SERCs and LEPCs. The ACP shall provide for a well-

coordinated response that is integrated and compatible, to the greatest extent possible, with all appropriate response plans of state, local, and non-federal entities, and especially the various response plans.

The ACPs shall include the available resources to respond to a multi-media incident, where such resources can be obtained, the waste disposal methods and facilities consistent with local and state plans developed under the Solid Waste Disposal Act (SWDA), and the local structure for responding to discharges or releases.

C. Multi-regional responses:

1. If a discharge or release moves from the area covered by one ACP or RCP or into another area, the authority for response actions should shift. If a discharge or release affects areas covered by two or more ACPs or RCPs, the response mechanisms of each applicable plan may be activated. In this case, response actions of all regions concerned shall be fully coordinated as detailed in the ACPs and RCPs.

2. There shall be only one OSC and/or RPM at anytime during the course of a response operation. Should a discharge or release affect two or more areas, the EPA, USCG, DOD, DOE, or other lead agency, as appropriate, shall give prime consideration to the area vulnerable to the greatest threat, in determining which agency should provide the OSC and/or RPM. The RRT shall designate the OSC and/or RPM if the RRT member agencies, who have response authority within the affected area, are unable to agree on the designation. The NRT shall designate the OSC and/or RPM if members of one RRT or two adjacent RRTs are unable to agree on the designation.

3. Where the USCG has initially provided the OSC for response to a release from hazardous waste management facilities located in the coastal zone, the responsibility for response action will shift to the EPA or another federal agency, as appropriate.

D. Once the federal EPA OSC has been contacted by the NRC, you can expect the OSC to follow these general guidelines. When the OSC receives a report of a discharge, actions normally should be taken in the following sequence:

1. Investigate the report to determine pertinent information, such as the type and quantity of polluting material, the source of the discharge, and the threat posed to public health or welfare or the environment.

2. Officially classify the size of the discharge as minor, medium, or major and the type of hazard as either a substantial threat to the public health or welfare, or worst-case discharge. These will determine the course of action to be followed to ensure effective and immediate removal, mitigation, or prevention of the discharge. Some discharges or spills may be further classified as national significance by the administrator of the EPA or the Commandant of the USCG.

3. When the reported discharge is an actual or potential major discharge, immediately notify the RRT, including the affected state, if appropriate, and the NRC, and ensure notification of the Natural Resource Trustees, as required by 40 CFR 300.305(D).

4. When the investigation shows that an actual or potential medium discharge exists, the OSC shall recommend activation of the RRT, if appropriate.

5. When the investigation shows that an actual or potential minor discharge exists, the OSC shall monitor the situation to ensure that proper removal action is being taken.

6. If the OSC determines that effective and immediate removal, mitigation, or prevention of a discharge can be achieved by private party efforts, and when the discharge does not pose a substantial threat to the public health or welfare of the United States, determine whether the responsible party or other person is properly carrying out removal. Removal is being done properly when:

   a. The cleanup is fully sufficient to minimize or mitigate threat(s) to public health and welfare, and the environment. Removal efforts are improper to the extent that federal efforts are necessary to minimize further threats or mitigate those threats.

   b. The removal efforts are in accordance with applicable regulation, including the NCP.

7. Where appropriate, determine whether a state or political subdivision has the capability to carry out response actions and/or all removal actions. If they have, the OSC may arrange funding to support these actions.

8. Ensure prompt notification of the trustees of affected natural resources in accordance with the applicable RCP and ACP.

9. Removal shall be considered complete when it is determined by the OSC in consultation with the governor or governors of the affected states. When the OSC considers removal complete, OSLFT removal funding shall not preclude applicable state law.

10. EPA OSCs have access to very large amounts of equipment and working capital to be used to control a discharge or release. OSCs have approximately $150,000.00 immediately available to use, as necessary, in a discharge or release. If the OSC expends these funds on the incident, they have access to an additional $2,000,000.00, after completing an "Action Memo," to use on the scene. If circumstances show a need for more funds to stabilize the incident, the OSC can obtain unlimited funds through a justification to EPA headquarters in Washington D.C.

11. If the discharge or release is some type of oil, the OSC can access the Oil Pollution Act Funds through the USCG, and receive all the necessary funding required to immediately stabilize the incident.

12. During all phases of response, the lead agency shall complete and maintain documentation to support all action taken under the NCP and to form the basis for cost recovery. All information and reports must be transmitted to the Chair of the RRT. Also the OSC is required to submit reports of the incident.

13. The OSC/RPM shall submit a complete report on the removal operation and the actions taken to the NRT or RRT. This report shall record the situation as it developed, the actions taken, the resources committed, and the problems encountered. Once the RRT has received the OSC report, they have 30 days in which to review the comments or recommendations.

E. Special response teams:

1. On-Scene Coordinator (OSC): Manages these federal responses.

2. Remedial Project Managers (RPM): Directs response efforts and coordinates all other efforts at the scene of a discharge or release. RPM shall be assigned by the lead agency to manage remedial or other response actions.

3. National Response Team (NRT): This body of 15 federal agency representatives with expertise related to handling incidents, coordinates the NRT system.

4. EPA's Office of Radiation Programs (ORP) Radiological Assistance Teams (RAT): Provides response and support for incident or sites containing radiological hazards. They provide expertise in radiation monitoring, radionuclide analysis, radiation health physics, and risk assessment. RAT can provide on-site support including mobile monitoring laboratories for field analysis of samples and fixed laboratories for radiochemical sampling and analysis. The team provides multimedia sampling and analysis, hazard evaluation, environmental assessment, and cleanup technique information.

5. The Coast Guard's Public Information Assist Team (PIAT): This is a unit of public affairs specialists that concentrates on maintaining a flow of timely information from the OSC to the public.

6. The National Oceanic and Atmospheric Administration's (NOAA) Scientific Support Coordinators (SSC) serve as members of the coastal zone OSC's staff as technical and scientific advisors. They also serve as the principal contact point for members of the scientific community. The EPA supplies SSC for the inland regions.

F. The National Response Team (NRT) is comprised of representative of 15 federal agencies which are as follows:

1. Environmental Protection Agency (EPA)
2. United States Coast Guard (USCG)
3. Federal Emergency Management Agency (FEMA)
4. Department of Justice (DOJ)
5. Department of Defense (DOD)
6. Department of Interior (DOI)
7. Department of Commerce (DOC)
8. Department of Agriculture (USDA)
9. Research and Special Programs Administration (RSPA)
10. Nuclear Regulatory Commission (NRC)
11. Department of Health and Human Services (DHHS)
12. Department of State (DOS)
13. Department of Energy (DOE)
14. Department of Labor (DOL)
15. General Service Administration (GSA)

X. SUMMARY

The Incident Command System is a resource that can be applied on an as-needed basis that provides a practical, realistic approach to incident management. If fully understood, it will not only make each job easier, it also will make it possible for everyone to be professional, emergency incident managers.

It is good to understand the entire system, but only apply what is necessary in a day-to-day incident. Regular use of the ICS provides the training for future expansion. When the correct terms are used, relationships are established and procedures are practiced so that the management of larger incidents can be built on a strong foundation. It is necessary to have justification for each level of expansion of the system.

Except for the simplest incident, there is more than one way to organize an incident, so flexibility and imagination are important. A thorough knowledge of the ICS and an agency's familiarity with it, will ensure a safer, more effective approach to emergency incident management.

An Incident Commander must be well aware of the LEPC, SERC, and Federal Contingency Plans (FCP) that apply to their jurisdiction and how the federal agencies interface with the Incident Command System (ICS).

As the incident exceeds the capabilities of the local authorities, they should call for additional assistance from the NRS. The NCP is there to provide efficient, coordinated, and effective response to discharge of oil and releases of hazardous substances, pollutants, and contaminants in accordance with the authorities of CERCLA and CWA.

In implementing the NCP, consideration shall be given to international assistance plans and agreements, security regulations and responsibilities based on international agreement, federal

statutes, and executive orders. Actions taken pursuant to the NCP shall conform to the provisions of International Joint Contingency Plans, where they are applicable. The Department of State shall be consulted, as appropriate, prior to taking any action which may affect its activities.

Response actions undertaken by participating agencies shall be carried out under existing programs and authorities, when available. Federal agencies are to make resources available, expend funds, or participate in response to discharge and releases under their existing authority. Interagency agreements may be signed when necessary to ensure that the federal resources will be available for a timely response to a discharge or release.

Additional information may be found in the following references:

National Oil and Hazardous Substances Pollution Contingency Plan (NCP) September 15,1994, 40 CFR 300

Occupation Safety and Health Agency's (OSHA) Hazardous Waste Operation and Emergency Response (HAZWOPER), March 1990, 29 CFR 1910.120 (Q)

Superfund Amendments and Reauthorization Act of 1986 (SARA) Public Law 99-499 42 U.S.C. 11022

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), Public Law 96-510, 40 CFR 305.103

National Fire Academy. 1993. The Incident Command System. National Emergency Training Center, Emmitsburg, MD.

Fire Protection Publication. 1983. Incident Command System. First Edition. Fire Protection Publications Oklahoma State University, Stillwater, OK.

National Interagency Fire Center. 1995 Incident Command System National Training Curriculum. National Interagency Fire Center, National Fire Training Support Group, Boise, ID.

INCIDENT COMMANDER

The Incident Commander is responsible for incident activities including the development and implementation of strategic decisions and for approving the ordering and releasing of resources.

DUTIES

1. Assess incident situation.
2. Discuss objectives and strategy with Command Staff and section chiefs.
3. Conduct initial briefing using Haz-Mat Response forms and Tactical command sheet.
4. Insure planning meeting is conducted.
5. Approve and authorize implantation of Scene Safety Plan.
6. Determine information needs and inform command personnel of needs.
7. Coordinate staff activity.
8. Manage incident operations.
9. Approve requests for additional resources and request for release of resources.
10. Authorize release of information to news media.
11. Approve plans for Incident Termination and Demobilization.

RECORDER

The Recorder reports to the Incident Commander. The Recorder is responsible for the collection and organization of incident status and situation information. Responsible evaluation, analysis, and display of information for use by ICS personnel, agency dispatchers, and the Incident Command Post.

DUTIES

1. Obtain briefing from Incident Commander.

2. Prepare and maintain command post displays.

3. Collect incident data at earliest possible opportunity and continue for duration of incident.

4. Prepare predictions at periodic intervals or upon request of Incident Commander

5. Participate in incident planning meetings.

6. Maintain incident unit log, ICS 214.

7. Obtain information from Science Officer and Resource Officer.

PUBLIC INFORMATION OFFICER

The Public Information Officer, a member of the Command Staff, is responsible for the formulation and release of information about the incident to the news media and other appropriate agencies and organizations.

DUTIES

1. Obtain briefing from the Incident Commander.
2. Contact other jurisdictional agencies to coordinate public information activities.
3. Establish Single Incident Information Center whenever possible.
4. Arrange for necessary work space, materials, telephone, and staffing.
5. Prepare initial information summary as soon as possible after arrival.
6. Observe constraints on the release of information imposed by the Incident Commander.
7. Obtain approval for releases to the news media from the Incident Commander.
8. Release news to the media, and post relative information on the incident in the command post and other appropriate areas.
9. Attend meeting to update informational releases.
10. Respond to special requests for information.

SECURITY OFFICER

During a major incident, a Security Officer will assume the duties as section leader for law enforcement activities. The Security Officer will contribute to determining overall objectives and the selection of a strategy to achieve those objectives. The Security Officer is responsible for all evacuation, on-and-off scene control, and traffic control.

DUTIES

1. Assess incident situation.

2. Discuss objectives and strategy with the Incident Commander.

3. Attend initial briefing.

4. Assign law enforcement officer as Assistant Security Officer. Brief Assistant Security Officer on responsibilities and provide direction for incident evacuation, on site control, and traffic control.

5. Brief Command and General Staff.

6. Attend planning meetings.

ASSISTANT SECURITY OFFICER

The Assistant Security Officer is under the command of the Incident Security Officer and coordinates operations with the Operations Section Chief. The Assistant Security Officer is responsible for on-scene control, traffic control and incident evacuation.

The law enforcement agency having jurisdiction over the incident shall provide a field supervisor as the Assistant Security Officer.

DUTIES

1. Obtain briefing and directions from the Security Officer and Operations Section Chief.
2. Appoint and brief staff, as needed.
3. Establish radio communications capability.
4. Direct on-scene control, traffic control and incident evacuation procedures.

OPERATIONS OFFICER

The Operations Section Chief, a Member of the General Staff, is responsible for the management of all operations directly applicable to the primary mission. The Operations Chief activates and supervises organizational elements in accordance with the establish goals and objectives and directs its execution. The Operation Chief also directs the preparation of unit operational plans, requests or releases resources, makes expedient changes to the goals and objectives as necessary; and reports such to the Incident Commander.

DUTIES

1. Obtain briefing from the Incident Commander.

2. Brief tactical operations personnel with goals and objectives.

3. Supervise tactical operations.

4. Determine and review suggested list of resources to be released and initiate recommendation for release of resources.

5. Report information about special occurrences to Incident Commander.

6. Complete Operation Officer Worksheet.

7. Prior to entry of the Hot Zone, the following will be completed:

   a. Hazardous materials safety briefing.
   b. Personnel decontamination procedures established and entry team is briefed.
   c. Back-up team is ready. (decontamination leader will ensure that back-up team is assisted with final donning of protective clothing before when needed.)
   d. Check entry team equipment before entering Hot Zone.
   e. Check communications equipment.
   f. Complete Entry Team Checklist.

8. Carry out incident termination and demobilization procedures.

SAFETY OFFICER

The Safety Officer, a member of the Command Staff, is responsible for monitoring and assessing hazardous and unsafe situation and developing measures for assuring personnel safety. Although the Safety Officer may exercise emergency authority to stop or prevent unsafe acts when immediate action is required, the officer will generally correct unsafe acts or conditions through the regular line of authority. The officer maintains awareness of active and developing situations, approves the Medical Plan, and includes safety messages in each Scene Safety Plan.

DUTIES

1. Obtain briefing from Incident Commander.

2. Identify hazardous situation associated with the incident.

3. Participate in planning meetings and attend all briefings on scene.

4. Develop and review Scene Safety Plans and brief operation personal of all items.

5. Exercise emergency authority to stop and prevent unsafe acts.

6. Investigate accidents that have occurred within incident area.

7. Review and approve Medical Plan.

9. Determine with Science Officer the level of protection and proper decontamination procedures and solution.

ASSISTANT SAFETY OFFICER

The Assistant Safety Officer reports to the Incident Safety Officer as an Assistant Safety Officer. The Assistant Safety Officer coordinates safety activities directly related to the Hazardous Materials Group operations as mandated by 29CFR part 1910.120. This position advises the incident Safety Officer on all aspects of health and safety and has the authority to STOP OR PREVENT UNSAFE ACTS. It is mandatory that an Assistant Safety Officer be appointed at all hazardous materials incidents. In a multi-activity incident the Assistant Safety Officer does not act as safety for the overall incident.

DUTIES

1. Obtain briefing from Incident Safety Officer.

2. Participates in the preparation of, and implements the Scene Safety Plan.

3. Advises the Incident Safety Officer of deviations from the Scene Safety Plan or any dangerous situation.

4. Has full authority to alter, suspend, or terminate any activity that may be judged to be unsafe.

5. Ensure protection of the Hazardous Materials Group personnel from physical, environmental, and chemical hazard/exposures.

6. Ensure provision of required emergency medical services for assigned personnel and coordinates with Medical Branch Director.

7. Ensures that medical related records for the Hazardous Materials Group personnel are maintained.

SCIENCE OFFICER

The Science Officer reports to the Incident Commander. The SO is responsible for management of the Identification Team, and reporting on progress of identification of unknown or known substances.

DUTIES

1. Obtain briefing from the Command Staff.

2. Establish ID Station near the Command Post area.

3. Attend command staff briefing and provide technical information as needed.

4. Based on incident information, advise command staff of the degree of hazard and level of required protection. Specifically, chemical properties, fire,health hazards, type of protective clothing needed,medical considerations, environmental considerations, and run off hazards.

5. Submit update information to Incident Commander as it becomes available.

6. Fill out chemical worksheet and Haz-Mat response form.

7. Ascertain and record any and all information on substance, and provide this information to the Safety Officer and Decontamination Officer.

8. Communicate with reference networks, such as CHEMTREC.

RESOURCE OFFICER

The Resource Officer reports to the Incident Commander. The Resource Officer is primarily responsible for ordering personnel, equipment, and supplies; receiving and staging all supplies for the incident; maintaining an inventory of supplies; and servicing nonexpendable supplies and equipment.

DUTIES

1. Obtain briefing from the Incident Commander.
2. Determine the type and amount of supplies in route.
3. Order, receive, distribute,and store supplies and equipment.
4. Receive and respond to requests for personnel, supplies, and equipment on site.
5. Maintain inventory of supplies and equipment.
6. Submit cost recovery reports to the Incident Commander.
7. Participate in the termination procedures and demobilization.

ENTRY TEAM

The Entry Team reports to the Operation Officer. The Entry Team will be the only personnel allowed into the Hot Zone (Exclusion Zone). Under the direction of the Operation Officer, the Entry Team will control, sample, contain, and any other appropriate actions required to mitigate the results of the uncontrolled release of the hazardous materials.

DUTIES

1. Obtain briefing from the Operation Officer.
2. Attend Safety briefing, avoid contact with spilled material(s) if at all possible.
3. Maintain proper monitoring procedures throughout entry.
4. Check communications.
5. Take vital signs before donning proper protective clothing.
6. Establish and properly brief personnel on decontamination procedures.
7. Attend final incident goals and objectives briefing before going into exclusion zone (Hot Zone).
8. Maintain communications with Operation Officer.
9. Take vital signs after doffing personal protective equipment.
10. After personnel wash Entry Team members, attend debriefing with Command Staff and Back-up Team and provide necessary site information and diagram to Command Staff.

BACK-UP TEAM

The Back-up Team reports to the Operation Officer. The Back-up Team personnel may only enter into the Hot Zone (Exclusion Zone) when instructed by the Operation Officer. Under the direction of the Operation Officer, they may assume the Entry Team responsibilities. The Back-up Team will stay in the ready position as long as the Entry Team is in the exclusion zone, or until assigned by the Operation Officer.

DUTIES

1. Follow dressout procedure and dress to ready position with same level and type of protective clothing as Entry Team.

2. Stage in support zone by entry port.

3. Assemble and prepare rescue equipment in stage at their location.

4. Monitor Entry Team radio communication.

5. Know the Entry Team responsibilities and duties.

DECONTAMINATION TEAM LEADER

The Decontamination Team Leader is responsible to the Operation Officer. The Team Leader supervises and controls all phases of the Contamination Reduction Zone (CRZ).

DUTIES

1. Obtains briefing from Operation Officer.

2. Locates, organizes, and supervises the Contamination Reduction Zone (CRZ).

3. Coordinates operations with the Operation Officer.

4. Coordinates with Safety Officer, District Health Department, Science Officer, Operation Officer to select appropriate decontamination procedures for both incident personnel and victims. Final decision will be made by the Command Staff.

5. Ensure that contaminated equipment is appropriately decontaminated at the site, or properly documentation, containerized and labeled for off-scene decontamination or disposal.

6. Ensure proper level and type of protective clothing is worn by the decontamination team as selected by the command staff.

7. Ensure extra breathing air supply is available.

8. Order sufficient water supply with required pressure at scene to provide the necessary water for washing as well as a protection water line and dermal shower.

9. Have Medical Branch do medical evaluation on Decon personnel and record.

10. Ensure decontaminate protective clothing is ready for future use.

11. Monitor workers for safety issues in CRZ.

12. Complete decontamination checklist.

DECONTAMINATION TEAM MEMBER

The Decontamination Team Member is responsible for appropriate decontamination procedures as assigned to them within the Contamination Reduction Corridor. These duties may vary, but must include the following:

DUTIES

1. Obtain briefing from Decontamination Team Leader.

2. Set up decontamination Reduction Corridor as described, check and ensure all equipment is in proper working order, and go through decontamination process with all decon personnel.

3. Suitup to appropriate level of protection.

4. Assist Entry Team, one by one, through the Decontamination Corridor. Wash off contaminants, remove protective clothing and equipment (remember "DON'T" place your hands inside of suit; just touch outside) and place in proper container. Remove SCBA backpack. The team member will take off their own mask.

5. Carefully use a minimum amount of water as each person advances from pool to pool. The objective is to keep all of the contaminants contained in the pools.

6. Before Decontamination Team Members leave decon they "MUST DECON THEMSELVES." Each Decon Team Member helps to decontaminate their own team members.

CHARACTERISTICS OF HAZARDOUS MATERIALS

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, participants will be able to:

1. Describe the difference between the fire triangle and the fire tetrahedron

2. Define the following terms relative to flammability:
   a. Flash point
   b. Upper explosive limit (UEL)
   c. Lower explosive limit (LEL)
   d. Flammable range
   e. Ignition temperature
   f. LEL/UEL

3. Determine whether an unknown hazardous material is acidic or basic when given the pH value

4. Explain how the following characteristics can affect the behavior of a hazardous material:
   a. Boiling point
   b. Melting point/freezing point
   c. Vapor pressure
   d. Specific gravity
   e. Vapor density
   f. Solubility.

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

NOTES

CHARACTERISTICS OF HAZARDOUS MATERIALS

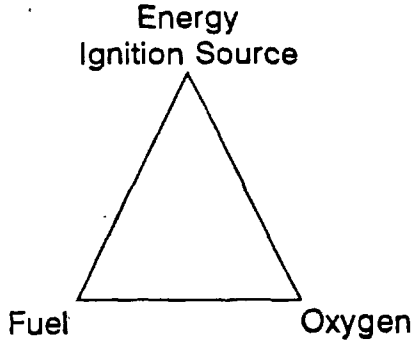
S-1

TYPES OF HAZARDS

Toxic	Irritation
Flammable	Sensitization
Carcinogenic	Explosive
Reactive	Biological
Radioactive	Corrosive
Teratogenic	Mutagenic

S-2

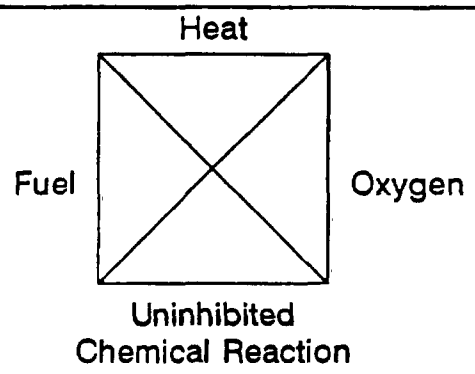
FIRE TRIANGLE



S-3

NOTES

FIRE TETRAHEDRON



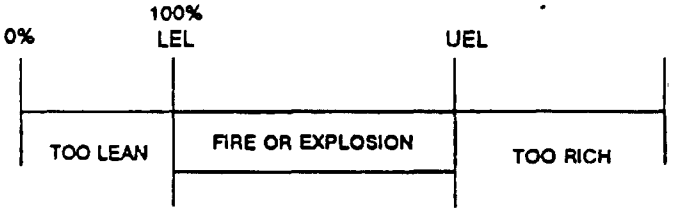
S-4

FLASH POINT

The temperature at which a liquid gives off flammable vapors just above its surface

S-5

FLAMMABLE LIMITS



S-6

NOTES

IGNITION TEMPERATURE

The minimum temperature to which a substance must be raised in order to ignite

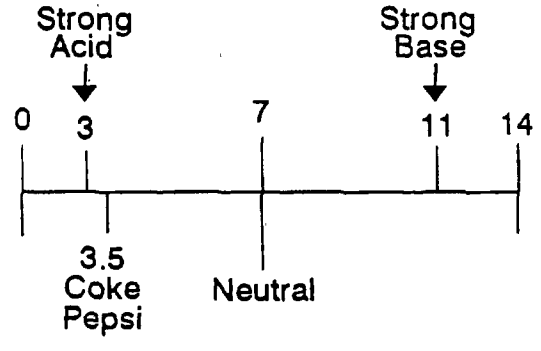
S-7

CORROSIVITY

The ability of a substance to generate hydronium (+) or hydroxyl (−) ions in sufficient concentrations to cause material or tissue degradation

S-8

pH - SCALE



S-9

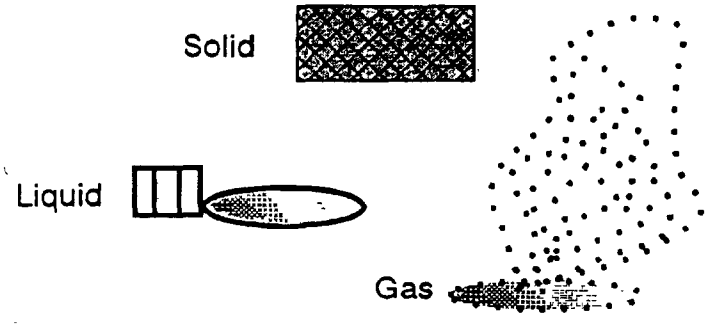
NOTES

EXAMPLES OF CORROSIVES

+	−
Acids	Bases
Acetic acid	Sodium hydroxide
Hydrochloric acid	Potassium hydroxide
Sulfuric acid	Calcium carbonate

S-10

PHYSICAL STATES



S-11

SPECIFIC GRAVITY

A relative measure of the density of a liquid in comparison to water given that water has a relative value of 1

S-12

NOTES

MELTING POINT

The temperature at which a substance's liquid phase is in equilibrium with its solid phase

- Freezing point
- With a flammable solid, may be the same as flash point or ignition temperature

S-13

BOILING POINT

The temperature of a liquid at which its vapor pressure is equal to the atmospheric pressure

- Condensation point

S-14

VAPOR DENSITY

The relative measure of the density of a vapor compared to air given that air has a relative value of 1

S-15

NOTES

VAPOR PRESSURE

The pressure exerted by a vapor at a given temperature, usually expressed in millimeters of mercury (mmHg) at a specific temperature

S-16

SOLUBILITY

The ability of a substance to blend uniformly with another, usually expressed as a percent by volume (%) or ppm or ppb

S-17

CHARACTERISTICS OF HAZARDOUS MATERIALS

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CHARACTERISTICS OF HAZARDOUS MATERIALS

I. INTRODUCTION

At an incident, response personnel may be exposed to a number of substances that are hazardous because of their biological, radiological, or chemical characteristics.

Biological agents are living organisms (or their products) that can cause sickness or death in exposed individuals.

Radiological materials are considered hazardous because of their ability to emit various types of radiation at intensities that may be harmful if response personnel are either inadequately shielded from the radiation source or exposed to the radiation for too long a time.

Chemical hazards are classified into several groups, including fire, toxic, corrosive, and reactive hazards. A material may elicit more than one chemical hazard during an incident. For example, toxic vapors can be released during chemical fires. The hazards can be a result of the physical/chemical properties of a material or of its chemical reactivity with other materials or the environment to which it is exposed.

Many hazards may be present at any one incident. It is important to understand the fundamentals of each hazard and their relationships so that effective safety practices may be employed to reduce the risk to the public and to response personnel.

II. BIOLOGICAL HAZARDS

There are five general categories of biological agents that are capable of causing infection or disease in exposed individuals. These categories are viral, rickettsial/chlamydial, bacterial, fungal, and parasitic. These agent types may be present at hazardous waste sites and hazardous material spills. Like chemical hazards, biological agents may be dispersed throughout the environment via wind and water.

Many biological agents have complex life cycles that require host and intermediate (carrier) host organisms to complete their growth cycles. Rodents, for example, which are commonly found at landfills, act as carriers for the rabies virus. Likewise, the Rocky Mountain Spotted Fever tick can carry the bacillus that produces this disease in man.

The same personal protective equipment (PPE) requirements that are used against a hazard can be applied to biological hazards. Body coverings and respiratory protective equipment should be used. Personal cleanliness is especially important. Showering after removing protective clothing and thoroughly washing exposed body parts, including hands and face, should help remove any residual contamination.

III. RADIATION HAZARDS

Radioactive materials that may be encountered at a site can emit three types of harmful radiation: alpha particles, beta particles, and gamma waves. All three forms harm living organisms by imparting energy which ionizes molecules in the cells. Hence, the three are referred to as ionizing radiation. Ionization may upset the normal cellular function, causing cell dysfunction or death.

An alpha particle is positively charged. A beta particle is an electron possessing a negative charge. Both particles have mass and energy. Both are emitted from the nucleus. They travel short distances in material before interactions with the material causes them to lose their energy. The outer layers of the skin and clothing generally protect against these particles. Therefore, they are considered hazardous primarily when they enter the body through inhalation or ingestion.

Gamma radiation is pure electromagnetic energy and is wave-like rather than particulate. Gamma waves pass through all materials to some degree. Clothing, including protective gear, will not prevent gamma radiation from interacting with body tissue.

Unlike many hazardous substances that possess certain properties which can alert response personnel to overexposures (odor, irritation, or taste), radiation has no such warning properties. Hence, preventing the radioactive material from entering the body or protecting against external radiation is the best protection. As with biological and chemical hazards, the use of respiratory equipment and PPE, coupled with scrupulous personal hygiene, will afford good protection against radioactive particulates.

IV. CHEMICAL HAZARDS

A. Fire Hazards

1. Combustibility

Combustibility is the ability of a material to act as a fuel. Materials that can be readily ignited and sustain a fire are considered combustible, whereas those that do not are noncombustible. Three elements are required for combustion to occur: fuel, oxygen, and heat. The concentration of the fuel and the oxygen must be high enough to allow ignition and maintain the burning process. Combustion is a chemical reaction that requires heat to proceed. Heat is either supplied by the ignition source and is maintained by the combustion, or is supplied from an external source. The relationship of these three components of fire is illustrated by the triangle in **Figure 1**.

Most fires can be extinguished by removing one of the three components. For example, water applied to a fire removes the heat, thereby extinguishing the fire. When a material by itself generates enough heat to self-ignite and combust, spontaneous combustion occurs, either as a fire or an explosion.

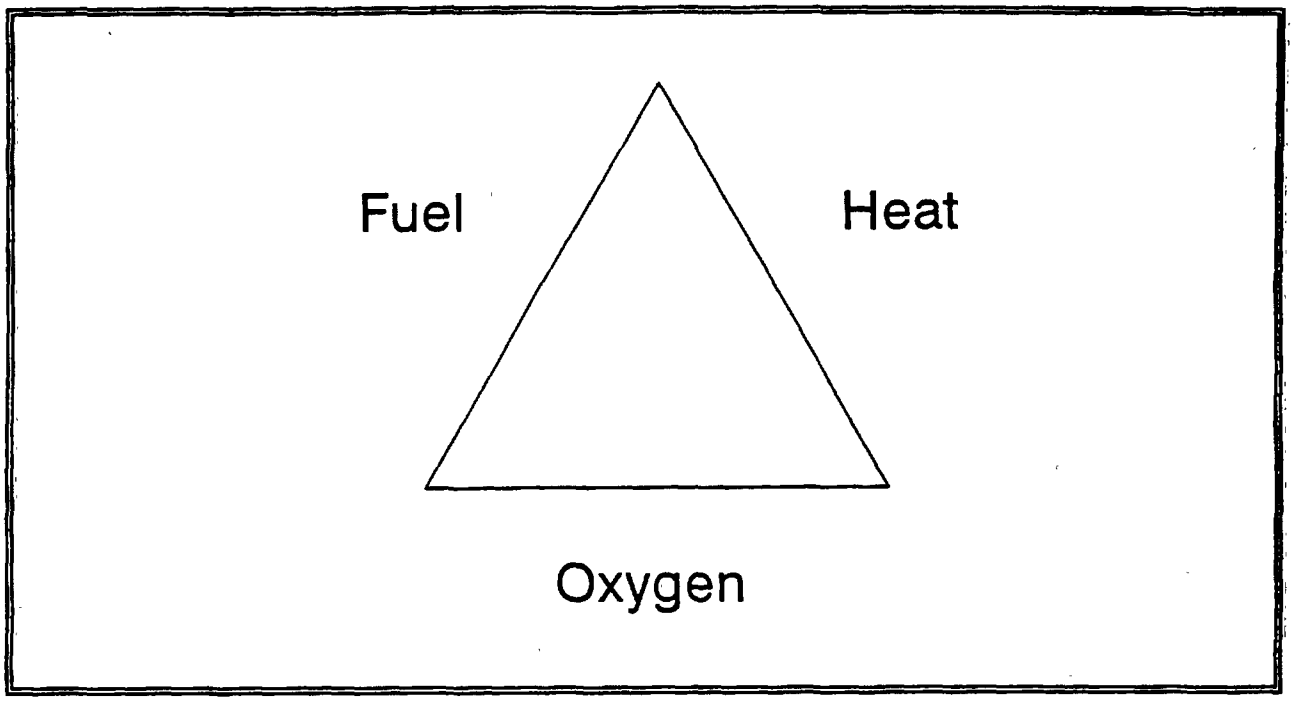


FIGURE 1
THE FIRE TRIANGLE

Although oxygen is the usual oxidizing agent during the combustion process, there are chemicals that can burn without oxygen being present. For example, calcium and aluminum will burn in nitrogen. So, the first side of the tetrahedron (**Figure 2**) is an oxidizing agent that permits the fuel to burn.

The fuel is the material that is oxidized. Because the fuel becomes chemically charged by the oxidizing process, it is called a reducing agent. This is the second side of the tetrahedron. Fuels can be anything from elements (carbon, hydrogen, magnesium) to compounds (cellulose, wood, paper, gasoline, petroleum compounds).

Some mixtures of reducing agent and oxidizing agent remain stable under certain conditions. However, when there is some activation energy, a chain reaction is started, which causes combustion. The factor that can trigger this chemical reaction can be as simple as exposing the combination to light. Once the chain reaction begins, extinguishment must take place by interrupting the chain reaction.

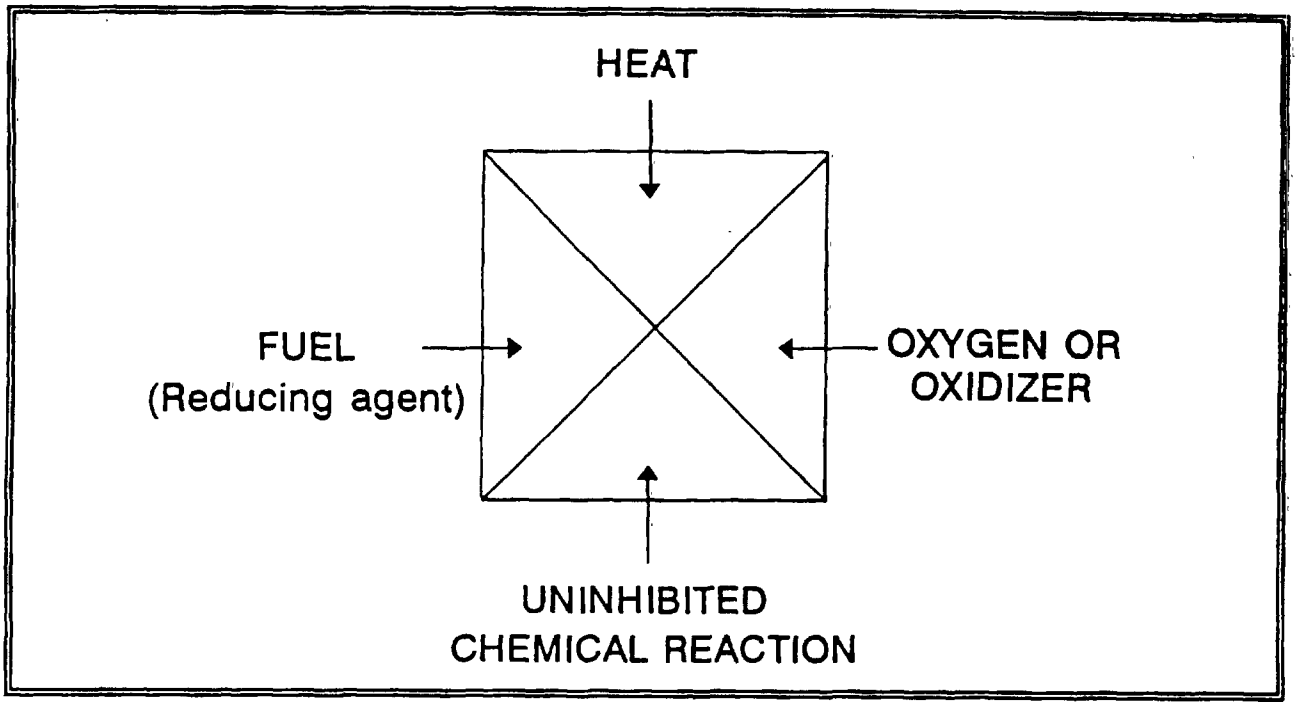


FIGURE 2
FIRE TETRAHEDRON

Scientists have known for many years that certain chemicals act as excellent extinguishing agents. However, they were at a loss to explain how these chemicals actually accomplished extinguishment, given the triangle of fire model. With the development of the tetrahedron model and the inclusion of the uninhibited chain reaction, a scientifically sound theory could be postulated. With this as a basis, the extinguishing capabilities of the halons and certain dry chemicals were possible.

The final side of the tetrahedron is temperature. The fact that temperature is used instead of heat is deliberate. Temperature is the quantity of the disordered energy, which is what initiates combustion. It is possible to have a high heat as indicated by a large reading of Btu and still not have combustion. Temperature, therefore, is the key ingredient and the one that influences the action of the tetrahedron.

2. Flammability

Flammability is the ability of a material (liquid or gas) to generate a sufficient concentration of combustible vapors under normal conditions to be ignited and produce a flame. It is necessary to have a proper fuel-to-air ratio (expressed as the percentage of fuel in air) to allow combustion. There is a range of fuel concentrations in air for each material that is optimal for the ignition and the sustenance of combustion. This is called the flammable range. The lowest concentration of fuel in this range is the lower flammable limit (LFL). Concentrations less than the LFL are not flammable because there is too little fuel; that is, the mixture is too "lean." The highest ratio that is flammable is the upper flammable limit (UFL).

Concentrations greater than the UFL are not flammable because there is too much fuel displacing the oxygen (resulting in too little oxygen). This mixture is too "rich." Fuel concentrations between the LFL and UFL are optimal for starting and sustaining fire. Example: the LFL for benzene is 1.3% (13,000 ppm); the UFL is 7.1% (71,000 ppm). Thus, the flammable range is 1.3% to 7.1%. UFL and LFL are the same as UEL and LEL (UEL - upper explosive limit, LEL - lower explosive limit).

A flammable material is considered highly combustible if it can burn at ambient temperatures (**Table 1**). But a combustible material is not necessarily flammable, because it may not be easily ignited or the ignition may not be maintained. Pyrophoric materials will ignite at room temperature in the presence of a gas or vapor or when a slight friction or shock is applied.

3. Gas or Vapor Explosions

A gas or vapor explosion is a very rapid, violent release of energy. If combustion is extremely rapid, large amounts of kinetic energy, heat, and gaseous products are released. The major factor contributing to the explosion is the confinement of a flammable material. When vapors or gases cannot freely dissipate, they enter the combustion reaction more rapidly. Confinement also increases the energy associated with these molecules, which enhances the explosive process. Poorly ventilated buildings, sewers, drums, and bulk liquid containers are examples of places where potentially explosive atmospheres may exist.

4. Practical Considerations

Fires and explosions require fuel, air (oxygen), and an ignition source (heat). At a hazardous material incident, the first two are not easily controlled. Consequently, while working onsite where a fire hazard may be present, the concentration of combustible gases in air must be monitored, and any potential ignition source must be kept out of the area.

TABLE 1 FLAMMABLE COMPOUNDS AND ELEMENTS	
FLAMMABLE LIQUIDS	**FLAMMABLE SOLIDS**
Aldehydes Ketones Amines Ethers Aliphatic hydrocarbons Aromatic hydrocarbons Alcohols Nitroaliphatics	Phosphorus Magnesium dust Zirconium dust Titanium dust Aluminum dust Zinc dust
Water-Reactive Flammable Solids	Pyrophoric Liquids
Potassium Sodium Lithium	Organometallic compounds Dimethyl zinc Tributyl aluminum

Note: The U.S. Department of Transportation (DOT), the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), and the National Fire Protection Association (NFPA) have established strict definitions for flammability based on the flash point of a material.

The most dangerous flammable substances:

- Are easily ignited (e.g., pyrophorics)
- Require little oxygen to support combustion
- Have low LFL/LEL and a wide flammable/explosive range.

Hazards that are related to fires and explosions include the following:

- Physical destruction due to shock waves, heat, and flying objects
- Initiation of secondary fires or creation of flammable conditions
- Release of toxic and corrosive compounds into the surrounding environment.

B. Explosive Hazards

1. Explosives

An explosive is a substance that undergoes a very rapid chemical transformation producing large amounts of gases and heat. The gases that are produced (e.g., nitrogen, oxygen, carbon monoxide, carbon dioxide, and

steam) rapidly expand because of the heat produced by the explosion at velocities exceeding the speed of sound. This creates both a shock wave (high-pressure wave front) and noise.

2. Types of Explosive Hazards

- High or detonating: Chemical transformation occurs very rapidly with detonation rates as high as 4 miles per second. The rapidly expanding gas produces a shock wave that may be followed by combustion.

  - Primary high explosive: detonating wave produced in an extremely short period of time. May be detonated by shock, heat, or friction. Examples are lead azide, mercury fulminate, and lead styphnate.

  - Secondary high explosive: generally needs a booster to cause them to detonate. Relatively insensitive to shock, heat, or friction. Examples are tetryl, cyclonite, dynamite, and TNT.

- Low or deflagrating: Rate of deflagration up to 1250 feet per second. Generally combustion followed by a shock wave. Examples are smokeless powder, black powder, and solid rocket fuel.

3. Practical Considerations

The high or low categories of explosion hazards do not indicate the explosion hazard (or power), but only the rate of chemical transformation.

Explosions can occur as a result of reactions between many chemicals not ordinarily considered explosives. Ammonium nitrate, a fertilizer, can explode under the right conditions. Alkali metals and water explode, as will water and peroxide salts. Picric acid and certain ether compounds become highly explosive with age. Gases, vapors, and finely divided particulates, when confined, can also explode if an ignition source is present.

C. Toxic Hazards

Toxic materials cause local or systemic detrimental effects in an organism. Exposure to such materials does not always result in death, although that is often the most immediate concern. Toxic hazards can be categorized by the physiological effect they have on the organism. A material may induce more than one physiological response, including asphyxiation, irritation allergic sensitization, systemic poisoning, mutagenesis, teratogenesis, and carcinogenesis.

The likelihood that any of these effects will be experienced by an organism depends not only on the inherent toxicity of the material itself (as measured

by its lethal dose) but also on the magnitude of the exposure (acute or chronic) and the route of exposure (ingestion, inhalation, or skin absorption).

These concepts will be described in greater detail in a later chapter.

D. Corrosive Hazards

1. Corrosion

Corrosion is a process of material degradation. Upon contact, a corrosive material may destroy body tissues, metals, plastics, and other materials. Technically, corrosivity is the ability of material to increase the hydrogen ion or hydronium ion concentrations of another material. It may have the potential to transfer electron pairs to or from itself or another substance. A corrosive agent is a reactive compound or element that produces a destructive chemical change in the material upon which it is acting. Common corrosives are halogens, acids, and bases (**Table 2**). Skin irritation and burns typically result when the body contacts an acidic or basic material.

The corrosiveness of acids and bases can be compared on the basis of their ability to dissociate (form ions) in solution. Those that form the greatest number of hydrogen ions (H^+) are the strongest acids, while those that form the most hydroxide ions (OH^-) are the strongest bases. The H^+ ion concentration in solution is called pH. Strong acids have a low pH (many H^+ in solution), whereas strong bases have a high pH.

The pH scale ranges from 0 to 14 as follows:

```
                Coke        Neutral
                Pepsi
0____3___ 3.5_________7_________11_____14
Strong                                Strong
Acid                                  Base
```

Measurements of pH are valuable because they can be quickly done onsite, providing immediate information on the corrosive hazard.

TABLE 2 CORROSIVES		
HALOGENS	**ACIDS**	**BASES (CAUSTICS)**
Bromines Chlorine Flourine Iodine Oxygen (ozone)	Acetic acid Hydrochloric acid Hydrofluoric acid Nitric acid Sulfuric acid	Potassium hydroxide Sodium hydroxide

2. Practical Considerations

When dealing with corrosive materials in the field, it is imperative to determine:

- How toxic is the corrosive material? Is it an irritant or does it cause severe burns?
- What kind of structural damage does it do, and what other hazards can it lead to? For example, will it destroy containers holding other hazardous materials, releasing them into the environment?

E. Hazards Due to Chemical Reactivity

1. Reactivity Hazards

A reactive material is one that can undergo a chemical reaction under certain specified conditions. Generally, the term "reactive hazard" is used to refer to a substance that undergoes a violent or abnormal reaction in the presence of water, or under normal ambient atmospheric conditions. Among this type of hazard are 1) the pyrophoric liquids that will ignite in air at or below normal room temperature in the absence of added heat, shock, or friction and 2) the water-reactive flammable solids that will spontaneously combust upon contact with water (**Table 1**).

2. Chemical Reactions

A chemical reaction is the interaction of two or more substances, resulting in chemical changes. Exothermic chemical reactions, which give off heat, can be the most dangerous. A separate source of heat is required to maintain endothermic chemical reactions. Removing the heat source stops the reaction.

Chemical reactions usually occur in one of the following ways:

• Combination	A + B	>	AB
• Decomposition	AB	>	A + B
• Single replacement	A + BC	>	B + AC
• Double replacement	AB + CD	>	AD + CB

The rate at which a chemical reaction occurs depends on the following factors:

- Surface area of reactants available at the reaction site - for example, a large chunk of coal is combustible, but coal dust is explosive.
- Physical state of reactant - solid, liquid, or gas
- Concentration of reactants
- Temperature
- Pressure
- Presence of a catalyst.

3. Compatibility

If two or more hazardous materials remain in contact indefinitely without reaction, they are compatible. Incompatibility, however, does not necessarily indicate a hazard. For example, acids and bases (both corrosive) react to form salts and water, which may not be corrosive.

Many operations on waste or accident sites involve mixing, or unavoidable contact between, different hazardous materials. It is important to know ahead of time if such materials are compatible. If they are not, then any number of chemical reactions could occur. The results could range from the formation of an innocuous gas to a violent explosion. **Table 3** illustrates what happens when some incompatible materials are combined.

TABLE 3 HAZARDS DUE TO CHEMICAL REACTIONS	
Result	**Incompatible Materials**
Heat generation	Acid and water
Fire	Hydrogen sulfide and calcium hypochlorite
Explosion	Picric acid and sodium hydroxide
Toxic gas or vapor production	Sulfuric acid and plastic
Flammable gas or vapor production	Acid and metal
Formation of a substance with greater toxicity than the reactants	Chlorine and ammonia
Formation of shock- or friction-sensitive compounds	Peroxides and organics *or* liquid oxygen and petroleum products
Overpressurization of closed vessels	Fire
Solubilization of toxic substances	Hydrochloric acid and chromium
Dispersal of toxic dusts and mists	Sodium or potassium cyanide and water or acid vapor
Ammonia and acryonitrile	Violent polymerization

The identity of unknown reactants must be determined by chemical analysis to establish compatibility. On the basis of their properties, a chemist then should be able to anticipate any chemical reactions resulting from mixing the reactants. Judging the compatibility of more than two reactants is very difficult; analysis should be performed on a one-to-one basis.

Response personnel who must determine compatibilities should refer to *A Method for Determining the Compatibility of Hazardous Wastes* (EPA 600/2-80-076), published by EPA's Office of Research and Development. Final decisions about compatibilities should only be made by an experienced chemist.

Sometimes the identity of a waste is impossible to ascertain because of monetary and time constraints. In this event, simple tests must be performed to determine the nature of the material or mixture. Tests such as pH, oxidation-reduction potential, and flashpoint are useful. In addition, very small amounts of the reactants may be carefully combined to determine compatibility.

4. Practical Considerations

If materials are compatible, they may be stored together in bulk tanks or transferred to tank trucks for ultimate disposal. It is necessary, then, to establish the compatibility of the materials through analyses prior to bulking them. Compatibility information is also very important in evaluating an accident involving several different hazardous materials. The ultimate handling and treatment of the materials may be partially based on such information.

F. Physical Properties of Chemicals

Chemical compounds possess inherent properties that determine the type and degree of the hazard they represent. Evaluating risks of an incident depends on understanding these properties and their relationship to the environment.

1. Solubility

The ability of a solid, liquid, gas, or vapor to dissolve in a solvent is solubility. An insoluble substance can be physically mixed or blended in a solvent for a short time but is unchanged when it finally separates. The solubility of a substance is independent of its density or specific gravity.

The solubility of a material is important when determining its reactivity, dispersion, mitigation, and treatment. Solubility can be given in parts per million (ppm) or milligrams per liter (mg/L).

2. Density/Specific Gravity

The density of a substance is its mass per unit volume, commonly expressed in grams per cubic centimeter (g/cc). The density of water is 1 g/cc because 1 cc has a mass of 1 g.

Specific gravity (SpG) is the ratio of the density of a substance (at a given temperature) to the density of water at the temperature of its maximum density (4°C).

Numerically, SpG is equal to the density in g/cc, but is expressed as a pure number without units. If the SpG of a substance is greater than 1 (the SpG of water), it will sink in water. The substance will float on water if its SpG is less than 1. This is important when considering mitigation and treatment methods.

3. Vapor Density

The density of a gas or vapor can be compared to the density of the ambient atmosphere. If the density of a vapor or gas is greater than that of the

ambient air, then it will tend to settle to the lowest point. If vapor density is close to air density or lower, the vapor will tend to disperse in the atmosphere. Vapor density is given in relative terms similar to specific gravity.

In settling, dense vapor creates two hazards. First, if the vapor displaces enough air to reduce the atmospheric concentration of oxygen below 16%, asphyxia may result. Second, if the vapor is toxic, then inhalation problems predominate even if the atmosphere is not oxygen deficient. If a substance is explosive and very dense, the explosive hazard may be close to the ground rather than at the breathing zone (normal sampling heights).

4. Vapor Pressure

The pressure exerted by a vapor against the sides of a closed container is called vapor pressure. Vapor pressure is temperature dependent. As temperature increases, so does the vapor pressure. Thus, more liquid evaporates or vaporizes. The lower the boiling point of the liquid, the greater the vapor pressure it will exert at a given temperature. Values for vapor pressure are most often given as millimeters of mercury (mmHg) at a specific temperature.

5. Boiling Point

The boiling point is the temperature at which a liquid changes to vapor; that is, it is the temperature where the pressure of the liquid equals atmospheric pressure. The opposite change in phases is the condensation point. Handbooks usually list temperatures as degrees Celsius (°C) or Fahrenheit (°F). A major consideration with toxic substances is how they enter the body. With high-boiling-point liquids, the most common entry is by body contact. With low-boiling-point liquids, the inhalation route is the most common and serious.

6. Melting Point

The temperature at which a solid changes phase to a liquid is the melting point. This temperature is also the freezing point, because a liquid can change phase to a solid. The proper terminology depends on the direction of the phase change.

If a substance has been transported at a temperature that maintains a solid phase, then a change in temperature may cause the solid to melt. The particular substance may exhibit totally different properties depending on phase. One phase could be inert while the other highly is reactive. Thus, it is imperative to recognize the possibility of a substance changing phase due to changes in the ambient temperature.

7. Flashpoint

The minimum temperature at which a substance produces sufficient flammable vapors to ignite is its flashpoint. If the vapor does ignite, combustion can continue as long as the temperature remains at or above the flashpoint. The relative flammability of a substance is based on its flashpoint. An accepted relation between the two is:

Highly flammable:	Flashpoint less than 141°F
Moderately flammable:	Flashpoint greater than 141°F but less than 200°F
Relatively inflammable:	Flashpoint greater than 200°F

TOXICOLOGY

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. List the four most common routes of exposure to hazardous materials

2. Define the following terms:
   a. LD_{50}
   b. LC_{50}
   c. LD_{LO}
   d. TLV-TWA
   e. TLV-STEL
   f. TLV-C
   g. IDLH
   h. PEL

3. Describe the difference between an acute and a chronic exposure to a hazardous material

4. List four factors that may account for the response variances in humans to toxic materials

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

STUDENT PERFORMANCE OBJECTIVES (cont.)

5. Describe the following reactions caused by the exposure to combinations or mixtures of chemicals:
   a. Additive
   b. Synergistic
   c. Potentiation
   d. Antagonistic
   e. Mutagenic
   f. Teratogenic
   g. Carcinogenic

6. Define dose-response relationship

7. Define toxicity.

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

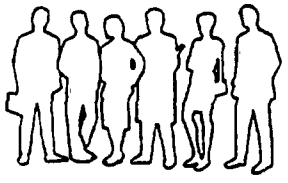
NOTES

TOXICOLOGY

S-1

TOXICITY

The capacity of a substance to harm an organism



S-2

DOSE

The quantity of a substance administered to an organism by a specific route

S-3

NOTES

DOSE-RESPONSE RELATIONSHIP

A quantitative relationship

between dose and effect

S-4

DOSE-RESPONSE TERMS

LD_{50} The amount of a substance expected to cause death in 50% of a test population

LC_{50} The concentration of a substance in air that is expected to cause death in 50% of a test population

S-5

DOSE-RESPONSE TERMS (cont.)

LD_{LO} The lowest amount of a substance that has been reported to cause death in humans or animals

LC_{LO} The lowest concentration of a substance in air that has been reported to cause death in humans or animals

S-6

NOTES

FACTORS INFLUENCING TOXICITY

- Duration and frequency
  - Acute
  - Chronic
  - Latent effect

S-7

INFLUENCING FACTORS (cont.)

- Route of entry
  - Inhalation
  - Ingestion
  - Absorption
  - Injection

S-8

INFLUENCING FACTORS (cont.)

- Interspecies variation
  - Human vs. mouse

S-9

NOTES

INFLUENCING FACTORS (cont.)

- Intraspecies variation
  - Age
  - Gender
  - Genetic makeup

S-10

INFLUENCING FACTORS (cont.)

- Environment
  - Past exposure
  - Daily exposure

S-11

INFLUENCING FACTORS (cont.)

- Chemical interactions
  - Addition (2+2=4)
  - Synergism (2+2=6)
  - Potentiation (0+2=4)
  - Antagonism (2+2=2)

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NOTES

PHYSIOLOGICAL EFFECTS OF EXPOSURE

- Respiratory tract
  - Simple asphyxiants
  - Chemical asphyxiants
  - Irritants
  - Necrosis
  - Fibrosis

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PHYSIOLOGICAL EFFECTS OF EXPOSURE (cont.)

- Central nervous system
  - Anoxia
  - Direct action on neurons

S-14

PHYSIOLOGICAL EFFECTS OF EXPOSURE (cont.)

- Target organ effects
  - Liver
  - Kidneys
  - Blood
  - Reproductive system

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NOTES

PHYSIOLOGICAL EFFECTS OF EXPOSURE (cont.)

- Toxic effects
  - Teratogenic
  - Mutagenic
  - Carcinogenic

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EXPOSURE GUIDELINES

- Occupational Safety and Health Administration (OSHA)
  - Permissible exposure limits (PEL)
  - Enforces standards

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EXPOSURE GUIDELINES (cont.)

- National Institute for Occupational Safety and Health (NIOSH)
  - Research agency
  - Recommendations to OSHA
  - Health hazard alerts
  - Immediately dangerous to life and health (IDLH)

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EXPOSURE GUIDELINES (cont.)

- United States Environmental Protection Agency (U.S. EPA)
  - Enforces standards in non-OSHA states, 40 CFR 311

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THRESHOLD LIMIT VALUE

Workers may be exposed to airborne concentrations of substances in work areas daily without adverse effects

- Industrial experience
- Experimental human studies
- Experimental animal studies
- Combination of all three

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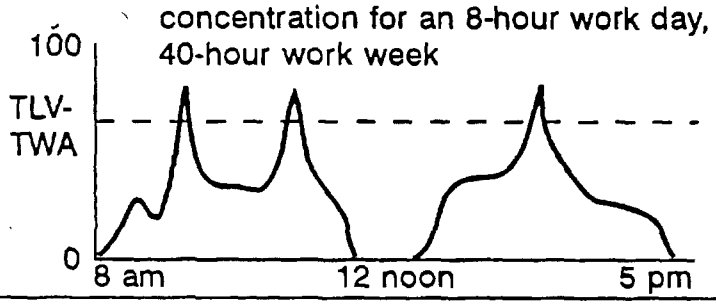
THRESHOLD LIMIT VALUE
Time-Weighted Average

- TLV-TWA
  - The time-weighted average concentration for an 8-hour work day, 40-hour work week



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NOTES

THRESHOLD LIMIT VALUE (cont.)
Short-Term Exposure Limit

- TLV-STEL–maximum concentrations
  - Continuous worker exposure for up to 15 minutes without suffering:
    - Irritation
    - Chronic or irreversible tissue change
    - Narcosis

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THRESHOLD LIMIT VALUE (cont.)
SHORT-TERM EXPOSURE LIMIT

- Worker limitations
  - No more than four excursions per day into concentration level
  - At least 60 minutes between excursions
  - TLV-TWA must not be exceeded

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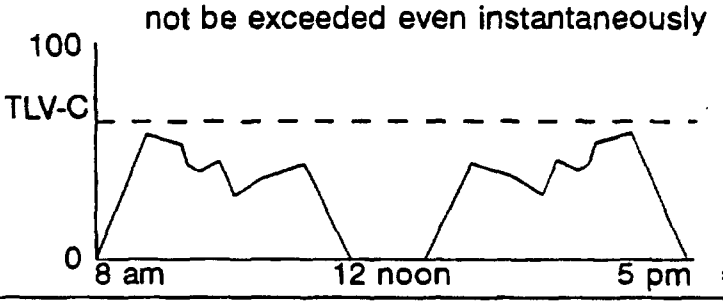
THRESHOLD LIMIT VALUE (cont.)
Ceiling

- TLV-C
  - The concentration that should not be exceeded even instantaneously



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NOTES

IMMEDIATELY DANGEROUS TO LIFE AND HEALTH

- IDLH
  - The maximum concentration level from which workers could escape after respiratory failure and 30 minutes exposure without any escape-impairing symptoms or irreversible health effects. The intent being to escape immediately

Reference: NIOSH/OSHA Pocket Guide to Chemical Hazards

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PRINCIPLES OF TOXICOLOGY

I. INTRODUCTION

"All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy."

This early observation concerning the toxicity of chemicals was made by Paracelsus (1493-1541). The classic connotation of toxicology was "the science of poisons." Since that time, the science has expanded to encompass several disciplines. Toxicology is the study of the interaction between chemical agents and biological systems. While the subject of toxicology is quite complex, it is necessary to understand the basic concepts in order to make logical decisions concerning the protection of personnel from toxic injuries.

Toxicity can be defined as the relative ability of a substance to cause adverse effects in living organisms. This "relative ability" is dependent upon several conditions. As Paracelsus suggests, the quantity or the dose of the substance determines whether the effects of the chemical are toxic, non-toxic or beneficial. In addition to dose, other factors may also influence the toxicity of the compound such as the route of entry, duration and frequency of exposure, variations between different species (interspecies) and variations among members of the same species (intraspecies).

To apply these principles to hazardous materials response, the routes by which chemicals enter the human body will be considered first. Knowledge of these routes will support the selection of personal protective equipment and the development of safety plans. The second section deals with dose-response relationships. Since dose-response information is available in toxicology and chemistry reference books, it is useful to understand the relevance of these values to the concentrations that are actually measured in the environment. The third section of this chapter includes the effects of the duration and frequency of exposure, interspecies variation and intraspecies variation on toxicity. Finally, toxic responses associated with chemical exposures are described according to each organ system.

II. ROUTES OF EXPOSURE

There are four routes by which a substance can enter the body: inhalation, skin (or eye) absorption, ingestion, and injection.

- Inhalation: For most chemicals in the form of vapors, gases, mists, or particulates, inhalation is the major route of entry. Once inhaled, chemicals are either exhaled or deposited in the respiratory tract. If deposited, damage can occur through direct contact with tissue or the chemical may diffuse into the blood through the lung-blood interface.

Upon contact with tissue in the upper respiratory tract or lungs, chemicals may cause health effects ranging from simple irritation to severe tissue destruction. Substances absorbed into the blood are circulated and distributed to organs which have an affinity for that particular chemical. Health effects can then occur in the organs which are sensitive to the toxicant.

- Skin (or eye) absorption: Skin (dermal) contact can cause effects that are relatively innocuous such as redness or mild dermatitis; more severe effects include destruction of skin tissue or other debilitating conditions. Many chemicals can also cross the skin barrier and be absorbed into the blood system. Once absorbed, they may produce systemic damage to internal organs. The eyes are particularly sensitive to chemicals. Even a short exposure can cause severe effects to the eyes or the substance can be absorbed through the eyes and be transported to other parts of the body causing harmful effects.

- Ingestion: Chemicals that inadvertently get into the mouth and are swallowed do not generally harm the gastrointestinal tract itself unless they are irritating or corrosive. Chemicals that are insoluble in the fluids of the gastrointestinal tract (stomach, small, and large intestines) are generally excreted. Others that are soluble are absorbed through the lining of the gastrointestinal tract. They are then transported by the blood to internal organs where they can cause damage.

- Injection: Substances may enter the body if the skin is penetrated or punctured by contaminated objects. Effects can then occur as the substance is circulated in the blood and deposited in the target organs.

Once the chemical is absorbed into the body, three other processes are possible: metabolism, storage and excretion. Many chemicals are metabolized or transformed via chemical reactions in the body. In some cases, chemicals are distributed and stored in specific organs. Storage may reduce metabolism and therefore, increase the persistence of the chemicals in the body. The various excretory mechanisms (exhaled breath, perspiration, urine, feces, or detoxification) rid the body, over a period of time, of the chemical. For some chemicals elimination may be a matter of days or months; for others the elimination rate is so low that they may persist in the body for a lifetime and cause deleterious effects.

III. THE DOSE-RESPONSE RELATIONSHIP

In general, a given amount of a toxic agent will elicit a given type and intensity of response. The dose-response relationship is a fundamental concept in toxicology and the basis for measurement of the relative harmfulness of a chemical. A dose-response relationship is defined as a consistent mathematical and biologically plausible correlation between the number of individuals responding and a given dose over an exposure period.

A. Dose Terms

In toxicology studies the dose given to test organisms is expressed in terms of the quantity administered:

- Quantity per unit mass (or weight). Usually expressed as milligram per kilogram of body weight. (mg/kg)

- Quantity per unit area of skin surface. Usually expressed as milligram per square centimeter. (mg/cm^2)

- Volume of substance in air per unit volume of air. Usually given as microliters of vapor or gas per liter of air by volume (ppm). Particulates and gases are also given as milligrams of material per cubic meter of air. (mg/m^3)

The period of time over which a dose has been administered is generally specified. For example, 5 mg/kg/3 D is 5 milligrams of chemical per kilogram of the subject's body weight administered over a period of three days. For dose to be meaningful it must be related to the effect it causes. For example, 50 mg/kg of chemical "X" administered orally to female rats has no relevancy unless the effect of the dose, say sterility in all test subjects, is reported.

B. Dose-Response Curves

A dose-response relationship is represented by a dose-response curve. The curve is generated by plotting the dose of the chemical versus the response in the test population. There are a number of ways to present this data. One of the more common methods for presenting the dose-response curve is shown in **Chart 1**. In this example, the dose is expressed in "mg/kg" and depicted on the "x" axis. The response is expressed as a "cumulative percentage" of animals in the test population that exhibit the specific health effect under study. Values for "cumulative percentage" are indicated on the "y" axis of the graph. As the dose increases, the percentage of the affected population increases.

Dose-response curves provide valuable information regarding the potency of the compound. The curves are also used to determine the dose-response terms that are discussed in the following section.

C. Dose-Response Terms

The National Institute for Occupational Safety and Health (NIOSH) defines a number of general dose-response terms in the "Registry of Toxic Substances" (1983, p. xxxii). A summary of these terms is contained in **Table 1**.

- Toxic dose low (TD_{LO}): The lowest dose of a substance introduced by any route, other than inhalation, over any given period of time, and reported to produce any toxic effect in humans or to produce tumorigenic or reproductive effects in animals.

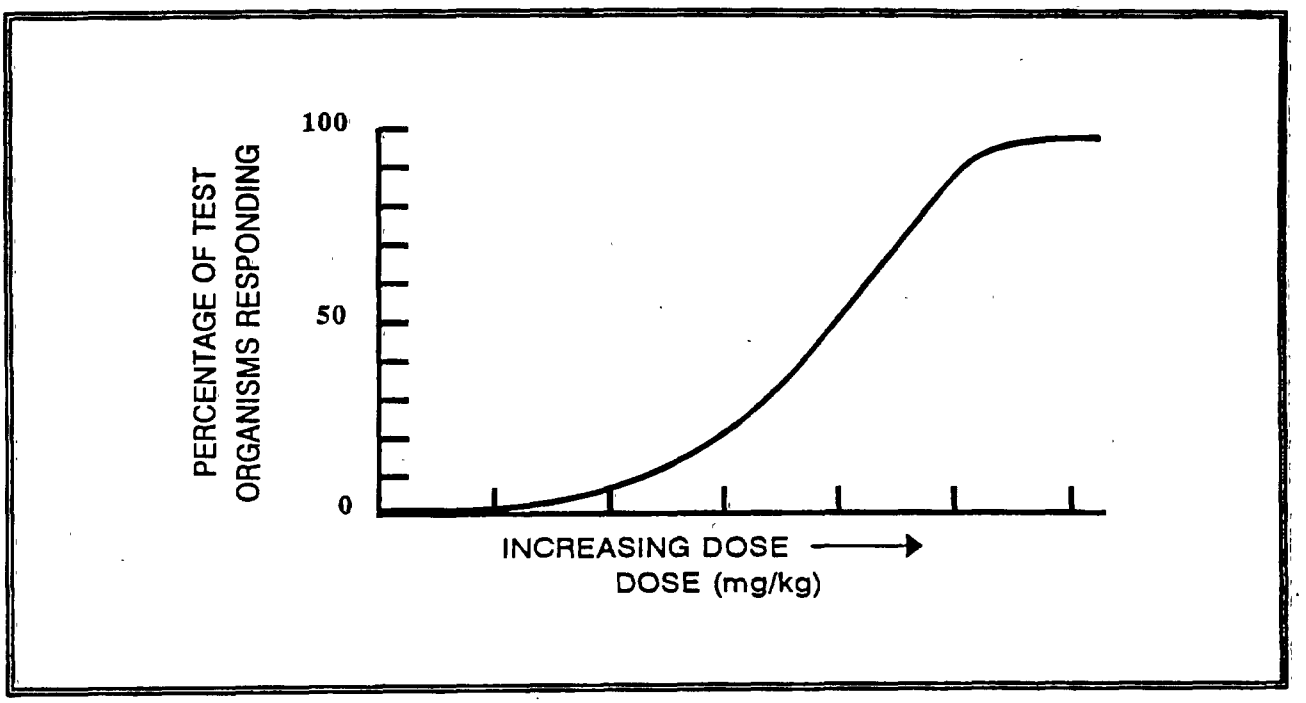

CHART 1
HYPOTHETICAL DOSE-RESPONSE CURVE

- Toxic concentration low (TC_{LO}): The lowest concentration of a substance in air to which humans or animals have been exposed for any given period of time that has produced any toxic effect in humans or produced tumorigenic or reproductive effects in animals.

- Lethal dose low (LD_{LO}): The lowest dose, other than LD_{50}, of a substance introduced by any route, other than inhalation, which has been reported to have caused death in humans or animals.

- Lethal dose fifty (LD_{50}): A calculated dose of a substance which is expected to cause the death of 50 percent of an entire defined experimental animal population. It is determined from the exposure to the substance by any route other than inhalation.

- Lethal concentration low (LC_{LO}): The lowest concentration of a substance in air, other than LC_{50}, which has been reported to have caused death in humans or animals.

- Lethal concentration fifty (LC_{50}): A calculated concentration of a substance in air, exposure to which for a specified length of time is expected to cause the death of 50 percent of an entire defined experimental animal population.

TABLE 1 SUMMARY OF DOSE-RESPONSE TERMS				
CATEGORY	EXPOSURE TIME	ROUTE OF EXPOSURE	TOXIC EFFECTS HUMAN	ANIMAL
TD_{LO}	Acute or chronic	All except inhalation	Any non-lethal	Reproductive, Tumorigenic
TC_{LO}	Acute or chronic	Inhalation	Any non-lethal	Reproductive, Tumorigenic
LD_{LO}	Acute or chronic	All except inhalation	Death	Death
LD_{50}	Acute	All except inhalation	Not applicable	Death (statistically determined)
LC_{LO}	Acute or chronic	Inhalation	Death	Death
LC_{50}	Acute	Inhalation	Not applicable	Death (statistically determined)

D. Limitations of Dose-Response Terms

Several limitations must be recognized when using dose-response data. First, it is difficult to select a test species that will closely duplicate the human response to a specific chemical. For example, human data indicates that Arsenic is a carcinogen, while animal studies do not demonstrate these results. Second, most lethal and toxic dose data are derived from acute (single dose, short-term) exposures rather than chronic (continuous, long-term) exposures. A third shortcoming is that the LD_{50} or LC_{50} is a single value and does not indicate the toxic effects that may occur at different dose levels. For example, in **Chart 2**, Chemical A is assumed to be more toxic than Chemical B based on LD_{50}, but at lower doses the situation is reversed. At LD_{20}, Chemical B is more toxic than Chemical A.

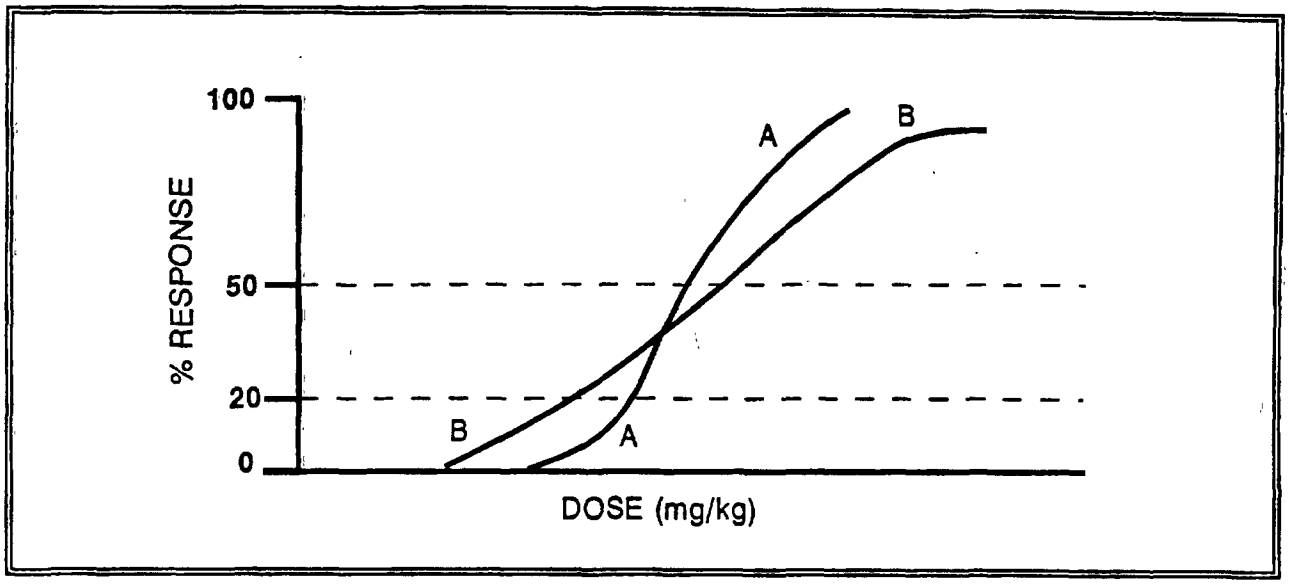

CHART 2
COMPARISON OF DOSE-RESPONSE CURVES FOR TWO SUBSTANCES

E. Factors Influencing Toxicity

Many factors effect the reaction of an organism to a toxic chemical. The specific response that is elicited by a given dose varies depending on the species being tested and variations that occur among individuals of the same species. These must be considered when using information such as that found in **Table 2**.

1. Duration and Frequency of Exposure

There is a difference in type and severity of effects depending on how rapidly the dose is received (duration) and how often the dose is received (frequency). Acute exposures are usually single incidents of relatively short duration - a minute to a few days. Chronic exposures involve frequent doses at relatively low levels over a period of time ranging from months to years.

If a dose is administered slowly so that the rate of elimination or the rate of detoxification keeps pace with intake it is possible that no toxic response will occur. The same dose could produce an effect with rapid administration.

2. Routes of Exposure

Biological results can be different for the same dose, depending on whether the chemical is inhaled, ingested, applied to the skin, or injected. Natural barriers impede the intake and distribution of material once in the body. These barriers can attenuate the toxic effects of the same dose of a chemical. The effectiveness of these barriers is partially dependent upon the route of entry of the chemical.

3. Interspecies Variation

For the same dose received under identical conditions, the effects exhibited by different species may vary greatly. A dose which is lethal for one specie may have no effect on another. Since the toxicological effects of chemicals on humans is usually based on animal studies, a test species must be selected that most closely approximates the physiological processes of humans.

TABLE 2
CLASSIFICATION OF FACTORS INFLUENCING TOXICITY

TYPE	EXAMPLES
Factors related to the chemical	Composition (salt, free base, etc.); physical characteristics (particle size, liquid, solid, etc.); physical properties (volatility, solubility, etc.); presence of impurities; break down products; carrier.
Factors related to exposure	Dose; concentration; route of exposure (ingestion, skin absorption, injection, inhalation); duration.
Factors related to person exposed	Heredity; immunology; nutrition; hormones; age; sex; health status; pre-existing diseases.
Factors related to environment	Carrier (air, water, food, soil); additional chemical present (synergism, antagonism); temperature; air pressure.

4. Intraspecies Variation

Within a given species, not all members of the population respond to the same dose identically. Some members will be more sensitive to the chemical and elicit response at lower doses than the more resistant members which require larger doses for the same response.

a. Age and Maturity

Infants and children are often more sensitive to toxic action than younger adults. Elderly persons have diminished physiological capabilities for the body to deal with toxic insult. These age groups may be more susceptible to toxic effects at relatively lower doses.

b. Gender and Hormonal Status

Some chemicals may be more toxic to one gender than the other. Certain chemicals can effect the reproductive system of either the male or female. Additionally, since women have a larger percentage of body fat than men, they may accumulate more fat-soluble chemicals. Some variations in response have also been shown to be related to physiological differences between males and females.

c. Genetic Makeup

Genetic factors influence individual responses to toxic substances. If the necessary physiological processes are diminished or defective the natural body defenses are impaired. For example, people lacking in the G6PD enzyme (a hereditary abnormality) are more likely to suffer red blood cell damage when given aspirin or certain antibiotics than persons with the normal form of the enzyme.

d. State of Health

Persons with poor health are generally more susceptible to toxic damage due to the body's decreased capability to deal with chemical insult.

5. Environmental Factors

Environmental factors may contribute to the response for a given chemical. For example, such factors as air pollution, workplace conditions, living conditions, personal habits, and previous chemical exposure may act in conjunction with other toxic mechanisms.

6. Chemical Combinations

Some combinations of chemicals produce different effects from those attributed to each individually:

a. Synergists: chemicals that, when combined, cause a greater than additive effect. For example, hepatotoxicity is enhanced as a result of exposure to both ethanol and carbon tetrachloride.

b. Potentiation: is a type of synergism where the potentiator is not usually toxic in itself, but has the ability to increase the toxicity of other chemicals. Isopropanol, for example, is not hepatotoxic in itself. It's combination with carbon tetrachloride, however, increases the toxic response to the carbon tetrachloride.

c. Antagonists: chemicals, that when combined, lessen the predicted effect. There are four types of antagonists.

- functional: Produces opposite effects on the same physiologic function. For example, phosphate reduces lead absorption in the gastrointestinal tract by forming insoluble lead phosphate.

- chemical: Reacts with the toxic compound to form a less toxic product. For example, chelating agents bind up metals such as lead, arsenic, and mercury.

- dispositional: Alters absorption, metabolism, distribution, or excretion. For example, some alcohols use the same enzymes in their metabolism:

  Ethanol--------> Acetaldehyde-------> Acetic acid
  Methanol------> Formaldehyde------> Formic acid

  The aldehydes cause toxic effects (hangover, blindness). ethanol is more readily metabolized than Methanol, so when both are present, methanol is not metabolized and can be excreted before forming formaldehyde. Another dispositional antagonist is antabuse which, when administered to alcoholics, inhibits the metabolism of acetaldehyde, giving the patient a more severe prolonged hangover.

- receptor: Occurs when a second chemical either binds to the same tissue receptor as the toxic chemical or blocks the action of receptor and thereby reduces the toxic effect. For example, atropine interferes with the receptor responsible for the toxic effects of organophosphate pesticides.

IV. SOURCES OF TOXICITY INFORMATION

Information on the toxic properties of chemical compounds and dose-response relationships is obtained from animal studies, epidemiological investigations of exposed human populations, and clinical studies or case reports of exposed humans.

A. Toxicity Tests

The design of any toxicity test incorporates:

- A test organism, which can range from cellular material and selected strains of bacteria through higher order plants and animals.
- A response or biological endpoint, which can range from subtle changes in physiology and behavior to death.
- An exposure or test period.
- A dose or series of doses.

The objective is to select a test species that is a good model of humans, a response that is not subjective and can be consistently determined for a given dose, and a test period that is relatively short.

B. Epidemiological and Clinical Studies

Epidemiological investigations and clinical cases are another means of relating human health effects and exposure to toxic substances. Epidemiological investigations are based upon a human population exposed to a chemical compared to an appropriate, non-exposed group. An attempt is made to determine whether there is a statistically significant association between health effects and chemical exposure. Clinical cases involve individual reports of chemical exposure.

V. USES OF TOXICITY INFORMATION

A. Comparison of Toxicity Data

Comparing the LD_{50} of chemicals in animals gives a relative ranking of potency or toxicity of each. For example, DDT (LD_{50} for rats = 113 mg/kg) would be considered more toxic than ethyl alcohol (LD_{50} for rats = 14,000 mg/kg). Using the LD_{50} (mg/kg) for a test species and multiplying by 70 kg (average mass of man) gives a rough estimate of the toxic potential of the substance for humans, assuming that humans are as sensitive as the subjects tested.

Since the extrapolation of human data from animal studies is complex, this value should only be considered as an approximation for the potency of the compound and used in conjunction with additional data (**Table 3; Table 4**).

TABLE 3 TOXICITY RATING TABLE	
TOXICITY RATING OR CLASS	**ORAL ACUTE LD_{50} FOR RATS**
Extremely toxic	1 mg/kg or less (Dioxin, Botulinum toxin)
Highly toxic	1 to 50 mg/kg (Strychnine)
Moderately toxic	50 to 500 mg/kg (DDT)
Slightly toxic	0.5 to 5 g/kg (Morphine)
Practically nontoxic	5 to 15 g/kg (Ethyl alcohol)

B. Establishing Exposure Guidelines

Toxicity data from both animal experimentation and epidemiological studies is sued to establish exposure guidelines. The method for deriving a guideline is dependent upon the type of chemical as well as duration and frequency of exposure. It is also important to make the distinction between an experimental dose (mg/kg) and an environmental concentration (mg/m^3 or ppm). In order to make safety decisions, exposure guidelines are presented as concentrations so that these values can be compared to concentrations measured by air monitoring instrumentation.

TABLE 4
TABLE OF LD_{50} VALUES FOR RATS FOR A GROUP OF WELL-KNOWN CHEMICALS

CHEMICAL	LD_{50} (mg/kg)
Sucrose (table sugar)	29,700
Ethyl alcohol	14,000
Sodium chloride (common salt)	3,000
Vitamin A	2,000
Vanillin	1,580
Aspirin	1,000
Chloroform	800
Copper sulfate	300
Caffeine	192
Phenobarbital, Sodium salt	162
DDT	113
Sodium nitrite	85
Nicotine	53
Aflatoxin B1	7
Sodium cyanide	6.4
Strychnine	2.5

VI. HEALTH EFFECTS

Human health effects caused by exposure to toxic substances fall into two categories: short-term and long-term effects. Short-term effects (or acute effects) have a relatively quick onset (usually minutes to days) after brief exposures to relatively high concentrations of material (acute exposures). The effect may be local or systemic. Local effects occur at the site of contact between the toxicant and the body. This site is usually the skin or eyes, but includes the lungs if irritants are inhaled or the gastrointestinal tract if corrosives are ingested. Systemic effects are those that occur if the toxicant has been absorbed into the body from its initial contact point, transported to other parts of the body, and cause adverse effects in susceptible organs. Many chemicals can cause both local and systemic effects.

Long-term (or chronic) effects are those with a long period of time (years) between exposure and injury. These effects may occur after apparent recovery from acute exposure or as a result of repeated exposures to low concentrations of materials over a period of years (chronic exposure).

The health effects manifested from acute or chronic exposure are dependent upon the chemical involved and the organ it effects. Most chemicals do not exhibit the same degree of toxicity for all organs. Usually the major effects of a chemical will be expressed in one or two organs. These organs are known as target organs which are more sensitive to that particular chemical than other organs. The organs of the body and examples of effects due to chemical exposures are listed below.

A. Respiratory Tract

The respiratory tract is the only organ system with vital functional elements in constant, direct contact with the environment. The lung also has the largest exposed surface area of any organ on a surface area of 70 to 100 square meters versus 2 square meters for the skin and 10 square meters for the digestive system.

1. Structure

The respiratory tract is divided into three regions:

- Nasopharyngeal: Extends from nose to larynx. These passages are lined with ciliated epithelium and mucous glands. They filter out large inhaled particles, increase the relative humidity of inhaled air, and moderate its temperature.

- Tracheobronchial: Consists of trachea, bronchi, and bronchioles and serves as conducting airway between the nasopharyngeal region and alveoli.

- These passageways are lined with ciliated epithelium coated by mucous, which serves as an escalator to move particles from deep in the lungs back up to the oral cavity so they can be swallowed. These ciliated cells can be temporarily paralyzed by smoking or using cough suppressants.

- Pulmonary acinus: is the basic functional unit in the lung and the primary location of gas exchange. It consists of small bronchioles which connect to the alveoli. The alveoli, of which there are 100 million in humans, contact the pulmonary capillaries.

2. Particle deposition

Inhaled particles settle in the respiratory tract according to their diameters:

- 5 - 30 micron are deposited in the nasopharyngeal region.

- 1 - 5 micron are deposited in the tracheobronchial region.

- less than 1 micron are deposited in the alveolar region by diffusion and Brownian motion.

  In general, most particles 5-10 microns in diameter are removed. However, certain small inorganic particles, settle into smaller regions of the lung and kill the cells which attempt to remove them. The result is fibrous lesions of the lung.

3. Types of inhaled toxicants

Many chemicals used or produced in industry can produce acute or chronic diseases of the respiratory tract when they are inhaled (**Table 5**). The toxicants can be classified according to how they affect the respiratory tract.

- Asphyxiants: gases that deprive the body tissues of oxygen

  -- simple asphyxiants are physiologically inert gases that at high concentrations displace air leading to suffocation. Examples: nitrogen, helium, methane, neon, argon.

  -- chemical asphyxiants are gases that prevent the tissues from getting enough oxygen. Examples: carbon monoxide and cyanide. Carbon monoxide binds to hemoglobin 200 times more readily than oxygen. Cyanide prevents the transfer of oxygen from blood to tissues by inhibiting the necessary transfer enzymes.

- Irritants: chemicals that irritate the air passages. Constriction of the airways occurs and may lead to edema (liquid in the lungs) and infection. Examples: Hydrogen fluoride, Chlorine, Hydrogen chloride, and Ammonia.

TABLE 5
EXAMPLES OF INDUSTRIAL TOXICANTS THAT PRODUCE DISEASE OF THE RESPIRATORY TRACT

TOXICANT	SITE OF ACTION	ACUTE EFFECT	CHRONIC EFFECT
Ammonia	Upper airways	Irritation, edema	Bronchitis
Arsenic	Upper airways	Bronchitis, irritation, pharyngitis	Cancer, bronchitis, laryngitis
Asbestos	Lung parenchyma	- - - - - - - - - - - - - - - - - -	Fibrosis, cancer
Chlorine	Upper airways	Cough, irritation, asphyxiant (by muscle cramps in larynx)	- - - - - - - - - - - - -
Isocyanates	Lower airways, alveoli	Bronchitis, pulmonary edema, asthma	- - - - - - - - - - - - -
Nickel carbony	Alveoli	Edema (delayed symptoms)	- - - - - - - - - - - - -
Ozone	Bronchi, alveoli	Irritation, edema, hemorrhage	Emphysema, bronchitis
Phosgene	Alveoli	Edema	Bronchitis, fibrosis, pneumonia
Toluene	Upper airways	Bronchitis, edema, bronchospasm	- - - - - - - - - - - - -
Xylene	Lower airways	Edema, hemorrhage	- - - - - - - - - - - - -

- Necrosis producers: Chemicals that result in cell death and edema: Examples: Ozone and Nitrogen dioxide.

- Fibrosis producers: Chemicals that produce fibrotic tissue which, if massive, blocks airways and decreases lung capacity. Examples: Silicates, Asbestos, and Beryllium.

- Allergens: Chemicals that induce an allergic response characterized by bronchoconstriction and pulmonary disease. Examples: Isocyanates and Sulfur dioxide.

- Carcinogens: Chemicals that are associated with lung cancer. Examples: cigarette smoke, coke emissions, asbestos, and arsenic.

Not only can various chemicals affect the respiratory tract, but the tract is also a route for chemicals to reach other organs. Solvents, such as benzene and tetrachloroethane, anesthetic gases, and many other chemical compounds can be absorbed through the respiratory tract and cause systemic effects.

B. Skin

The skin is, in terms of weight, the largest single organ of the body. It provides a barrier between the environment and other organs (except the lungs and eyes) and is a defense against many chemicals.

1. Structure

The skin consists of the epidermis (outer layer) and the dermis (inner layer). In the dermis are sweat glands and ducts, sebaceous glands, connective tissue, fat, hair follicles, and blood vessels. Hair follicles and sweat glands penetrate both the epidermis and dermis. Chemicals can penetrate through the sweat glands, sebaceous glands, or hair follicles.

Although the follicles and glands may permit a small amount of chemicals to enter almost immediately, most pass through the epidermis, which constitutes the major surface area. The top layer is the stratum corneum, a thin cohesive membrane of dead surface skin. This layer turns over every 2 weeks by a complex process of cell dehydration and polymerization of intracellular material. The epidermis plays the critical role in skin permeability. Below the epidermis lies the dermis, a collection of cells providing a porous, watery, nonselective diffusion medium.

2. Natural Defenses

Intact skin has a number of functions:

- Epidermis: Prevents absorption of chemicals and is a physical barrier to bacteria.

- Sebaceous glands: Secrete fatty acids which are bacteriostatic and fungistatic.

- Melanocytes (skin pigment): Prevent damage from ultraviolet radiation in sunlight.
- Sweat glands: Regulate heat.
- Connective tissue: Provides elasticity against trauma.
- Lymph-blood system: Provide immunologic responses to infection.

3. Absorption Characteristics

The ability of skin to absorb foreign substances depends on:

- Properties and health of the skin.
- Chemical properties of the substances.

Absorption is enhanced by:

- Breaking top layer of skin by abrasions or cuts.
- Increasing hydration of skin.
- Increasing temperature of skin which causes sweat cells to open up and secrete sweat, which can dissolve solids.
- Increasing blood flow to skin.
- Increasing concentrations of the substance.
- Increasing contact time of the chemical on the skin.
- Increasing the surface area of affected skin.
- Altering skin's normal pH of 5.
- Decreasing particle size of substance.
- Adding agents which will damage skin and render it more susceptible to penetration.
- Adding surface-active agents or organic chemicals. DMSO, for example, can act as a carrier of the substance.
- Inducing ion movement by an electrical charge.

Absorption of a toxic chemical through the skin can lead to:

- Local effects, such as irritation and necrosis, through direct contact.
- Systemic effects.

Many chemicals can cause a reaction with the skin resulting in inflammation called dermatitis. These chemicals are divided into three categories:

- Primary irritants: Act directly on normal skin at the site of contact (if chemical is in sufficient quantity for a sufficient length of time). Skin irritants include: Acetone, benzyl chloride, carbon disulfide, chloroform, chromic acid and other soluble chromium compounds, ethylene oxide, hydrogen chloride, iodine, methyl ethyl ketone, mercury, phenol, phosgene, styrene, sulfur dioxide, picric acid, toluene, xylene.
- Photosensitizers: Increase in sensitivity to light, which results in irritation and redness. Photosensitizers include: Tetracyclines, acridine, creosote, pyridine, furfural, and naphtha.
- Allergic sensitizers: May produce allergic-type reaction after repeated exposures. They include: Formaldehyde, phthalic anhydride, ammonia, mercury, nitrobenzene, toluene diisocyanate, chromic acid and chromates, cobalt, and benzoyl peroxide.

C. Eyes

The eyes are affected by the same chemicals that affect skin, but the eyes are much more sensitive. Many materials can damage the eyes by direct contact:

- Acids: Damage to the eye by acids depends on pH and the protein-combining capacity of the acid. Unlike alkali burns, the acid burns that are apparent during the first few hours are a good indicator of the long-term damage to be expected. Some acids and their properties are:
  - -- Sulfuric acid: In addition to its acid properties, it simultaneously removes water and generates heat.
  - -- Picric acid and tannic acid: No difference in damage they produce in entire range of acidic pHs.
  - -- Hydrochloric acid: Severe damage at pH 1, but no effect at pH 3 or greater.

- Alkalies: Damage that appears mild initially but can later lead to ulceration, perforation, and clouding of the cornea or lens. The pH and length of exposure have more bearing on the amount of damage than the type of alkali. Some problem alkalies are:

  -- Sodium hydroxide (caustic soda) and potassium hydroxide.

  -- Ammonia penetrates eye tissues more readily than any other alkali; Calcium oxide (lime) forms clumps when it contacts eye tissue and is very hard to remove.

- Organic solvents: Organic solvents (for example, ethanol, toluene, and acetone) dissolve fats, cause pain, and dull the cornea. Damage is usually slight unless the solvent is hot.

- Lacrimators: Lacrimators cause instant tearing at low concentrations. They are distinguished from other eye irritants (hydrogen chloride and ammonia) because they induce an instant reaction without damaging tissues. At very high concentrations lacrimators can cause chemical burns and destroy corneal material. Examples are chloroacetophenone (tear gas) and mace.

In addition, some compounds act on eye tissue to form cataracts, damage the optic nerve, or damage the retina. These compounds usually reach the eye through the blood system having been inhaled, ingested or absorbed rather than direct contact. Examples of compounds that can provide systemic effects damaging to the eyes are:

- Naphthalene: Cataracts and retina damage.

- Phenothiazine (insecticide): Retina damage

- Thallium: cataracts and optic nerve damage.

- Methanol: Optic nerve damage.

D. Central Nervous System

1. Anoxia as a Basic Action

Neurons (nerve cells) have a high metabolic rate but little capacity for anaerobic metabolism. Subsequently, inadequate oxygen flow (anoxia) to the brain kills cells within minutes. Some may die before oxygen or glucose transport stops completely.

Because of their need for oxygen, nerve cells are readily affected by both simple asphyxiants and chemical asphyxiants. Also, their ability to receive adequate oxygen is affected by compounds that reduce respiration and thus reduce oxygen content of the blood (barbiturates, narcotics). Other examples include compounds that reduce blood pressure or flow due to cardiac arrest,

extreme hypotension, hemorrhaging, or thrombosis such as arsine, nickel, ethylene chlorohydrin, tetraethyl lead, aniline, and benzene.

2. Direct Action on Neurons

Some compounds damage neurons or inhibit their function through specific action on parts of the cell. The major symptoms from such damage include: dullness, restlessness, muscle tremor, convulsions, loss of memory, epilepsy, idiocy, loss of muscle coordination, and abnormal sensations. Examples are:

- Fluoroacetate: Rodenticide.
- Triethyltin: Ingredient of insecticides and fungicides.
- Hexachlorophene: Antibacterial agent.
- Lead: Gasoline additive and paint ingredient.
- Thallium: Sulfate used as a pesticide and oxide or carbonate used in manufacture of optical glass and artificial gems.
- Tellurium: Pigment in glass and porcelain.
- Organomercury compounds: Methyl mercury used as a fungicide; is also a product of microbial action on mercury ions. Organomercury compounds are especially hazardous because of their volatility and their ability to permeate tissue barriers.

Some chemicals are noted for producing weakness of the lower extremities and abnormal sensations (along with previously mentioned symptoms):

- Acrylamide: Soil stabilizer, waterproofer.
- Carbon disulfide: Solvent in rayon and rubber industries.
- n-Hexane: Used as a cleaning fluid and solvent. Its metabolic product, hexanedione, causes the effects.
- Methyl butyl ketone: Same as for hexane.
- Organophosphorus compounds: Often used as flame retardants (triorthocresyl phosphate) and pesticides (leptofor and mipafox).

Agents that prevent the nerves from producing proper muscle contraction and may result in death from respiratory paralysis are DDT, lead, botulinum toxin, and allethrin (a synthetic insecticide). DDT, mercury, manganese, and monosodium glutamate also produce personality disorders and madness.

E. Liver

Liver injury induced by chemicals has been known as a toxicologic problem for hundreds of years. It was recognized early that liver injury is not a simple entity, but that the type of lesion depends on the chemical and duration of exposure. Three types of response to hepatotoxins can be identified:

- Acute:

  Cell death from:

  -- Carbon tetrachloride: solvent, degreaser.

  -- Chloroform: Used in refrigerant and the manufacture of solvent.

  -- Trichloroethylene: solvent, dry cleaning fluid, degreaser.

  -- Tetrachloroethane: Paint and varnish remover, dry cleaning fluid.

  -- Bromobenzene: solvent, motor oil additive.

  -- Tannic acid: Ink manufacture, beer and wine clarifier.

  -- Kepone: pesticide.

- Chronic:

  -- Cirrhosis: a progressive fibrotic disease of the liver associated with liver dysfunction and jaundice. Among agents implicated in cirrhosis cases are carbon tetrachloride, alcohol, and aflatoxin.

  -- Carcinomas: malignant, growing tissue. For example, vinyl chloride (used in polyvinyl chloride production) and arsenic (used in pesticides and paints) are associated with cancers.

- Biotransformation of toxicants: the liver is the principal organ that chemically alters all compounds entering the body. For example:

  Ethanol---> Acetaldehyde---> Acetic acid---> Water+Carbon dioxide

  This metabolic action by the liver can be affected by diet, hormone activity, and alcohol consumption. Biotransformation in the liver can also lead to toxic metabolites. For example:

  Carbon tetrachloride---> Chloroform

F. Kidneys

The kidney is susceptible to toxic agents for several reasons:

- The kidneys constitute 1 percent of the body's weight, but receive 20-25 percent of the blood flow (during rest). Thus, large amounts of circulating toxicants reach the kidneys quickly.

- The kidneys have high oxygen and nutrient requirements because of their work load. They filter 1/3 of the plasma reaching them and reabsorb 98-99% of the salt and water. As they are reabsorbed, salt concentrates in the kidneys.

- Changes in kidney pH may increase passive diffusion and thus cellular concentrations of toxicants.

- Active secretion processes may concentrate toxicants.

- Biotransformation is high.

A number of materials are toxic to the kidneys:

- Heavy metals, may denature proteins as well as produce cell toxicity. Heavy metals (including mercury, chromium, arsenic, gold, cadmium, lead, and silver) are readily concentrated in the kidneys, making this organ particularly sensitive.

- Halogenated organic compounds, which contain chlorine, fluorine, bromine, or iodine. Metabolism of these compounds, like that occurring in the liver, generates toxic metabolites. Among compounds toxic to the kidneys are carbon tetrachloride, chloroform, 2,4,5-T (a herbicide), and ethylene dibromide (a fumigant).

- Miscellaneous, including carbon disulfide (solvent for waxes and resins) and ethylene glycol (automobile antifreeze).

G. Blood

The blood system can be damaged by agents that affect blood cell production (bone marrow), the components of blood (platelets, red blood cells, and white blood cells), or the oxygen-carrying capacity of red blood cells.

1. Bone marrow

Bone marrow is the source of most components in blood. Agents that suppress the function of bone marrow include:

- Arsenic, used in pesticides and paints.
- Bromine, used to manufacture gasoline antiknock compounds, ethylene dibromide, and organic dyes.
- Methyl chloride, used as a solvent, refrigerant, and aerosol propellant.
- Ionizing radiation, produced by radioactive materials and x-rays is associated with leukemia.
- Benzene, a chemical intermediate associated with leukemia.

2. Blood components

Among platelets (thrombocytes) are blood components that help prevent blood loss by forming blood clots. Among chemicals that affect this action are:

- Aspirin, which inhibits clotting.
- Benzene, which decreases the number of platelets.
- Tetrachloroethane, which increases the number of platelets.

Leukocytes (white blood cells) are primarily responsible for defending the body against foreign organisms or materials by engulfing and destroying the material or by producing antibodies. Chemicals that increase the number of leukocytes include naphthalene, magnesium oxide, boron hydrides, and tetrachloroethane. Agents that decrease the number of leukocytes include benzene and phosphorous.

Erythrocytes (red blood cells) transport oxygen in the blood. Chemicals that destroy (hemolyze) red blood cells include arsine (a gaseous arsenic compound and contaminant in acetylene), naphthalene (used to make dyes), and warfarin (a rodenticide).

3. Oxygen Transport

Some compounds affect the oxygen carrying capabilities of red blood cells. A notable example is carbon monoxide which combines with hemoglobin to form carboxyhemoglobin. Hemoglobin has an affinity for carbon monoxide 200 times greater than that for oxygen.

While carbon monoxide combines reversibly with hemoglobin, some chemicals cause the hemoglobin to change such that it cannot combine reversibly with oxygen. This condition is called methemoglobinemia. Some chemicals that can cause this are:

- Sodium nitrite, used in meat curing and photography.

- Aniline, used in manufacture of rubber accelerators and antioxidants, resins, and varnishes.

- Nitrobenzene and dinitrobenzene, used in manufacture of dyestuffs and explosives.

- Trinitrotoluene (TNT), used in explosives.

- Mercaptans, used in manufacture of pesticides and as odorizers for hazardous odorless gases.

- 2-nitropropane, used as a solvent.

4. Spleen

The spleen filters bacteria and particulate matter (especially deteriorated red blood cells) from the blood. Iron is recovered from the hemoglobin for recycling. In the embryo, the spleen forms all types of blood cells. In the adult, however, it produces only certain kinds of leukocytes. Examples of chemicals that damage the spleen are:

- Chloroprene, used in production of synthetic rubber.

- Nitrobenzene, used as chemical intermediate.

H. Reproductive System

Experimental results indicate that certain agents interfere with the reproductive capabilities of both sexes, causing sterility, infertility, abnormal sperm, low sperm count, and/or affect hormone activity in animals. Many of these also affect human reproduction. Further study is required to identify reproductive toxins and their effects. Some examples of chemicals that have been implicated in reproductive system toxicity include:

- Male: Anesthetic gases (halothane, methoxyflurane), cadmium, mercury, lead, boron, methyl mercury, vinyl chloride, DDT, kepone, chlordane, PCB's, dioxin, 2,4-D, 2,4,5-T, carbaryl, paraquat, dibromochloropropane, ethylene dibromide, benzene, toluene, xylene, ethanol, radiation, heat.

- Female: DDT, parathion, carbaryl, diethylstilbestrol (DES), PCB's, cadmium, methyl mercury, hexafluoroacetone, anesthetic gases.

VII. TYPES OF TOXIC EFFECTS

A. Teratogenic

Teratology is derived from Latin and means the study of monsters. In a modern context, teratology is the study of congenital malformations. Teratology is a relatively new discipline that started in 1941 with the correlation of German measles to birth defects. In the 1960's, the first industrial link to teratogens was discovered. The chemical involved was methyl mercury.

1. Causes of congenital malformations

The following conditions have been associated with congenital malformations:

- Heredity.
- Maternal diseases such as German measles and viral infections during pregnancy.
- Maternal malnutrition.
- Physical injury.
- Radiation.
- Exposure to chemicals.

2. Gestation period

Most major structural abnormalities occur during the embryonic period, 5-7 weeks, while physiologic and minor defects occur during the fetal period, 8-36 weeks. Studies using lab animals show the need to evaluate exposure of chemicals for each day of pregnancy. Thalidomide, for example, caused birth defects in rats only when administered during the 12th day of gestation.

A number of chemicals are reactive or can be activated in the body during the gestation period. The degree and nature of the fetal effects then depend upon:

- Developmental state of embryo or fetus when chemical is administered.
- Dose of chemical, route, and exposure interval.
- Transplacental absorption of chemical and levels in tissues of embryo/fetus.

- Ability of maternal liver and placenta to metabolize or detoxify chemical.
- Biologic half-life of chemical or metabolites.
- State of cell cycle when chemical is at toxic concentrations.
- Capacity of embryonic/fetal tissues to detoxify or bioactivate chemicals.
- Ability of damaged cells to repair or recover.

3. Animal Studies

Teratogenic potential has been suggested by animal studies under various conditions:

- Dietary deficiency: Vitamins A, D, E, C, riboflavin, thiamine, nicotinamide, folic acid, zinc, manganese, magnesium, cobalt.
- Hormonal deficiency: Pituitary, thyroxin, insulin.
- Hormonal excess: Cortisone, thyroxin, insulin androgens, estrogens, epinephrine.
- Hormone and vitamin antagonists: 3-acetylpyridine, 6-aminonicotinamide, thiouracils.
- Vitamin excess: Vitamin A, nicotinic acid.
- Antibiotics: Penicillin, tetracyclines, streptomycin.
- Heavy metals: Methyl mercury, mercury salts, lead, thallium, selenium, chelating agents.
- Azo dyes: Trypan blue, evans blue, niagara sky blue 6B.
- Producers of anoxia: Carbon monoxide, carbon dioxide.
- Chemicals: Quinine, thiadiazole, salicylate, 2,3,7,8-TCDD, caffeine, nitrosamines, hydroxyurea, boric acid, insecticides, pesticides, DMSO, chloroform, carbon tetrachloride, benzene, xylene, cyclohexanone, propylene glycol, acetamides, formamides, sulfonamides.
- Physical conditions: hypothermia, hyperthermia, radiation, anoxia.

- Infections: Ten viruses (including German measles and cytomegalovirus), syphilis, gonorrhea.

4. Teratogens Known to Affect Humans

Far fewer agents have been conclusively shown to be teratogenic in humans:

- Anesthetic gases.
- Organic mercury compounds.
- Ionizing radiation.
- German measles.
- Thalidomide.

B. Mutagenic

Mutagens are agents that cause changes (mutations) in the genetic code, altering DNA. The changes can be chromosomal breaks, rearrangement of chromosome pieces, gain or loss of entire chromosomes, or a changes within a gene.

Among agents shown to be mutagenic in humans are:

- Ethylene oxide, used in hospitals as a sterilant.
- Ethyleneimine, an alkylating agent.
- Ionizing radiation.
- Hydrogen peroxide, a bleaching agent.
- Benzene, a chemical intermediate.
- Hydrazine, used in rocket fuel.

The concern over mutagenic agents covers more than the effect that could be passed into the human gene pool (germinal or reproductive cell mutations). There is also interest in the possibility that somatic cell mutations may produce carcinogenic or teratogenic responses.

C. Carcinogenic

Two types of carcinogenic mechanisms have been identified.

- Genotoxic: Electrophilic carcinogens that alter genes through interaction with DNA. There are three types:

- direct or primary carcinogens: Chemicals that act without any bioactivation - for example, bis (chloromethyl) ether, ethylene dibromide, and dimethyl sulfate.

- procarcinogens: Chemicals that require biotransformation to activate them to a carcinogen - for example, vinyl chloride and 2-naphthylamine.

- inorganic carcinogen: Some of these are preliminarily categorized as genotoxic due to potential for DNA damage. Other compounds in the group may operate through epigenetic mechanisms.

- Epigenetic: These are carcinogens that do not act directly with genetic material. Several types are possible:

  - Cocarcinogen: Increases the overall response of a carcinogen when they are administered together - for example, sulfur dioxide, ethanol, and catechol.

  - Promoter: Increases response of a carcinogen when applied after the carcinogen but will not induce cancer by itself - for example, phenol, dithranol.

  - Solid-state: Works by unknown mechanism, but physical form vital to effect (asbestos, metal foils).

  - Hormone: Usually is not genotoxic, but alters endocrine balance; often acts as promoter (DES, estrogens).

  - Immunosuppressor: Mainly stimulates virally induced, transplanted, or metastatic neoplasms by weakening host's immune system (antilymphocytic serum, used in organ transplants).

Genotoxic carcinogens are sometimes effective after a single exposure, can act in a cumulative manner, or act with other genotoxic carcinogens which affect the same organs. Some epigenetic carcinogens, however, only cause cancers when concentrations are high and exposure long. The implication is that while there may be a "safe" threshold level of exposure for some carcinogens, others may have "zero" threshold - that is, one molecule of the chemical can induce a cancer.

1. Role of DNA

Various considerations indicate that DNA is a critical target for carcinogens:

- Many carcinogens are or can be metabolized so that they react with DNA. In these cases, the reaction can usually be detected by testing for evidence of DNA repair.

- Many carcinogens are also mutagens.

- Inhibitors and inducers of carcinogens affect mutagenic activity.

- Chemicals often are tested for mutagenic and carcinogenic activity in the same cell systems.

- Defects in DNA repair predispose to cancer development.

- Several inheritable or chromosomal abnormalities predispose to cancer development.

- Initiated dormant tumor cells persist, which is consistent with a change in DNA.

- Cancer is inheritable at the cellular level and, therefore, may result from an alteration of DNA.

- Most, if not all, cancers display chromosomal abnormalities.

Although cancer ranks as the second most common cause of death in the United States, the process of carcinogenesis is not yet clearly defined. As a result, there are several problems encountered when evaluating the carcinogenic potential of various agents in the environment. First, human health can be affected by a wide range of factors including the environment, occupation, genetic predisposition and lifestyle (i.e., cigarette smoking, diet). Therefore, it is often difficult to determine the relationship between any one exposure and the onset of cancer. Second, many cancers are latent responses - that is, the disease may not be manifested until many years after the initial exposure. Third, the mechanisms for carcinogenesis may differ according to the type and the site of cancer.

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APPENDIX I
EXPOSURE GUIDELINES

I. INTRODUCTION

During response activities involving hazardous materials, it is necessary to acknowledge and plan for the possibility that response personnel will be exposed to the materials present at some time and to some degree. Since most materials have levels of exposure which can be tolerated without adverse health effects, it is important to determine not only the identity of the materials involved, but also the type and extent of exposure, possible health effects from overexposure, and most important, the exposure levels that are considered safe for each material encountered.

There are several reference sources available which contain information about toxicological properties and safe exposure limits for many different materials. These sources can be grouped into two general categories: 1) Those sources that provide toxicological data and general health hazard information and warnings and 2) references that describe specific legal exposure limits or recommended exposure guidelines. Both source categories, when considered together, provide useful information that can be used to assess the exposure hazards that might be present at a hazardous materials incident. In the following discussion, these source categories are described in greater detail.

II. GENERAL GUIDELINES

The effects of chemical exposure with the route and dosage required can be found in NIOSH's Registry of Toxic Effects of Chemical Substances. However, because most of the data is for animal exposures, there may be problems in trying to use the data for human exposure guidelines.

Other sources give some general guides on chemical exposure. They may say that the chemical is an irritant or corrosive, or they may give a warning like "AVOID CONTACT" or "AVOID BREATHING VAPORS". This gives the user information about the possible route of exposure and effects of the exposure. However, this does not give a safe exposure limit. One may question if the warning means to "AVOID ANY POSSIBLE CONTACT" or if there is a certain amount that a person can contact safely for a certain length of time.

Two sources of information go a little further and use a ranking system for exposure to chemicals. Irving Sax, in Dangerous Properties of Industrial Materials, gives a Toxic Hazard Rating (THR) for certain chemicals. These ratings are NONE, LOW, MODERATE, and HIGH. The route of exposure is also given. For example, Butylamine is listed as a HIGH toxic hazard via oral and dermal routes and a MODERATE toxic hazard via inhalation. HIGH means that the chemical is "capable of causing death or permanent injury due to the exposures of normal use; incapacitating and poisonous; requires special handling".

In their book, Fire Protection Guide on Hazardous Materials, the National Fire Protection Association (NFPA) also uses a ranking system to identify the toxic hazards of a chemical.

These numbers are part of the NFPA 704 M identification system, which is discussed further in Hazard Recognition - Part I. The numbers used range from 0 to 4 where 0 is for "materials which on exposure under fire conditions would offer no health hazard beyond that of ordinary combustible material" and 4 is for materials where "a few whiffs of the gas or vapor could cause death; or the gas, vapor, or liquid could be fatal on penetrating the fire fighters' normal full protective clothing which is designed for resistance to heat". The degree of hazard is based upon the inherent properties of the chemical and the hazard that could exist under fire or other emergency conditions. This rating is based on an exposure of "a few seconds to an hour" and the possibility of large quantities of material being present. Thus it is not completely applicable to long-term exposure to small quantities of chemicals. It is more useful for spills or fires where a person could come in contact with a large amount of the chemical.

The Sax and NFPA sources provide information about the routes of exposures and some effects along with a rating system which indicates which chemicals require extra precaution and special protective equipment.

III. SOURCES FOR SPECIFIC GUIDELINES FOR AIRBORNE CONTAMINANTS

While there are many sources for general exposure guidelines, there are only a few that give more specific information about what is considered a safe exposure limit. Many of the following organizations have exposure guidelines for exposures to hazards other than airborne contaminants (e.g., heat stress, noise, radiation). This part will deal only with chemical exposures.

A. American Conference of Governmental Industrial Hygienists (ACGIH)

One of the first groups to develop specific exposure guidelines was the American Conference of Governmental Industrial Hygienists (ACGIH). In 1941, ACGIH suggested the development of Maximum Allowable Concentrations (MACs) for use by industry. A list of MACs was compiled by ACGIH and published in 1946. In the early 1960's, ACGIH revised those recommendations and renamed them Threshold Limit Values (TLVs®).

Along with the TLVs®, ACGIH publishes Biological Exposure Indices (BEIs). BEIs are intended to be used as guides for evaluation of exposure where inhalation is not the only possible route of exposure. Since the TLVs® are for inhalation only, they may not be protective if the chemical is ingested or is absorbed through the skin. Biological monitoring (e.g., urine samples, breath analysis) can be used to assess the overall exposure. This monitoring uses information about what occurs in the body (e.g., metabolism of benzene to phenol) to determine if there has been an unsafe exposure. The BEIs serve as a reference for biological monitoring just as TLVs® serve as a reference for air monitoring.

The TLVs® are reviewed yearly and are published in their booklet, Threshold Limit Values and Biological Exposure Indices.

B. American National Standards Institute (ANSI)

The American National Standards Institute (ANSI) has published standards that are a consensus of the people who have a concern about the subject the standard covers (e.g., hardhats, respirators). An ANSI standard is intended as a guide to aid manufacturers, consumers, and the general public. ANSI has standards covering many aspects of the working environment. Many of these have been adopted by OSHA (see later discussion) as legal requirements.

Some of the standards were exposure guidelines. They gave "acceptable concentrations" which were "concentrations of air contaminants to which a person may be exposed without discomfort or ill effects". These exposure limits were withdrawn in 1982. However, some were adopted by OSHA before the withdrawal and still may be in use.

C. Occupational Safety and Health Administration (OSHA)

In 1971, the Occupational Safety and Health Administration (OSHA) promulgated Permissible Exposure Limits (PELs). These limits were extracted from the 1968 TLVs®, the ANSI standards, and other Federal standards. The PELs are found in 29 CFR 1910.1000 (see Appendix I). Since then, additional PELs have been adopted and a few of the originals have been changed. These have been incorporated into specific standards for chemicals (e.g., 29 CFR 1910.1028 - benzene). There are also standards for thirteen carcinogens in which there is no allowable inhalation exposure.

In 1989, OSHA published major revisions to the PELs. Since only a few of the PELs had been updated since 1971, it was decided to updated the entire list of PELs by changing existing ones and adding new ones. Again, OSHA looked to the TLVs, but also considered recommendations from the National Institute for Occupational Safety and Health (NIOSH).

Since OSHA is a regulatory agency, their PELs are legally enforceable standards and apply to all private industries and Federal agencies. They may also apply to state and local employees depending upon the state laws.

D. National Institute for Occupational Safety and Health (NIOSH)

The National Institute for Occupational Safety and Health (NIOSH) was formed at the same time as OSHA to act as a research organization. It is changed in part, with making recommendations for new standards and revising old ones as more information is accumulated. The exposure levels NIOSH has researched have been used to develop new OSHA standards, but there are many Recommended Exposure Limits (RELs) that have not been adopted. Thus, they are in the same status as the exposure guidelines of ACGIH and other groups. The RELs are found in the "NIOSH Recommendations for Occupational Health Standards".

E. American Industrial Hygiene Association (AIHA)

The American Industrial Hygiene Association has provided guidance for industrial hygienists for many years. In 1984, AIHA developed exposure guidelines that it calls Workplace Environmental Exposure Level Guides (WEELs). These are reviewed and updated each year. Appendix III has the current list of WEELs. While the list is not as large as others, AIHA has chosen chemicals for which other groups do not have exposure guidelines. Thus, they are providing information to fill the gaps left by others.

IV. TYPES OF EXPOSURE GUIDELINES

While there are different organizations that develop exposure guidelines, the types of guidelines they produce are similar.

A. Time Weighted Average (TWA)

A time weighted average exposure is determined by averaging the concentrations of the exposure with each concentration weighted based on the duration of exposure. For example, an exposure to acetone at the following concentrations and durations:

1000 ppm for 3 hours
500 ppm for 2 hours
200 ppm for 3 hours

would have an 8 hour time weighted average exposure of

$$\frac{(3\ hrs)(1000\ ppm + (2\ hrs)(500\ ppm) + (3\ hrs)(200\ ppm)}{8\ hrs} = 3000\ ppm + 1000\ ppm + 600\ \frac{ppm}{8} = 575\ ppm$$

This exposure would be compared to an 8 hour TWA exposure limit.

While a TWA can be the average concentration over any period of time, most TWAs are the average concentration of a chemical most workers can be exposed to during a 40-hour week and a normal 8-hour work day without showing any toxic effects. NIOSH TWA recommendations, on the other hand, can also be based on exposures up to 10 hours. The time weighted average permits exposure to concentrations above the limit, provided they are compensated by equal exposure below the TWA. **Chart 1** shows an example that illustrates this point for a chemical with a TWA exposure limit of 750 ppm.

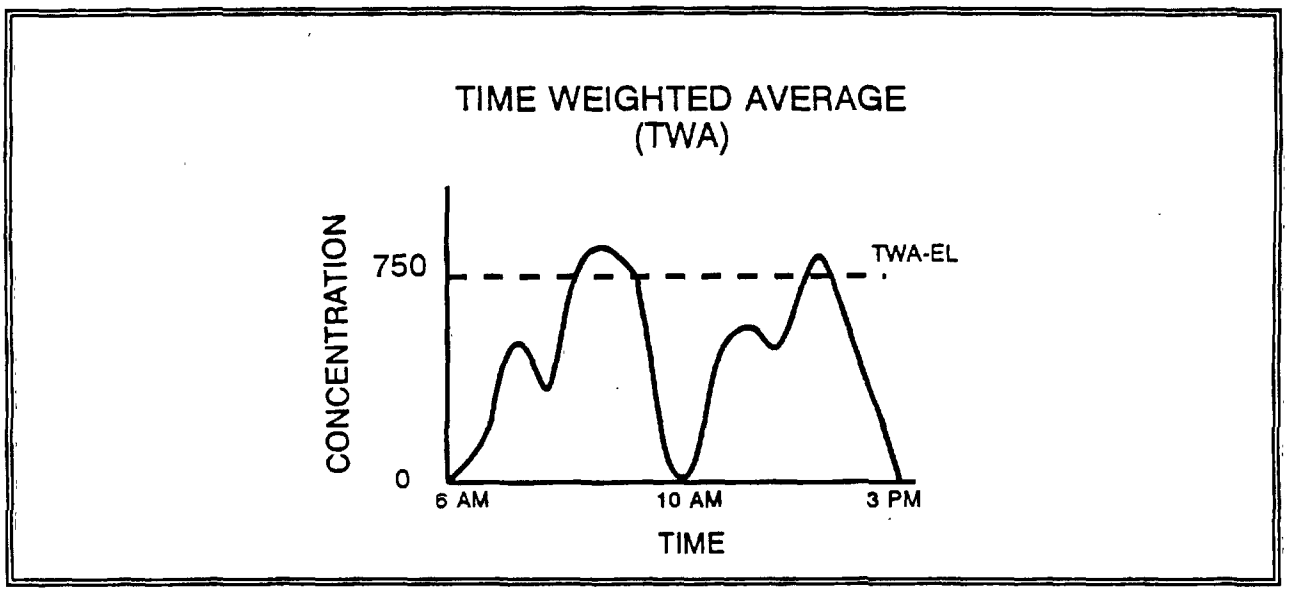

CHART 1
EXAMPLE OF AN EXPOSURE COMPARED TO A TWA EXPOSURE LIMIT

B. Short Term Exposure Limit (STEL)

Because the excursions allowed by the TWA could involve very high concentrations and cause an adverse effect, but still be within the allowable average, some organizations felt there was a need for some limit to these excursions. In 1976, ACGIH added STELs to its TLVs®. The STEL is a 15 minute time-weighted average exposure. Excursions to the STEL should be at least 60 minutes apart, no longer than 15 minutes in duration and should not be repeated more than 4 times per day. Because the excursions are calculated into the 8-hour TWA, the exposure must be limited to avoid exceeding the TWA. **Chart 2** illustrates an exposure that exceeds the 15 minute limit for an STEL of 1000 ppm.

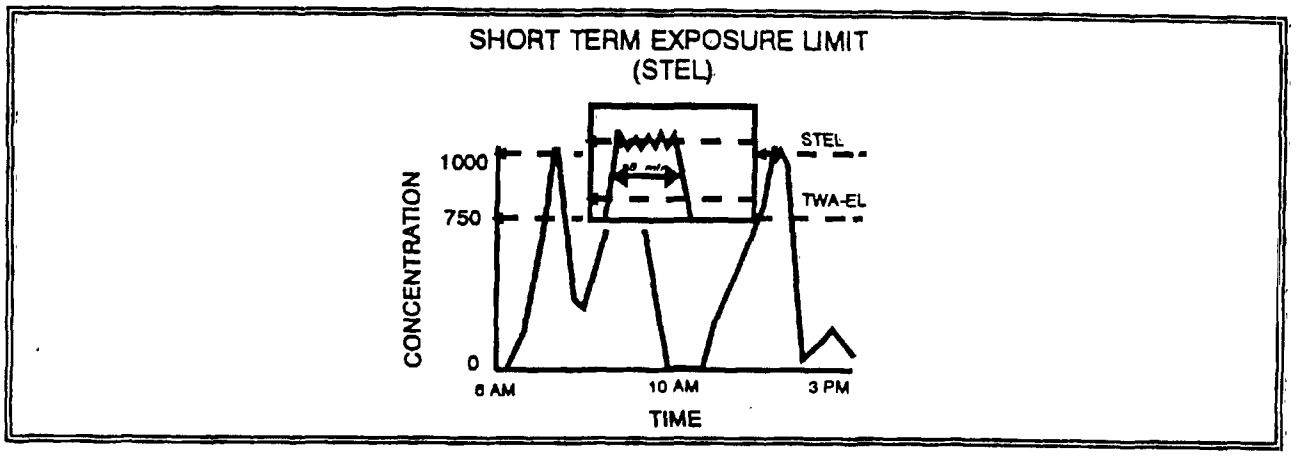

CHART 2
EXAMPLE OF AN EXPOSURE COMPARED TO A STEL AND A TWA

The STEL supplements the TWA and reflects an exposure limit protecting against acute effects from a substance which primarily exhibits chronic toxic effects. This concentration is set at a level to protect workers against irritation, narcosis, and irreversible tissue damage. OSHA added STELs to its PELs with the 1989 revisions.

AIHA has some short-term TWAs which are similar to the STELs. The times used vary from 1 to 30 minutes. These Short-Term TWAs are used in conjunction with, or in place of, the 8-hour TWA. There is no limitation on the number of these excursions or the rest period between each excursion.

C. Ceiling (C)

Ceiling values exist for substances which exposure results in a rapid and particular type of response. It is used where a TWA (with its allowable excursions) would not be appropriate. ACGIH and OSHA state that a ceiling value should not be exceeded even instantaneously. They denote a ceiling value by a "C" preceding the exposure limit.

NIOSH also uses ceiling values. However, their ceiling values are more like a STEL. Many have time limits (from 5 to 60 minutes) associated with the exposure. **Chart 3** illustrates an exposure that does not exceed a ceiling value of 5 ppm.

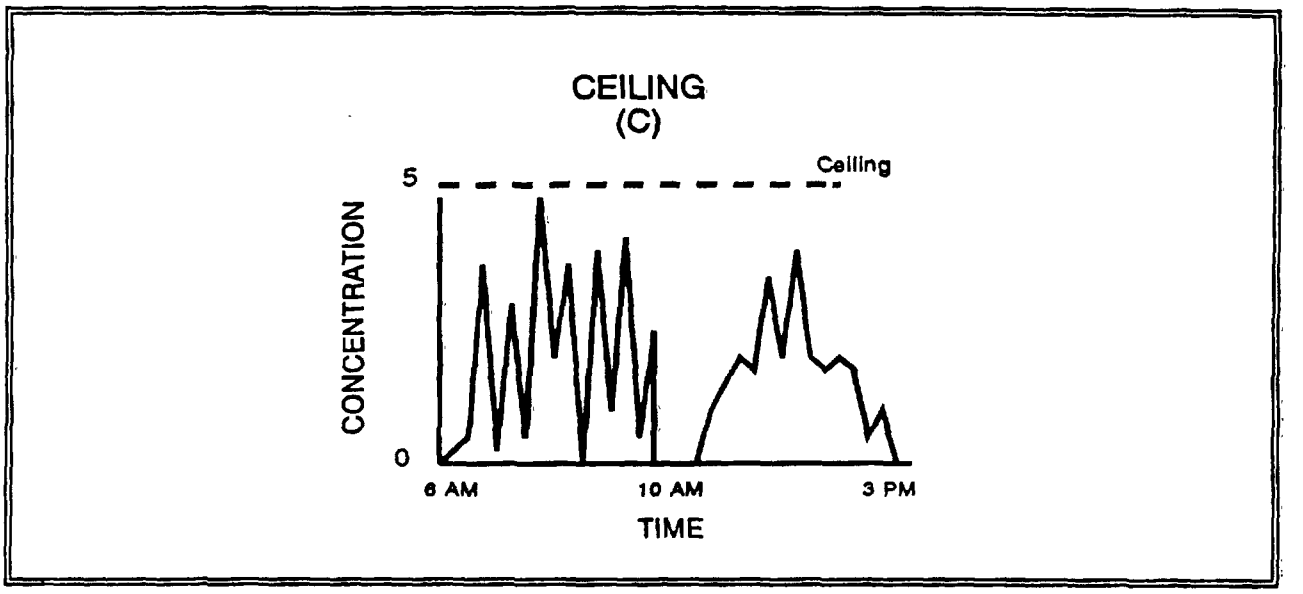

CHART 3
EXAMPLE OF AN EXPOSURE COMPARED TO A CEILING EXPOSURE LIMIT

D. Peaks

Until recently ANSI, and OSHA where they have adopted ANSI standards, had used a peak exposure limit. This peak exposure is an allowable excursion above their ceiling values. The duration and number of exposures at this peak value is limited. For example, ANSI allowed the 25 ppm ceiling value for Benzene to be exceed to 50 ppm but only for 10 minutes during an 8 hour period. ANSI withdrew its exposure limit standards in 1982. With the revision of the PELs in 1989, OSHA has dropped most of its peak values.

E. "Skin" Notation

While these exposure guidelines are based on exposure to airborne concentrations of chemicals, the organizations recognize that there are other routes of exposure in the workplace. In particular, there can be a contribution to the overall exposure from skin contact with chemicals that can be absorbed through the skin. Unfortunately, there is very little data available that quantifies the amount of allowable skin contact. But some organizations provide qualitative information about skin absorbable chemicals. When a chemical has the potential to contribute to the overall exposure by direct contact with the skin, mucous membranes or eyes, it is given a "skin" notation.

This "skin" notation not only points out chemicals that are readily absorbed through the skin, but also notes that if there is skin contact, the exposure guideline for inhalation may not provide adequate protection. The inhalation exposure guidelines are designed for exposures only from inhalation. If additional routes of exposure are added, there can be detrimental effects even if the exposure guideline is not exceeded.

F. Immediately Dangerous to Life or Health (IDLH)

In the May 1987 "NIOSH Respirator Decision Logic", IDLH is defined as a condition "that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment. The purpose of establishing an IDLH exposure level is to ensure that the worker can escape from a given contaminated environment in the event of failure of the respiratory protection equipment." Other organizations, such as ANSI, OSHA, and the Mine Safety and Health Administration (MSHA), have defined IDLH similarly. It is accepted by all of these groups that IDLH conditions include not only toxic concentrations of contaminants, but also Oxygen deficient atmospheres and explosive, or near-explosive, (above, at, or near the lower explosive limits) environments.

At hazardous material incidents, IDLH concentrations should be assumed to represent concentrations above which only workers wearing respirators that provide the maximum protection (i.e., a positive-pressure, full-facepiece, self-contained breathing apparatus [SCBA] or a combination positive-pressure, full-facepiece, supplied-air respirator with positive-pressure escape SCBA) are permitted. Specific IDLH concentrations values for many substances can be found in the NIOSH "Pocket Guide to Chemical Hazards". Guidelines for potentially explosive, Oxygen deficient, or radioactive environments can be found in the U.S. EPA "Standard Operating Safety Guidelines" and the NIOSH/OSHA/USCG/EPA " Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities.

V. MIXTURES

The exposure limits that have been discussed are based upon exposure to single chemicals. Since many exposures include more than one chemical, values are adjusted to account for the combination. When the effects of the exposure are considered to be additive, a formula can be used to determine whether total exposure exceeds the limits. The calculation used is:

$$E_m = (C_1 \div L_1 + C_2 \div L_2) + \ldots (C_n \div L_n)$$

Where: E_m is the equivalent exposure for the mixture.
C is the concentration of a particular contaminant.
L is the exposure limit for that substance.

The value of E_m should not exceed unity (1).

An example using this calculation would be as follows.

Chemical A	C = 200 ppm	L = 750 ppm
Chemical B	C = 100 ppm	L = 500 ppm
Chemical C	C = 50 ppm	L = 200 ppm

$$E_m = 200 \div 750 + 100 \div 500 + 50 \div 200$$

$E_m = 0.27 + 0.20 + 0.25$
$E_m = 0.72$

Since E_m is less than unity, the exposure combination is within acceptable limits. This calculation applies to chemicals where the effects are the same and are additive. If the combination is not additive, the calculation is not appropriate.

VI. APPLICATION OF EXPOSURE GUIDELINES

In 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response" standard, OSHA specifies the use of certain exposure limits. The exposure limits specified are OSHA's permissible exposure limits (PELs) and "published exposure levels". The "published exposure levels" are used when no PEL exists. A "published exposure level" is defined as "the exposure limits published in 'NIOSH Recommendations for Occupational Health Standards' dated 1986 incorporated by reference. If none is specified, the exposure limits published in the standards specified by the American Conference of Governmental Industrial Hygienists in their publication 'Threshold Limit Values and Biological Exposure Indices for 1991-92' dated 1991 incorporated by reference."

A. Engineered Controls and Work Practices

29 CFR 1910.120 (g) (1) (i) states "Engineering controls and work practices shall be instituted to reduce and maintain employee exposure to or below the permissible exposure limits for substances regulated by 29 CFR Part 1910, to the extent required by Subpart Z, except to the extent that such controls and practices are not feasible." (emphasis added) Whenever engineering controls and work practices are not feasible, personal protective equipment shall be used to reduce and maintain exposures.

For those substances or hazards where there is no PEL, the published exposure levels, published literature and MSDS will be used for evaluation. In these circumstances, a combination of engineering controls, work practices and PPE shall be used to reduce and maintain exposures.

B. Personal Protective Equipment (PPE)

Since PPE must be selected based on the hazards present at the site, the exposure limits are used to evaluate the effectiveness of the PPE. Comparing the actual or expected exposure to the PEL or other exposure limits gives the wearer information on selection of the proper PPE. A discussion of the use of exposure limits for the selection of PPE is found in Section 3 of this manual.

C. Medical Surveillance

29 CFR 1910.120(f)(2)(i) requires a medical surveillance program for all employees exposed to substances or hazards above the PEL for 30 or more days per year. If there is no PEL, then the published exposure levels are used for evaluation. The exposures are considered even if a respirator was being used at the time of exposure.

VII. LIMITATIONS AND RESTRICTIONS OF USE

The exposure guidelines discussed in this part are based on industrial experience, experimental human studies, experimental animal studies, or a combination of the three. The guidelines were developed for workers in the industrial environment. Thus, they are not meant to be used for other purposes. ACGIH in its Threshold Limit Values and Biological Exposure Indices for 1991-1992 states -

> These limits are intended for use in the practice of industrial hygiene as guidelines or recommendations in the control of potential health hazards and for no other use, e.g., in the evaluation or control of community air pollution nuisances, in estimating the toxic potential of continuous, uninterrupted exposures or other extended work periods, as proof or disproof of an existing disease or physical condition, or adoption by countries whose working conditions differ from those in the United States of America and where substances and processes differ. These limits *are not* fine lines between safe and dangerous concentration nor are they a relative index of toxicity, and *should not* be used by anyone untrained in the discipline of industrial hygiene".

As can be seen from this qualifier, these exposure limits are not intended as exposure limits for exposure by the public.

There is the limitation on the use of the exposure guideline as a relative index of toxicity. This is because the exposure limits are based on different effects for different chemicals. For example, the TLV®-TWA for Acetone is chosen to prevent irritation to the eyes and respiratory system. The TLV®-TWA for Acrylonitrile is chosen to reduce the risk to cancer. Exposures to these chemicals at other concentration levels could lead to other effects. Thus, when evaluating the risk of chemical exposure, all toxicological data should be consulted.

VIII. DISPERSION OF CHEMICALS IN THE ENVIRONMENT

A. Introduction

Whether a chemical is accidentally spilled or is slowly leaking from an old rusty drum, it is important to determine its dispersion characteristics and its ultimate fate in the environment. In general, the pathways for dispersion are air, surface water, groundwater, and soil. If the specific pathways of various materials can be identified from their chemical/physical characteristics, potential threats to human health and the environment can be anticipated and appropriate response actions taken. The interaction of the natural setting of an incident and the specific compounds involved will ultimately determine dispersion and dictate the response actions needed.

B. Information needed to determine dispersion pathways

1. Characteristics of Chemicals Involved

The more important dispersion pathways can be determined, at least tentatively, from the identity of the chemical(s) if known. The physical/chemical properties such as reactivity, physical state, phase-change temperatures, vapor pressure, density, specific gravity, and viscosity, will help to determine how a chemical behaves when released into a specific environment. The physical/chemical properties of the receiving environment are equally important. In addition to the above considerations, both the amount of material released and the rate of release factor into the determination of potential pathways.

Determining specific pathways will require a further evaluation of factors such as land use, physical setting, biological setting, and climate. All these factors are interrelated and should be evaluated as a whole.

2. Land Use

Land use of the site and adjoining properties can affect dispersion of the materials from the site. If the site is located near a town or large metropolitan area, the number of potential pathways of dispersion may be greater than in an agricultural or natural setting. Urbanized areas may contain natural as well as manmade (e.g. storm or sanitary sewers) pathways of dispersion. A spill in or adjacent to an irrigated field could result in the eventual spreading of the spill across the whole field. Without irrigation, it would tend to converge due to natural drainage patterns.

3. Physical Setting

The physical setting of the site controls what pathways a chemical may follow. There are four major aspects to consider: topography, geology, surface hydrology, and groundwater hydrology. A topographic map of the area is very useful, not only in discerning variations in surface elevation, but also in locating surface water features and patterns. The topography of an area affects how fast material disperses and the primary direction of transport. A topographic map may also serve as an indicator of regional groundwater flow patterns.

The geology of the area, including soil and underlying rock, may dictate the speed and direction of dispersion of a material released to the ground. Sandy soil permits faster infiltration than does a tightly packed clay soil. Previously undetected zones of variable permeability, solution channels, and fractures in underlying soil and rock may divert the material in directions not originally anticipated.

Geological and hydrologic maps of the area may assist in estimating depth to the water table and regional groundwater flow patterns. Local water well drillers may provide valuable information when assessing local groundwater conditions.

4. Biological Setting

The ecosystem in which an incident occurs may considerably affect dispersion pathways. Many contaminants may be dispersed through the food chain. As an example, vegetation which has absorbed a contaminant could be consumed by a rodent which in turn may be eaten by a bird of prey. The concentration of the contaminant may progressively increase in the tissues of the organisms at each successive step in the food chain. Such a phenomenon, known as bioaccumulation, can be detected particularly when the chemicals tend to be environmentally and biologically persistent.

The ecosystem type can also affect the rate of dispersion. A sparsely vegetated area will not contain a spill as well as a densely vegetated area.

5. Climate

The local climatological and meteorological conditions influence dispersion of a contaminant in the environment. Temperature has a direct effect on a chemical's physical/chemical behavior. For example, an increased temperature may cause a volatile chemical to vaporize faster and the reaction rate among chemicals to increase.

Changes in precipitation patterns and volumes can affect surface runoff and soil absorption rates. Dispersion is also affected by wind direction, wind speed, and atmospheric conditions.

General climatic conditions can impact the rates and pathways of dispersion. A hot, arid climate and a temperate, wet climate would cause the same chemical to behave differently during transport. When studying a local weather forecast, the general climate of the area should also be considered. For example, a different evaluation of the situation is needed when 2 days of rain are forecast in a season when rain is expected every day, as compared to 2 days of rain in a relatively dry season.

C. Basic Dispersion Pathways

1. Atmosphere

In order for a material to become airborne, it must be gaseous or particulate. Particulates are microscopic (less than 100 micrometers in size) solid or liquid particles dispersed in air. As a material is emitted to the atmosphere,

dispersion of the material is influenced by local atmospheric phenomena (e.g. effects of air currents around buildings) as well as larger scale wind circulation phenomena such as land/sea breezes and terrain effects.

A volatile liquid (one which has a high vapor pressure) will vaporize more rapidly as the ambient temperature approaches the boiling point of that liquid. If the vapor density of contaminant is greater than that of air, it will tend to sink and follow the terrain, flowing downhill and collecting in valleys. A substance with a vapor density less than air will tend to rise and disperse readily. The dispersion of a substance in the atmosphere is dependent on many factors, including the change in atmospheric temperature with increasing altitude.

When a substance becomes airborne, it may behave in several different ways. It may react with other contaminants in the air, forming a new substance (e.g. photochemical smog). It may react with or dissolve in water droplets, which will ultimately return to the earth as precipitation (one theory of acid rain formation). If the substance is either a large particle or a collection of particles (an agglomerate), its weight may cause it to fall back to the earth's surface as fallout (a process known as dry deposition). Finally, if it is chemically or physically unstable, its presence in the atmosphere may be localized and shortlived (for example, carbon monoxide).

Therefore, the fate of substance emitted to the atmosphere is dependent on both the characteristics of the substance and the local atmosphere.

2. Surface Water

A chemical can be introduced to surface water directly via spills and/or runoff or indirectly by contaminated groundwater via surface expressions of groundwater such as springs and seeps, or by groundwater recharge to larger bodies of water. Climate can affect the size and number of streams, rivers, lakes, and marshes in a region. An area with high annual precipitation rates will tend to have a greater number of these while a more arid area may have just one large river, originating in the mountains, carrying runoff and snow melt towards lower elevations.

The transport of a material in water is based primarily on its solubility (tendency to dissolve in water) and specific gravity (its weight relative to water). A highly soluble solid or liquid will readily dissolve and disperse in the water. An insoluble material may remain intact and travel downstream as a concentrated slug. A material having a specific gravity of one will be suspended in the body of water. The material will float if its specific gravity is less than one, and sink it its specific gravity is greater than one. This tendency to float or sink can be very important when determining how to contain or remove a material from a body of water.

To help characterize the dispersion of a material in surface water, the volume and flow rate of the body of water should be known. That information, along with the amount of substance released, permits a good estimate of its dispersion pattern.

The movement of materials that sink will be affected by other physical characteristics of the stream in addition to flow rate. The presence of natural barriers (i.e. dams, sandbars, large rocks, fallen trees) will inhibit a uniform dispersion of the contaminants along the stream bed and may facilitate containment.

3. Soil and Underlying Rock

A material spilled or released into the environment may enter the soil and be dispersed both vertically and horizontally. A solid must be dissolved or suspended in a liquid to be transported into the subsurface. An insoluble solid can be broken into smaller pieces or particulates and be dispersed by wind. Eventually, these particles may find their way into the soil.

A liquid spilled onto the ground may penetrate the soil and disperse quickly if it has low viscosity. A liquid with a higher viscosity, such as motor oil, may take many years to disperse a few feet in the ground as it tends to adhere or "stick to" soil particles. The solubility of the liquid also affects the rate of dispersion. Highly soluble materials will disperse more rapidly. Substances can also have an affinity for soil particles due to their physical/chemical properties (e.g. dioxin).

The type of soil can directly control the rate and degree of infiltration of a chemical. Less permeable geologic formations such as clay slow down penetration rates and can alter the direction of dispersion. Solution channels, fractures and faults in the rock can further alter dispersion pathways. Rates of groundwater flow and subsequent contaminant dispersion in unconsolidated formations (sand, gravel, clay) depend upon the permeability of each formation.

4. Groundwater

Eventually, a chemical introduced to the soil may reach groundwater. How that chemical disperses in groundwater is based on its chemical and physical characteristics such as solubility, Ph, temperature and specific gravity, as well as the chemistry and hydrology of the area. Some behavior patterns in groundwater are similar to those in surface water, however the rate of dispersion in groundwater is generally much slower. The nature of groundwater flow tends to be laminar (streamlined and even) whereas surface water flow is more turbulent. Also, fluids in groundwater must flow around individual particles in the geologic formation whereas surface water flow is relatively unimpeded. The combination of these factors results in slower dispersion in groundwater.

The hydrology of the area is dependent upon subsurface strata, topography, and source of water. The depth to groundwater is variable and is influenced by local geology and local rate of groundwater recharge. The proximity to bodies of water also influences location, velocity, and direction of groundwater flow. Groundwater and bodies of surface water can interact directly. Streams and lakes can be fed by groundwater discharge in addition to surface runoff from precipitation.

D. Fate of chemicals in the environment

Knowing how a chemical disperses is essential. Even more important is to be able to predict where the chemical is transported to at the end of a specified tie period, how it affects the environment, and what are its potential impacts to human health. Being aware of the ultimate fate of chemicals in the environment helps prevent adverse effects by facilitating effective management of the problem. The following sections describe potential fates of chemicals in the environment.

1. Dilution and Degradation

Once a chemical enters and interacts with the environment it may undergo physical and/or chemical changes, such as dilution or degradation, so that either its concentration is diluted or its chemical composition is altered irreversibly. Dilution may reduce the potential threat to human health and the environment. A change in chemical composition (that is, the formation of a new chemical) may or may not reduce the impact on human health. A new chemical may be formed that is either more or less toxic than the original chemical.

2. Environmental Isolation

Another scenario is environmental isolation of a chemical. Once released, the material may not be able to disperse readily due to the transport limitations of the setting. A chemical introduced into an environment that has severely restricted flow patterns may not be able to move anywhere after its initial introduction. In this case, the chemical's potential hazard to human health may be localized.

3. Chemical Transport

Chemicals which persist in the environment are those which resist degradation. Barring environmental isolation, persistent chemicals will be transported. Persistent chemicals which are toxic or produce adverse effects when present at certain concentrations are of great concern. Their pathways should be well defined, based on their inherent properties and the setting in which they are released.

The most direct pathway to humans is by atmospheric dispersion. Some substances can be easily dispersed in the air and eventually be inhaled.

Winds can carry contaminated air a great distance before the contaminant is diluted to a safe concentration.

Direct consumption of contaminated water is another exposure path for humans. Contaminated streams or wells should be identified and their use as a drinking water source halted. If a persistent chemical is released and finds its way into a storm sewer or sanitary sewer, problems may result. A storm sewer may lead to a stream which is used for drinking water. Hazardous chemicals in a sanitary sewer system can render the treatment system inoperable.

Chemicals which are allowed to disperse in the environment may eventually enter the food chain. A chemical entering a lake or stream may be ingested by a fish, which may become sick or die. If the chemical accumulates in the fish and that fish is caught and eaten, the chemical is ingested in a concentrated form. If a chemical is spilled on a field, vegetation can take up the chemical and accumulate it. If an animal eats a large amount of the contaminated vegetation, the person consuming that animal will also be ingesting a food source containing an increased concentration of that chemical. The effects of the contaminant may be immediate and severe unless the chemical is excreted or inactivated.

Chemicals released at a hazardous waste site or spill may cause adverse impacts on humans and the environment. Prevention of such damage requires immediate action. All potential pathways of dispersion must be identified. Overlooking just one can have severe repercussions. Pathways can be properly evaluated only if the behavior of the chemical is known and a thorough description of the setting is available.

INFORMATION RESOURCES

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. Recognize the various response reference resources available for use in the field at hazardous materials incidents/accidents

2. Recognize the various information resources available in the field for use at hazardous materials incidents/accidents

3. Describe the use of computer databases in emergency response

4. List five reference books that could be included in a basic reference library.

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

NOTES

INFORMATION RESOURCES

TP-1

U.S. DOT EMERGENCY RESPONSE GUIDEBOOK

- Useful in identifying hazardous materials involved in transportation incidents
- Contains an indexed listing of identification numbers (UN/NA)
- Contains an indexed listing of DOT regulated materials

TP-2

U.S. DOT EMERGENCY RESPONSE GUIDEBOOK (cont.)

- Emergency action guidelines are provided for indexed listings
- Guidelines summarize potential health and fire hazards

TP-3

NOTES

HAZARDOUS MATERIALS IN SURFACE TRANSPORTATION

- Commodity-specific emergency response information for each hazardous material regulated by DOT
- Enviromental considerations:
  - Land and water spills
  - Air emissions

TP-4

HAZARDOUS MATERIALS IN SURFACE TRANSPORTATION (cont.)

- Standard transportation commodity codes (STCC)
- DOT identification numbers

TP-5

NIOSH POCKET GUIDE

- Organized, concise, alphabetical format
- Physical/chemical properties of 398 chemicals
- Carcinogen listing
- Identifies IDLH

TP-6

NOTES

NIOSH POCKET GUIDE (cont.)

- Chemical incompatibilities/reactions
- Trade names and synonyms
- Health hazard data
- Respirator selection criteria
- Ionization potential

TP-7

EMERGENCY ACTION GUIDE

- Chemical emergency planning information
- Accident assessment
- Evacuation recommendations

TP-8

EMERGENCY ACTION GUIDE (cont.)

- Personal protective clothing requirements
- General spill site safety precautions
- Subscription Action Guide updates for chemical data sheets

TP-9

NOTES

CHEMICAL HAZARD RESPONSE INFORMATION SYSTEM

- Volume 1
  - Condensed Guide to Chemical Hazards
  - First responders
- Volume 2
  - Hazardous Substance Data Manual
  - The most useful of the manuals

TP-10

CHEMICAL HAZARD RESPONSE INFORMATION SYSTEM (cont.)

- Volume 3
  - Hazard Assessment Handbook
- Volume 4
  - Response Methods Handbook

TP-11

FIRE PROTECTION GUIDE ON HAZARDOUS MATERIALS

- Hazardous chemical data - health, fire, and reactivity hazards for approximately 325 chemicals (49)
- Fire hazard properties of flammable liquids, gases, and volatile solids (325M)
  - Greater than 1300 substances
  - Alphabetical order

TP-12

FIRE PROTECTION GUIDE ON HAZARDOUS MATERIALS (cont.)

- Manual of Hazardous Chemical Reactions (491M)
  - 3550 reactive mixtures of two or more chemicals in alphabetical order
- Recommended system for implementation of fixed facility hazard marking (704M)

TP-13

FARM CHEMICAL HANDBOOK

- Provides information on farm chemicals used in the United States
- Published annually
- Compounds listed by chemical and trade names

TP-14

CONDENSED CHEMICAL DICTIONARY

- Chemical compounds, raw materials, and processes
- Physical/chemical properties
- Health hazards, brief description
- I.D. by trade name of many products used in the chemical industry

TP-15

NOTES

DANGEROUS PROPERTIES OF INDUSTRIAL MATERIALS "SAX"

- Hazard description for 18,000 industrial and laboratory materials
- Emphasis on toxicological information
- Synonyms
- First-aid information

TP-16

RAPID GUIDE TO HAZARDOUS CHEMICALS IN THE WORKPLACE

- Provides information on 700 common chemicals
- Synonym listing provides information on over 1000 chemicals
- Condensed and limited information

TP-17

INFORMATION SOURCES

- U.S. Geological Service survey maps
- On-line computer systems
- Aerial photography
- Remote sensing

TP-18

NOTES

INFORMATION SOURCES (cont.)

- Technical assistance organizations
  - IRAP
  - U.S. Coast Guard National Strike Force
  - U.S. EPA Emergency Response Team
  - CHEMTREC
  - CHLOREP
  - Pesticide Safety Team Network
  - TEAP

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INFORMATION RESOURCES

I. INTRODUCTION

Many reference texts and organizations can provide response personnel with technical data and physical assistance regarding both the hazards associated with an incident and methods to deal with them. It is necessary to be aware of these resources and know how to use them.

The information, which may include data on sites, topography, meteorology, physical/chemical properties of the material, applicable treatment methods, and available cleanup resources, can be provided by various agencies, maps, reference books, and manuals. It is advisable to get data from at least two sources and use the latest edition of any reference, especially when searching for hygienic standards or toxicological data.

Access to on-line computer files may be possible at the site if a telephone, portable terminal, and 120-volt outlet are available. Aerial photographs can also provide useful information when properly interpreted.

II. BASIC REFERENCES

A. A Compendium of Superfund Field Operations Methods: Developed by the U.S. EPA Office of Emergency and Remedial Response, EPA/540/P-87/001.

The compendium was written primarily to assist the site manager as he/she conducts site investigations and assessments. It discusses record keeping, site safety, sampling, laboratories, geology, hydrology, quality assurance and a number of other important topics. The information is presented in an easy to understand format, but is not arranged for quick reference (an index is not included).

B. CHRIS: Chemical Hazard Response Information System, developed by the U.S. Coast Guard. Access through the National Response Center, telephone 800/424-8802.

CHRIS consists of four manuals, a regional contingency plan, a Hazard Assessment Computer System (HACS), and an organizational entity at Coast Guard Headquarters. Volume 1 (CG-446-1) is designed to be used by the first responders at an incident. Volumes 2, 3, and 4 (CG-446-2, CG-446-3, and CG-446-4, respectively) are intended for use by the On-Scene Coordinator's (OSC) office along with the Regional and National Response Centers. Main Coast Guard stations will usually have these manuals.

1. Volume 1: Condensed Guide to Chemical Hazards

   Volume 1 is intended for use by the first responders on the scene of an incident. The chemicals involved must be known, however, before the appropriate information can be obtained from the manual. This volume also contains a list of questions needed to access Volume 3. All information in this volume can be found in Volume 2.

2. Volume 2: Hazardous Substance Data Manual, (also available from the U.S. Government Printing Office, Washington, DC 20402, GPO stock number 050-012-00147-2)

   Volume 2 is probably the most useful in responding to spills/ waste sites. It contains information on hazardous chemicals shipped in large volume by water and is intended to be used by port security personnel and others who may be first to arrive at the scene. The easily understood information regarding chemical, physical, and toxicological properties can help quickly determine the actions to be taken immediately to safeguard life, property, and the environment.

C. Condensed Chemical Dictionary, Gessner G. Hawley, Van Nostrand Reinhold Co., 135 W. 50th St., NY, NY 10020

This book, a compendium of technical data and descriptive information covering many thousands of chemicals and reactions, is designed for use in industrial situations and can be helpful in assessing a hazardous waste site or spill. However, information pertaining to environmental behavior of chemicals is limited and can be misleading. Three distinct types of information are presented:

1. Technical descriptions of compounds, raw materials, and processes.

2. Expanded definitions of chemical entities, phenomena, and terminology.

3. Description or identification of a wide range of trade-name products used in the chemical industry.

D. Dangerous Properties of Industrial Materials, edited by N. Irving Sax, Van Nostrand Reinhold, Co., 135 W. 50th St., NY, NY 10020

This book provides a single source of concise information on the hazards of nearly 13,000 common industrial and laboratory materials. Descriptive information and technical data are given in the three sections of the book. The main section "General Information" is designed to expedite retrieval of hazard information. The three sections are:

1. "General Information": synonyms, description, formula, physical constants.

2. "Hazard Analysis": toxicity, fire hazard, explosive hazard.

3. "Countermeasures": handling, storage, shipping, first aid, firefighting, personnel protection.

This book is not intended for use on site. It can be useful later, however, to verify hazards associated with the emergency.

E. Documentation of the Threshold Limit Values (TLV®), ACGIH Publications Office, 6500 Glenway Avenue, Building D-5, Cincinnati, OH 45211

This reference includes pertinent scientific information about each substance with references to literature sources used to determine each TLV. Each documentation also defines the type of toxic response for which the limit is used. This book should be consulted for a better understanding of TLVs.

F. Emergency Action Guidesheets, Hazardous Materials Systems, Association of American Railroads, 50F Street, NW; Washington, DC, 20001.

Contains detailed information on the 134 hazardous commodities most often shipped by volume. The commodities listed make up 95% of all hazardous material shipments, by volume, in North America. The book is available either on Tyvek, or paper.

G. Emergency Handling of Hazardous Materials in Surface Transportation, Hazardous Materials Systems, Association of American Railroads, 50 F Street, NW; Washington, D.C. 20001.

Provides commodity specific response information for over 3,900 hazardous materials. The book also includes emergency environmental mitigation procedures for each EPA-named hazardous substance. This book is considered one of the standards used by emergency response personnel for dealing with incidents involving hazardous materials.

H. U.S. Dot Emergency Response Guidebook: developed under the supervision of the Office of Hazardous Materials Transportation, Research and Special Programs Administration, U.S. Department of Transportation.

The guidebook is intended to assist first responders in making informed judgements during the initial phases of a transportation incident involving hazardous materials. It lists the UN/NA numbers designated for hazardous materials, identifies potential hazards associated with the materials and recommends emergency actions to be taken following a spill. It also makes recommendations as to when areas should be evacuated or isolated in the event of a spill. The guidebook is available through UNZ&CO, 190 Baldwin Avenue, Jersey City, NJ 07306.

I. Farm Chemical Handbook, Meister Publishing Company, 37841 Euclid Avenue, Willoughby, OH 44094.

This reference provides information on pesticides and chemicals used in agriculture. It also provides information by both generic and trade names.

J. Firefighters Handbook of Hazardous Materials, Maltese Enterprises, Inc., 8309 W. Morris Street, Indianapolis, IN 46231, 317/243-2211.

Provides chemical and physical properties of common and brand name chemicals. The potential hazards and immediate action for chemicals are cross-referenced under the "Remarks" column. The immediate action guidelines provide general recommendations for the hazard; actions to be taken in the event of a fire, spill or leak; and general first aid information.

K. Fire Prevention Guide on Hazardous Materials, National Fire Protection Association (NFPA), Quincy, MA 02269

The four NFPA documents that make up this guide can be used to identify the hazardous properties of most of the chemicals in commercial use today, as well as many that are available in laboratory sample quantities. These four sections present information on:

1. Hazardous Chemicals Data NFPA 49 1991 Edition

   Data for approximately 325 chemicals on their health, fire and reactivity hazards. Recommendations on storage and fire fighting. Hazard index markings (see NFPA 704) for all entries. Chemicals arranged alphabetically by DOT shipping names. Common names are listed by a cross-reference index at the end of the document.

2. Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids NFPA 325M 1991 Edition

   The fire hazard properties of more than 1,300 flammable substances are listed alphabetically by chemical name. The values selected are representative figures suitable for general use. Hazard index markings (see NFPA 704) are included for most entries.

3. Manual of Hazardous Chemical Reactions NFPA 491M 1991 Edition

   Includes 3,550 mixtures of two or more chemicals reported to be potentially dangerous in that they may cause fires, explosions, or detonations at ordinary or moderately elevated temperatures. Arranged alphabetically by chemical name. Reactions referenced.

4. Recommended System for the Identification of The Fire Hazards of Materials NFPA 704 1990 Edition

This identification system simplifies determining the degree of health, flammability, and reactivity hazard of materials. The system also permits identification of reactivity with water, radioactivity hazards, and fire control problems.

This manual presents a large amount of information, but deals with pure chemicals, not mixtures. Some experience is required to interpret the manual properly.

L. GATX Tank Car Manual, General American Transportation Corporation, 120 S. Riverside Plaza, Chicago, IL 60606.

This reference provides information on railroad tank car shape, design and DOT specifications. Also, the common materials carried in each type of railcar.

M. Handbook of Chemical Property Estimation Methods: by Warren J. Lyman, William F. Reehl and David H. Rosenblatt, published by McGraw-Hill Book Company, New York, NY.

This handbook is designed to assist environmental scientists in estimating the fate of specific chemicals when they are released into the environment. The properties covered by this book include a variety of conventional properties of pure materials such as density, boiling point, and refractive index, and some properties that describe how a chemical behaves with a second substance. The fate of trace concentrations of certain chemicals in specific environmental situations is also discussed.

N. Handbook of Environmental Data on Organic Chemicals: by Karen Verschueren, published by Van Nostrand Reinhold Company, Inc. 115 Fifth Avenue, New York, NY 10003.

This handbook provides information on: properties of organic chemicals; air pollution factors; water pollution factors; and biological effects. Where entries are not complete, it may be assumed that no reliable data were provided by the references utilized. The author uses numerous abbreviations which are explained in the first section of the book. Individuals who are not familiar with the abbreviations will find themselves referring to the first section frequently in order to understand listings of specific chemicals.

O. Handbook of Reactive Chemical Hazards: by L. Brethrerick, published by Butterworths of London.

The information presented on reactive hazards is of two main types, specific or general, and these types of information have been arranged differently in their respective separate sections. Specific information on instability of individual chemical compounds, and on hazardous interactions of elements and/or compounds,

is contained in the main formula-based section of the handbook. General information relating to classes or groups of elements or compounds possessing similar structural or hazardous characteristics is contained in a separate section. Both theoretical and practical hazard topics, are included.

P. Hazardous Materials Injuries: A Handbook for Prehospital Care, Bradford Communications Corp., 7500 Greenway Center Drive, Greenbelt, MD 20770.

This reference provides information on prehospital care. The handbook is set-up similar to the US DOT Guidebook.

Q. The Merck Index, Merck and Co., Inc., Rahway, NJ 07065

The Merck Index is a comprehensive, interdisciplinary encyclopedia of chemicals, drugs, and biological substances. It describes 9,856 chemicals in a structured format. An extensive index and cross index make the manual easy to use. It is designed to serve a variety of purposes. For response personnel, it provides information on physical/chemical properties of chemicals and their toxicity.

R. National Institute of Occupational Safety and Health

1. NIOSH Pocket Guide to Chemical Hazards, U.S. Government Printing Office, Washington, DC 20402

   Information in this pocket guide comes from the NIOSH/OSHA Occupational Health Guidelines. Presented in a tabular format, it is a reference for industrial hygiene and medical surveillance practices. Included are chemical names and synonyms, permissible exposure limits, chemical and physical properties, signs and symptoms of overexposure, environmental and medical monitoring procedures, recommended respiratory and personal protective equipment, and procedures for treatment.

2. NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards, U.S. Government Printing Office, Washington, DC 20402

   This three-volume document provides technical data for most of the substances listed in the "NIOSH/OSHA Pocket Guide". The information is much more detailed and is designed primarily for use by industrial hygienists and medical surveillance personnel. In addition to the information found in the "Pocket Guide", "Occupational Health Guidelines" includes recommended medical surveillance practices, air monitoring and measurement procedures, protective equipment, and spill and disposal techniques.

S. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities: developed by NIOSH/OSHA/USCG/EPA, U.S. Government Printing Office, Washington, DC 20402.

This manual is a guidance document for managers responsible for occupational safety and health programs at inactive hazardous waste sites. It is intended for federal, state, and local officials and their contractors. It may be used: as a planning tool by government or private individuals; as a management tool by upper level or field managers; as an educational tool to provide a comprehensive overview of all aspects of safety and health protection at hazardous waste sites; or as a reference document for site personnel who need to review important aspects of health and safety.

T. OHMTADS: Oil and Hazardous Materials Technical Assistance Data System, developed by the EPA. Access through EPA Regional Offices.

OHMTADS is a computerized data retrieval system available in the form of a computer printout, manuals, or microfiche. For each of more than 1,000 oil and hazardous substances, there are 126 possible information segments on, for example, toxicity and associated hazards, personnel safety precautions, cleanup and disposal methods, materials handling, and fire fighting. However, not all information is available for all materials.

U. Rapid Guide to Chemical Hazards in the Workplace, edited by N. Irving Sax and Richard J. Lewis, Sr. Published by Van Nostrand Reinhold Company, 115 Fifth Avenue, New York, NY 10003.

This book provides a concise summary of the harmful health effects of almost 700 common chemicals. It also includes over 1,000 synonyms.

V. Registry of Toxic Effects of Chemical Substances, U.S. Government Printing Office, Washington, DC 20402.

This annual publication is sponsored by NIOSH and contains toxic dose data with references to source documents and major standards and regulations for 35,000 chemicals.

III. TECHNICAL ASSISTANCE:

Technical assistance is available from many sources and in a variety of forms. Listed below are on-line databases, where you can dial into a host-computer and search for information and database services where you call and ask someone to search their computer for you. Addresses and phone numbers of several access providers are listed at the end of this section.

A. On-line Databases

1. The Alternative Treatment Technology Information Center (ATTIC):

ATTIC is a comprehensive automated information retrieval system that integrates existing hazardous waste data sources into a unified, searchable resource. Through ATTIC the user will be able to central resource to collect information on various hazardous waste treatment technologies. ATTIC contains several resident databases such as the RREL Treatability Database, and the Hazardous Waste Collection Database. Attic can also access the Record of Decision (ROD) Database, the OSWER Bulletin Board and EPA DIALCOM system for access into E-Mail. At present, over 600 technical reports have been evaluated, summarized, and entered into the ATTIC system. Presently, the system is distributed on floppy diskette. In December '90, the full system should be accessible by modem.

2. Chemical Evaluation Search and Retrieval System (CESARS):

Contains toxicological data on approximately 195 chemicals. Data items covered include physical and chemical properties, toxicity, carcinogenicity, mutagenicity, teratogenicity and environmental fate. This database is updated on a quarterly basis. The data are obtained from literature, textbooks, journals, documents and computerized information searches.

3. Chemical Information System (CIS):

This data base provides cross-reference to all citations of a chemical or class of chemicals cited in the Federal Register (FR) since January 1, 1978. Each mention of a substance in the Register results in a citation in the data base, with a description of the FR article as it concerns the cited substance or substances, the agency or agencies involved, the actions being taken or proposed, significant dates and the affected section of the CFR (Code of Federal Regulations).

4. Chemical Regulations and Guidelines System (CRGS):

CRGS provides an index to U.S. Federal regulatory material on the control of chemical substances and covers federal statutes, promulgated regulations, available federal guidelines, standards and support documents. CRGS follows the regulatory cycle and includes an up-to-date reference to each document, including main documents and revisions published in the Federal Register. Each chemical cited in a regulatory document is indexed by name, CAS Registry Number and a chemical role tag. The latter shows the context in which the substances appear in the document. Citations show publication title, date, abstract, index terms and chemical identifiers.

5. Dataport Bulletin Board:

Dataport is an electronic bulletin board system (BBS) operated by EPA's Environmental Response Team (ERT). The purpose of Dataport is to serve as a means of communications and information transfer among OSC's, RPM's and other Superfund response personnel. Dataport serves as a forum for exchanging technical information such as computer programs used in the field, EPA Standard Operating and Safety Guidelines and chemical information databases.

6. Hazard Assessment Computer System (HACS):

HACS is the computerized version of the CHRIS manual which makes it possible to obtain very detailed hazard evaluations through the computer at Coast Guard Headquarters. 1-800-424-8802.

7. HAZARDLINE:

HAZARDLINE contains regulatory, health, and precautionary data on about 5000 hazardous chemicals. Users can retrieve data on specific chemical substances by searching on various criteria, including chemical name, synonym, keyword, chemical formula, CAS Registry Number, RTECS NUMBER, DOT UN/PLACARD number or symptoms of exposure. HAZARDLINE includes a chemical database and the Material Safety Data Sheets system developed for the Occupational Safety and Health Administration (OSHA). In addition, it includes the Environmental Health Newsletter. It contains extensive information on regulatory requirements and first responder guidance such as protective clothing and respiratory protection. Sources of data include OSHA and EPA standards and regulations, National Institute of Occupational Safety and Health (NIOSH) criteria documents, important and relevant court decisions and selected relevant standards and guidelines from such other organizations as the American National Standards Institute (ANSI).

8. ICI/ICIS/CIS:

Information Consultants, Inc.'s Chemical Information System (ICIS) and Chemical Information System, Inc.'s (Fein Marquart Associates) System (CIS) are two competing companies which offer approximately 35 databases each, some similar, others different. Databases available for searching include, for example: Oil and Hazardous Materials Technical Assistance Data Systems (OHMTADS); Registry of Toxic Effects of Chemical Substances (RTECS); Chemical Carcinogenesis Research Information System (CCRIS); GENETOX with genetic assay studies; AQUIRE with aquatic toxicity information; DERMAL with dermal toxicity information.

9. Integrated Risk Information System (IRIS):

The EPA developed IRIS to assist in risk assessment and risk management activities. IRIS is an on-line database of chemical specific risk information the relationship between chemical exposure and estimated human health effects. The database presents a summary of information on chemical hazard identification and dose-response assessment, and provides quantitative risk values and qualitative health effects information. The quantitative risk values and supporting explanations are based upon available studies on a substance and have been reviewed and agreed upon by scientists from across the Agency. Currently IRIS includes over 380 chemical risk summaries. The database is updated monthly.

10. National Pesticide Information Retrieval System (NPIRS):

NPIRS contains information on about 60,000 pesticide products registered by the EPA and with U.S. state agencies that have registration programs. The system also covers some pest control products that have been canceled by the EPA and are no longer legally sold or used. Full text of the newsletters (since 1984) of the EPA Office of Pesticide Programs (OPP) are available. Also contains EPA fact sheets, providing summaries on a pesticide product formulation and Material Safety Data Sheets (MSDS) providing information on hazardous chemical substances. The system is soon to include EPA's Pesticide Data Management System Database which will contain information on 160,000+ different scientific studies and related documents submitted to EPA by companies seeking pesticide production registration.

11. Occupational Health Services Material Safety Data Sheets (OHSMSDS):

This database contains chemical and safety information required by OSHA for more than 75,000 substances. Includes substance identification, physical data, fire and explosion data, toxicity and health effects and spill and leak procedures.

12. Oil and Hazardous Materials - Technical Assistance Data System (OHM-TADS):

OHM-TADS was developed in 1971 by the EPA to aid spill response teams by providing rapid retrieval of chemical-specific resource information for the identification, containment, and disposal of oil and hazardous materials. The original emphasis was on harmful effects to water quality, but now all media and biota are included. It also provides general information about each chemical. It contains all types of chemical substances, with no exclusions, based on spill history, high volume production, exposure data and toxicity data. OHM-TADS data records contain 126 data elements and currently present 1,402 chemical profiles. The system has somewhat limited application given that the data is several years out of date.

13. Office of Solid Wastes and Emergency Response Bulletin Board (OSWER): The OSWER electronic bulletin board is intended to facilitate communications and the dissemination of information among EPA Regional staffs, OSWER headquarter and EPA's research laboratories. It includes specialized information in eight mini-bulletin boards. A few of these deal with field operations, QA/QC, groundwater, treatment methods, enforcement practices and risk assessment.

14. Scientific Parameters for Health and the Environment, Retrieval and Estimation (SPHERE):

    SPHERE was developed to support risk assessment of chemicals under Sections 4, 5, 6 and 8 of the Toxic Substances Control Act (TSCA). It contains three databases under its umbrella. AQUIRE deals with data pertaining to toxic effects of over 2500 chemical substances on aquatic organisms. DERMAL contains information on the qualitative and quantitative health effects of approximately 650 chemical substances administered to humans and test animals via the dermal route. GENETOX database includes those chemicals for which mutagenicity assays have been performed and published.

15. Studies on Toxicity Applicable to Risk Assessment (STARA):

    STARA has been created to aid in the development of risk assessment methodology and to facilitate the evaluation of potential public health dangers due to uncontrolled hazardous waste site releases and chemical spills. STARA focuses on toxicity studies containing quantitative as well as descriptive information on a test animal or human study group, exposure and type of effects. It is specifically designed for easy access by statistical routines and mathematical modelling programs. Thus, it is especially suitable for development on testing or risk assessment algorithms and extrapolation models.

16. Toxicology Data Network (TOXNET): A component of the National Library of Medicine's database, TOXNET is a computerized collection of toxicological oriented data banks. the TOXNET files include:

    Hazardous Substances Data Bank (HSDB) - A scientifically reviewed and edited data bank containing toxicological information and other data related to environmental, emergency, safety and handling and regulatory issues for over 4200 chemicals.

    Registry of Toxic Effects of Chemicals (RTECS) - RTECS contain toxic effects data on 90,000 chemicals. Both acute and chronic effects are covered and skin/eye irritation, carcinogenicity, mutagenicity and reproductive consequences.

Chemical Carcinogenesis Research Information System (CCRIS) - A scientifically evaluated and fully referenced data bank developed and maintained by the National Cancer Institute containing carcinogenicity, tumor promotion and mutagenicity test results for over 100 chemicals.

Toxic Release Inventory (TRI) - Contains information on the annual estimated releases into the environment and is based upon data collected by EPA on SARA Title III's form Rs.

Environmental Teratology Information Center Backfile (ETICBACK) - ETICBACK is a you database covering literature on teratology and developmental and reproductive toxicology. It contains approximately 46,000 citations to literature published from 1950 - 1988.

Environmental Mutagen Information Center Backfile (EMICBACK) - EMICBANK is a bibliographic database on chemical biological and physical agents that have been tested for genotoxic activity. It contains approximately 67,000 citations to literature published from 1950 - 1988.

Directory of Biotechnology Information Resources (DBIR) - DBIR contains information on a wide range of resources related to biotechnology. Among these are online databases and networks, publications, organizations, collections and repositories of cells and subcellular elements.

17. TSCA Initial Inventory and TSCA Plus: Contains information on the approximately 56,000 chemical substances in commerce in the U.S. covered in the Toxic Substances Control Act (TSCA) initial inventory published June 1, 1979. TSCA Plus includes the additional chemicals listed in the inventory since 1981.

B. Assisted Data Base Services and Microcomputer Services

1. Computer-Aided Management of Emergency Operations (CAMEO):

CAMEO is a computer program designed by the National Atmospheric and Oceanic Administration (NOAA) to help emergency planners and first responders plan for, and safely handle, chemical accidents. CAMEO II contains response information and recommendations for 2,629 commonly transported chemicals; an air dispersion model to assist in evaluating release scenarios and evacuation options; and several easily adaptable databases and computational programs that address the emergency planning provisions of Title II, the Emergency Planning and Community Right-To-Know Act of 1986.

2. Graphical Exposure Modeling System (GEMS):

GEMS supports exposure and risk assessments by providing access to single medium and multimedia fate and exposure models, physical/chemical property estimation techniques, and statistical analysis, graphics, and mapping programs with related data on environments, sources, receptors and

populations. Available model types include atmospheric, surface water, land unsaturated and saturated zones, and multimedia models.

3. Micro-Chemical Substances Information Network (CSIN):

The Micro-CSIN Workstation is designed to translate a user's request for bibliographic, factual/numeric, and/or chemical identification information into the proper form for interaction with a large number of commercial database vendors.

4. Occupational Safety and Health Administration Computerized Information System (OCIS):

OCIS is designed to aid OSHA, State OSHA and OSHA Area office staff in responding by maintaining quick access to various computerized information. Current OCIS files include Chemical Information File, Standards Interpretations File, Hazard Abatement File, Hazard Waste Site File, Federal Register Reference File and Memorandums of Understanding/Speeches.

C. Agencies (Public and Private)

1. Chemical Emergency Preparedness Program (CEPP): A toll free hotline to provide technical assistance for chemical emergencies; 1-800-535-0202.

2. Chemical Referral Center (CRC): The Chemical Manufacturers Association (CMA) makes available to the general public information that pertains to non-emergency health and safety related issues on chemicals. 1-800-CMA-8200.

3. Chemical Transportation Emergency Center (CHEMTREC):

The Chemical Manufacturers Association set up the CHEMTREC system to provide immediate assistance to those at the scene of an accident, 24 hours a day. CHEMTREC requires an immediate response and the manufacturer is unable to respond promptly, CHEMTREC can activate CHEMNET. CHEMNET is an industry wide mutual aid program established to provide chemical expertise at the scene of more than 77 chemical producers, their response teams, and more than 50 private contractor emergency response teams. It can also provide emergency responders with a product during emergencies. The HIT (Hazardous Information Transmission) program requires that response personnel be preregistered and have access to a personal computer with a modem and printer. CHEMTREC 1-800-424-9300.

4. CHLOREP/Chlorine Emergency Plan:

CHLOREP was established by the Chlorine Institute to handle chlorine emergencies in the U.S. and Canada. The system operates through CHEMTREC. Upon receiving an emergency call, CHEMTREC notifies the nearest manufacturer in accordance with a mutual aid plan. This

manufacturer then contacts the emergency response scene to determine if a technical team should be sent to assist. Each participating manufacturer has trained personnel and equipment available for emergencies.

5. Coast Guard National Strike Force (NSF):

The NSF is a part of the National Response Team. It consists of high seas oil cleanup equipment and trained personnel available to assist the OSC upon request during the containment and countermeasures phase, the cleanup, mitigation and disposal and the documentation and cost recovery phase of cleanup. Access through the National Response Center; 1-800-424-8801.

6. Environmental Photograph Interpretation Center (Regions I-IV); Environmental Monitoring and Support Laboratory (Regions V-X):

Aerial photography can provide a means to monitor facilities that produce or store chemicals. Once photographs have been interpreted, spill prevention personnel can use the results to inspect areas or facilities in a minimum amount of time because they can concentrate on those areas with the spill problem.

7. Environmental Response Team (ERT)

The National Contingency Plan directed EPA to establish the ERT to advise OSC's and Regional Response Teams on environmental issues related to spill containment, cleanup and damage assessment. The Team provides expertise in biology, chemistry and engineering of environmental emergencies. The Team is EPA's focal point for technical assistance to the Regions and Program Offices during emergency episodes involving hazardous substances. ERT is located in Edison, NJ and Cincinnati, OH. ERT is responsible for coordinating the Environmental Emergency Response Unit (EERU), a cooperative effort between the Team, the Office of Research and Development's Oil and Hazardous Materials Spills Branch and contractor personnel. Services available through the Response Unit include prototype spill control equipment such as the mobile flocculation/sedimentation system, contract laboratory analytical services and pilot plant treatment studies.

8. U.S. Department of Transportation (DOT):

A hotline was established to assist those requesting information on interpreting U.S. DOT regulations, as defined in Chapter 49 of the Code of Federal Regulations. 1-202-426-2975.

9. Interagency Radiological Assistance Plan (IRAP):

IRAP is designed to assist in coping with radiation emergencies. It operates through DOE, but works closely with other Federal, State, military and regional groups. If a spill or leak is serious, IRAP assistants will contact the

Nuclear Regulatory Commission (NRC). The main functions of the response team are to assess the hazard, inform the public, and recommend emergency actions to minimize the hazard. 1-800-424-9300.

10. Superfund and Resource Conservation and Recovery Act Information (CERCLA):

    EPA established the toll free technical assistance hotline in 1980 to answer questions and provide documents to those needing information on the Superfund and Resource Conservation and Recovery Act. 1-800-424-9346.

11. U.S. Geological Survey (USGS):

    The U.S. Geological Survey is responsible for using remote-sensing techniques to inventory, manage and monitor natural resources. This can provide a chronological overview of an area, thereby establishing the extent of damage over time. The U.S. Geological Survey also provides several types of maps: topographical, hydrological, land use and land cover.

IV. REMOTE SENSING AND MAP INTERPRETATION

A. Aerial Photography

1. Environmental Photograph Interpretation Center, Warrenton, VA 22186, telephone 703/557-3110 (EPA Regions I-IV).

   Environmental Monitoring and Support Laboratory, Las Vegas, NV 89114, telephone 702/798-2237 (EPA Region V-X).

   Aerial photography can also provide a means to monitor facilities that produce or store chemicals. Spill and spill-threat conditions that exist in many such facilities may also be photographically documented. Aerial photographers can assist with the monitoring of chemical facilities for compliance with the spill prevention regulations issued under the Federal Water Pollution Act as amended in 1977. Aerial reconnaissance missions effectively and economically augment compliance monitoring efforts of EPA Regions or other regulatory agencies. An airplane can fly over a large number of areas and facilities in a brief period of time. Once the photographs have been interpreted, spill prevention personnel can use the results to inspect areas or facilities in a minimum amount of time because they can concentrate on those areas with the spill problem.

2. EROS Data Center, User Services, Sioux Falls, SD 57198

   The EROS system, run by the U.S. Geological Survey, uses remote-sensing techniques to inventory, monitor, and manage natural resources. EROS includes research and training in the interpretation and application of remotely sensed data and provides these data at nominal cost.

At the heart of the EROS Data Center is a central computer complex which controls a data base of over 6 million images and photographs of the earth's surface features, searches for geographic data on areas of interest, and serves as a management tool for the entire data reproduction process. The computerized data storage and retrieval system is based on latitude and longitude, supplemented by information about image quality, cloud cover, and type of data.

Information received from the EROS Data Center can be used in much the same way as information received from the Environmental Monitoring and Support Laboratory. EROS data provide a chronological overview of an area, thereby establishing the extent of damage over time.

B. U.S. Geological Survey Maps

1. Topographic quadrangle maps

Topographic maps are useful in that they show the contours of the land, the network of water features, and elevations. They also show cities and urban areas and can be used to determine the proximity of a spill or waste site to a lake, river, stream, or population centers.

2. Hydrologic maps

Hydrologic maps show water in or beneath the land surface. They are very useful when evaluating water supply and water related hazards such as flooding. They also show drainage areas, depth to ground water, and the thickness of water bearing formations. In the case of a spill or waste site, a hydrologic map can indicate any possible contamination of the ground water and/or drainage area.

3. Land use and land cover maps

Land use and land cover maps have been prepared by using the standard topographic quadrangle maps or larger-scale low altitude aerial photographs as a base. These maps provide detailed information about the use of land or about the vegetation cover. This information could be useful at a spill or waste site. For example, if chemicals enter an area being used for crops, authorities should be advised of the chemical(s) involved and their possible effects.

4. Sources of maps

Maps are available in areas east of the Mississippi River, including Minnesota, Puerto Rico, and the Virgin Islands, from:

Branch of Distribution
U.S. Geological Survey
1200 South Eads St.
Arlington, VA 22202
Telephone: 703/557-2751

Maps of areas west of the Mississippi River, including Alaska, Hawaii, Louisiana, Guam, and American Somoa, available from:

Branch of Distribution
U.S. Geological Survey
Box 25286, Federal Center
Denver, CO 80225
Telephone: 303/234-3832

V. FEDERAL HAZARD COMMUNICATION STANDARD (HazCom)

A. In 1983, OSHA announced its Federal Hazard Communications Standard, 29 CFR 1910.1200, referred to as HazCom. The Occupational Safety and Health Administration administers this program. The law guarantees the right to information about hazardous chemicals in the workplace. This law is referred to as the "Right to Know" law.

The Federal Hazard Communication Standard, HazCom, establishes requirements in the following areas:

- Determining the chemical hazards in a workplace.
- Labeling chemicals that are hazardous.
- Maintaining Material Safety Data Sheets that provide information about the hazardous chemicals.
- Providing a written hazardous chemical training program.

1. Determining chemical hazards in a workplace

There are many different hazardous chemicals. HazCom groups hazardous chemicals into two (2) types: physical hazards and health hazards.

Chemicals that are physical hazards are flammable, corrosive, or reactive. Flammable chemicals can cause fires; corrosive chemicals can cause chemical burns; and reactive chemicals can cause explosions or release toxic fumes.

Chemicals that are health hazards are toxic chemical poisons. Overexposure to these chemicals can cause acute, or immediate, effects such as nausea or vomiting. Overexposure to some of these chemicals can cause chronic, or long-term, effects such as liver damage or cancer.

2. Labeling requirements

HazCom requires that all containers of hazardous chemicals entering or leaving the workplace must be labeled. The label must show the identity of the hazardous chemical, appropriate hazard warnings (i.e. flammable,

corrosive), and the name and address of the manufacturer, distributor or importer.

The label may also include picture symbols that help to identify the hazard and show the proper personal safety equipment to use when working with the chemical.

Labeling is also required for portable containers filled with chemicals from other containers. Tanks and other non-movable containers may be labeled by using the National Fire Protection Association (NFPA) fire diamonds or the Hazardous Materials Identification System (HMIS) labels.

3. Material Safety Data Sheets

Material Safety Data Sheets required by HazCom must contain the following information:

- The identity of the material
- Am emergency telephone number
- A list of hazardous ingredients
- Fire and explosion data
- Health hazard data
- Precautions for safe handling and use
- Proper employee protection measures

4. Written Training Program

Written training programs are required by HazCom. The training program details how a company intends to implement HazCom, and the type and kinds of training the company intends to conduct.

B. HazCom Identification Systems

Labeling for hazardous chemicals entering or leaving the workplace are governed by federal regulations. HazCom and Department of Transportation (DOT) regulations govern labels, placards, and warning signs for shipping hazardous chemicals.

Each of the different types of signs and labels serves a purpose. One type of chemical labeling are written warnings such as:

- Corrosive - Chemicals that cause chemical burns
- Flammable - Chemicals that can cause fires

- Toxic - Poisonous chemicals

- Oxidizer - Chemicals that support combustion

- Dangerous when wet - Chemicals that react with water and explode or produce toxic fumes

Another type of labeling is color coding. Three systems that are used in color coding are the National Fire Protection Association (NFPA), the Hazardous Materials Identification System (HMIS) and Department of Transportation (DOT).

1. NFPA 704 System (NFPA) labels are referred to as the fire diamonds because they are in the shape of a diamond. Four small diamonds make up a fire diamond label. The smaller diamonds are colored red, blue, yellow, and white. Numbers inside these diamonds are used to identify the severity of different types of hazards. The numbers range from "0" to "4". The higher the number, the more severe the hazard. For example:

    - The red diamond identifies the fire hazard. A "0" in the red diamond indicates that the material in the tank or vessel will not burn, while a "4" indicates that the material may explode when heated.

    - The blue diamond indicates a materials health hazard. A "0" indicated that a material is non-toxic, while a "4" indicates a material that can be lethal.

    - The yellow diamond indicates a materials reactivity. A "0" indicates a material that is non-reactive, while a "4" indicates a material that is unusable at normal temperatures.

    - The white diamond provides special information about a hazardous chemical. Letters or symbols are used instead of numbers to indicate the hazard. For example: COR in the white diamond indicates a corrosive, while a "W" with a line through it means no water, because the material reacts with water and explodes or produces toxic fumes.

2. The Hazardous Materials Identification System (HMIS) labels also use the colors red, blue, yellow and white and number 0 through 4. HMIS labels are rectangular, with the colors in horizontal stripes. As with the NFPA system, the red, blue, and yellow stripes indicate fire, health, and reactivity respectively, and higher numbers show more severe hazards. The white section is used to show the proper personal protection gear to be used when working with the hazardous chemical.

3. U.S. Department of Transportation (DOT) labels are similar to the picture symbols discussed earlier. DOT labels are color coded squares or diamonds that are attached to hazardous chemicals being shipped. Some examples of DOT labels are:

• Red	Flammable liquid or gas	Flame
• Yellow	Oxygen or oxidizer	Flame circled at base.
• Orange	Explosive	Explosion
• Green	Compressed gas	Gas cylinder
• Black & White	Corrosive/ Miscellaneous	Drops eating a hole in a person's hand/ vertical black and white stripes
• Blue	Dangerous when wet	Flame

U.S. DOT placards are fixed to the outside of the vehicles that carry hazardous chemicals. They are similar to the warning labels, but they may not carry a written warning. Instead, they may contain a four-digit number that is the United Nations identification code for that material being shipped.

APPENDIX I

REFERENCES AND RESOURCES

I. INTRODUCTION

This list provides the titles of references and organizations which may be of value to those responding to hazardous material incidents. Other resources are available which are not names here. This list can be expanded based on personal preferences and requirements.

The references are categorized by subject. The title, author, publisher, and place of publication are given for each. The year of publication is not always given because many are revised annually. The user should attempt to obtain the most recent edition.

The last section lists sources of these references as well as other information that might be useful. Usually, these agencies or associations will provide a catalogue on request. Where available, phone number are listed.

Items identified with an asterisk (*) may be particularly useful in "emergency response" situations.

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8. Handling Radiation Emergencies, Purington and Patterson, NFPA.

9. Hazardous Materials Injuries, A Handbook for Pre-Hospital Care, Douglas R. Stutz, Robert C. Ricks, Michael F. Olsen, Bradford Communications Corp., Greenbelt, MD.

10. National Safety Council Safety Sheets, National Safety Council, Chicago, IL.

11. NIOSH Certified Equipment List, U.S. Dept. of Health and Human Services.

12. Personal Protective Equipment for Hazardous Materials Incidents: A Selection Guide, NIOSH, U.S. Department of Health and Human Services.

13. Protecting Health and Safety at Hazardous Waste Sites: An Overview, U.S. Environmental Protection Agency.

14. Radiation Protection - A Guide for Scientists and Physicians, Shapiro, Jacob, Harvard University Press, Cambridge, MA.

15. Radiological Health Handbook, U.S. Dept. of Health, Education and Welfare.

*16. Radiological Health - Preparedness and Response in Radiation Accidents, U.S. Dept. of Health and Human Services.

17. A Review of the Department of Transportation Regulations for Transportation of Radioactive Materials, U.S. Department of Transportation.

*18. SCBA-A Fire Service Guide to the Selection, Use, Care, and Maintenance of Self-Contained Breathing Apparatus, NFPA, Batterymarch Park, Quincy, MA.

*19. Standard First Aid and Personal Safety, American Red Cross.

20. Underwriters Laboratories Testing for Public Safety, Annual Directory, Underwriters Laboratories, Inc., Northbrook, IL.

E. Planning Guides

1. Chemical Emergency Planning Program, U.S. EPA.

2. Detoxification of Hazardous Wastes, Exner, Jurgen H., Ann Arbor Science.

*3. Federal Motor Carrier Safety Regulations Pocketbook, (U.S. Dept. of Transportation) J.J. Keller and Associates, Inc.

4. Handbook for Remedial Action at Waste Disposal Sites, EPA 625/682-006 (June 1982).

5. Hazardous and Toxic Materials: Safe Handling and Disposal, Fawcett, H.H., John Wiley and Sons.

6. Hazardous Chemical Spill Cleanup, Noyes Datat Corporation, Ridge Park, New Jersey.

7. Hazardous Materials Emergency Planning Guide, National Response Team, U.S. Environmental Protection Agency, 401 M. Street S.W., Washington, DC 20460 (1987).

8. Hazardous Materials Spills Handbook, Gary F. Bennett, Frank S. Feates, Ira Wilder, McGraw-Hill Book Co., New York, NY.

9. Hazardous Waste Regulation - An Interpretive Guide, Mallow, Alex, Van Nostrand Reinhold Company.

10. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH/OSHA/USCG/EPA, U.S. Dept. of Health and Human Services, NIOSH.

11. Standard Operating Safety Guides, Environmental Response Branch, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency.

12. State Decision-Makers Guide for Hazardous Waste Management, SW 612, U.S. EPA (1977).

*13. 1984 Emergency Response Guidebook - Guidebook for Hazardous Materials Incidents, DOT P 5800.3 USDOT, Materials Transportation Bureau, Attn: DMT-11, Washington, DC 20590.

III. TECHNICAL INFORMATION AND POTENTIAL RESPONSE/INFORMATION SOURCES

1. Agency for Toxic Substances Disease Registry
   Centers for Disease Control
   Shamlee 28 S., Room 9
   Atlanta, GA 30333
   404/639-6360

2. American Conference of Governmental Industrial Hygienists
   6500 Glenway Avenue, Building D-5
   Cincinnati, OH 45211
   513/742-2020

3. American Industrial Hygiene Association
   475 Wolf Ledges Parkway
   Akron, OH 44311-1087
   703/849-8888

4. American Insurance Association (AIA)
   (National Board of Fire Underwriters)
   Engineering and Safety Service
   85 John St.
   New York, NY 10038

5. American National Standards Institute, Inc.
   1430 Broadway
   New York, NY 10018

6. American Petroleum Institute (API)
   1220 L Street N.W., 9th Floor
   Washington, DC 20005
   202/682-8000

7. American Society of Mechanical Engineering (ASME)
   United Engineering Center
   345 East 47th Street
   New York, NY 10017
   212/644-7722

8. ARMY ORDINANCE UNIT

9. Ashland Chemical Company
3849 Risher Road
Columbus, OH 43228
614/276-6143

10. Association of American Railroads (AAR)
50 F Street N.W.
Washington, DC 20001
202/639-2100

11. Association of American Railroads (AAR)
59 East Van Buren Street
Chicago, IL 60650

12. BOMB HANDLERS

13. Bureau of Explosives
American Association of Railroads
1920 L Street, N.W.
Washington, DC 20036
202/293-4048

14. Center for Disease Control
Atlanta, GA
404/633-5313

15. CHEMICAL INFORMATION

16. CHEMICAL RESPONSE INFORMATION

17. Chemical Manufacturer's Association
2501 M St. N.W.
Washington, DC 20037

18. CHEMISTS

19. Chemtrec
Washington, DC
800/424-9300

20. CIVIL DEFENSE CLEANUP CONTRACTORS

21. The Clorine Institute
342 Madison Avenue
New York, NY 10017

22. The Compressed Gas Association, Inc. (CGA)
500 Fifth Avenue
New York, NY 10036

23. CONSTRUCTION COMPANIES (HEAVY EQUIPMENT)

24. CRC Press, Inc.
2000 Corporate Blvd., N.W.
Boca Raton, FL 33431

25. DEPARTMENTS OF ENVIRONMENTAL QUALITY (STATE, LOCAL)

26. DEPARTMENT OF TRANSPORTATION (STATE)

27. Dow Chemical Company
Midland, MI 48640
517/636-4400

28. DuPont Company
1007 Market Street
Wilmington, DE 19898
302/774-7500

29. Energy Research Development Admin.
Albuquerque Office
Albuquerque, NM 87101

30. ENVIRONMENTAL PROTECTION AGENCY

31. EPIDEMIOLOGISTS

32. Factory Mutual Engineering Corp. Lab
1150 Boston-Providence Turnpike
Norwood, MA 02062
617/762-4300

33. The Fertilizer Institute (TFI)
1015 18th St., N.W.
Washington, DC 20036
202/861-4900

34. FIRE DEPARTMENTS

35. GAS COMPANIES

36. GATX RAIL CAR MFGR.
312/621-6200

37. HAZARDOUS MATERIALS EXPERTS

38. HAZARDOUS MATERIALS TEAMS

39. HEALTH DEPARTMENT

40. HIGHWAY DEPARTMENT

41. HOSPITALS

42. Institute of Makers of Explosives (IME)
420 Lexington Avenue
New York, NY 10017
212/986-6920

43. J. T. Baker, Inc
Phillipsburgh, NY 08856
908/859-2151

44. Kerr-McGee Chemical Corp.
Kerr-McGee Center
Oklahoma City, OK 73125
405/270-1313

45. LAW ENFORCEMENT AGENCIES

46. Mallinckrodf, Inc.
P.O. Box 5439
St. Louis, MO 63147
314/895-0123

47. Manufacturing Chemists Association, Inc.
1825 Connecticut Avenue N.W.
Washington, DC 20009

48. MANUFACTURERS REPRESENTATIVES

49. MOTOR CARRIER SAFETY

50. National Bureau of Standards
U.S. Department of Commerce
Washington, DC 20234

51. National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

52. National Institute for Occupational Safety and Health
Division of Technical Services
46765 Columbia Parkway
Cincinnati, OH 45226
513/684-8302

53. National Response Center (USCG and EPA)
800/424-8802

54. National Safety Council
444 North Michigan St.
Chicago, IL 60611

55. National Tank Truck Carriers, Inc.
1616 P St.
Washington, DC 20036

56. National Transportation Safety Board
800 Independence Avenue
Washington, DC 20594

57. NATX Rail Car Mfgr.

58. Occupational Safety and Health Administration
U.S. Department of Labor
Washington, DC

59. Oil and Hazardous Material Technical Assistance Data System
202/245-3045

60. Poison Control Center
Charleston, SC

61. PORT AUTHORITIES

62. PUBLIC INFORMATION MEDIA

63. PUBLIC WORKS

64. RADIOACTIVE MATERIAL HAULERS

65. Radiological Assistance Zone 3
Savannah River Operations Office
Aiken, SC 29801
803/725-6211, x3333

66. RADIO STATIONS

67. RAILROAD DIVISION SUPERINTENDENT

68. RAILROAD MATERIAL HANDLERS

69. RAILROADS

70. REGIONAL RESPONSE TEAMS

71. SANITATION AGENCIES

72. SHERIFF'S OFFICE

73. SHIPPER REPRESENTATIVES

74. STATE FIRE MARSHAL

75. STATE POLICE

76. STEVEDORING COMPANIES

77. STREET DEPARTMENT

78. STRUCTURAL ENGINEERS

79. Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402
202/783-3238

80. TELEVISION STATIONS

81. TOXICOLOGISTS

82. Underwriters' Laboratories
207 East Ohio St.
Chicago, IL 60611

83. Union Carbide Corp.
Linde Div.
51 Cragwood Road
S. Plainfield, NJ 07080

84. U.S. Army Explosive and Ordnance Disposal

85. U.S. COAST GUARD

86. U.S. DEPARTMENT OF AGRICULTURE

87. U.S. Department of Defense
Nuclear Accident Center

88. U.S. Department of Energy
Washington, DC 20545

89. U.S. Department of Transportation
Materials Transportation Bureau
Office of Hazardous Materials Operations
400 7th St. S.W.
Washington, DC 20590
202/366-4555

90. U.S. EPA
Office of Research and Development
Publications - CERI
Cincinnati, OH 45268
513/684-7562

91. U.S. EPA
Office of Solid Waste
(WH-562)
Superfund Hotline
401 M. St. SW
Washington, DC 20460
800/424-9346

92. U.S. Mine Safety and Health Administration
Department of Labor
4015 Wilson Blvd. Room 600
Arlington, VA 22203
703/235-1452

93. U.S. National Oceanic and Atmospheric Administration
Hazardous Materials Response Branch
N/OMS 34
7600 Sand Point Way, N.E.
Seattle, WA 98115
206/527-6317

94. U.S. Nuclear Regulatory Commission
Washington, DC 20555
301/492-7000

95. UTLX Rail Car Mfgr.
312/431-3111

96. UTILITIES

97. WASTE DISPOSAL COMPANIES

98. WATER COMPANIES

99. WRECKING COMPANIES

APPENDIX II

PROPERTIES AND REFERENCE SOURCES

PROPERTY	VALUE	SOURCE
Solubility	Useful in determining if the substance will mix with water.	EAG, NFPA, CHRIS, CCD
Vapor Density	Determines if the vapor will rise or fall in relation to air.	SAX/1, EAG, CCD, NFPA, NIOSH
Specific Gravity	Determines if the substance will float on the surface or sink in water.	SAX/1, EAG, CCD, CHRIS, NFPA
Boiling Point	Determines if the substance will be found as a gas or liquid.	NIOSH, EAG, CHRIS, CCD, NFPA, SAX/1
Melting Point	Determines if the substance will be found as a liquid or a solid.	NIOSH, EAG, CHRIS, CCD, MERCK
Flash Point	Most important indicator of relative flammability. Temperature at which sufficient vapors are produced to allow for momentary ignition if an ignition source is present.	NFPA, CHRIS, NIOSH, CCD, EAG, SAX/1
Ignition Temperature	The temperature at which a substance will ignite without the presence of an ignition source. Important when pyrophoric material are involved.	NFPA, CHRIS, CCD, EAG
Flammable Limits	Determines the degree of flammability hazard present. Includes LEL, UEL, and the flammable range.	NFPA, EAG, NIOSH, CCD, CHRIS
LD_{50}	Dose in mg/kg required to kill 50% of a test population.	SAX/1
LC_{50}	Concentration in ppm required to kill 50% of a test population.	SAX/1
LC_{LO}	The lowest concentration known to produce an adverse reaction.	SAX/1
TLV	Threshold Limit Value	SAX/1, SAX/2
IDLH	Immediately Dangerous to Life or Health	NIOSH

REFERENCE SOURCES

EAG	-	Emergency Action Guides, Bureau of Explosives
NIOSH	-	NIOSH Pocket Guide to Chemical Hazards
SAX/1	-	Dangerous Properties of Industrial Materials (N. Irving Sax)
SAX/2	-	Rapid Guide to Hazardous Chemicals in the Workplace (N. Irving Sax)
CCD	-	Condensed Chemical Dictionary
MERCK	-	Merck Index
CHRIS	-	Chemical Hazard Response Information System, U. S. Coast Guard

IDENTIFICATION OF HAZARDOUS MATERIALS

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. Describe the use of preplans in relation to buildings, property, and transportation routes

2. List six types of specification containers used in transportation of hazardous materials

3. Explain the use of U.S. Department of Transportation placards and labels in transportation of hazardous materials

4. Describe the NFPA 704M marking system and its use

5. List various types of shipping documents used in the transportation of hazardous materials by rail, air, water, and highway

6. Discuss the use of direct-reading instruments in determining the presence of hazardous materials

7. Explain the advantages and disadvantages of using the five senses to determine the presence of hazardous materials

8. List five clues used to determine the presence of hazardous materials.

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

- What protective clothing and equipment will be required for the responders as well as equipment operators?

- Will the product react with water or materials used for construction of dikes, retention structures, etc.?

- Will vapors accumulate after the product is controlled? Are the vapors corrosive, toxic, flammable, etc.?

- What are the physical limitations of the responders? Is it reasonable to ask five responders to dike spills of 1,000 gallons or more? Always consider the physical and psychological strain that they are under.

- What are the potential hazards to responders associated with fires or explosives at a hazardous materials incident?

V. SUMMARY

Controlling a release using confinement and containment measures requires response personnel to preplan the use of general control measures. Response personnel must be prepared, on arrival at the incident, to confine materials that have been released into the air, spilled on the land, into surface waters, and, sometimes, into groundwater. Personnel must also be prepared to contain materials that have been released by making sure that a variety of leak control tools and equipment is available on the response vehicle. When response personnel are prepared to confine and contain materials in an emergency, they are in the best position to mitigate (prevent or reduce) the incident's impact on public health, property and the environment.

REGULATORY OVERVIEW

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. Identify the major components of SARA Title I, Section 126, 29 CFR 1910.120 Paragraph Q, Emergency Response

2. Identify state and local government and industry requirements mandated by SARA Title III

3. Identify Title III planning requirements for both state and local committees and industry

4. Describe the benefits of SARA as they relate to safety in the field

5. Identify the mandated components of an emergency response plan

6. Describe the required procedure for handling an emergency response

7. Describe the necessity of an incident command system to direct emergency response

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

STUDENT PERFORMANCE OBJECTIVES (cont.)

8. State the mandated duties of the incident commander

9. Describe how skilled support personnel can be used during an emergency response

10. Describe the duties of specialists during an emergency response

11. Identify the various mandated levels of training, including the type of training for each level

12. Identify who must participate in a medical surveillance program and what an employer must do to maintain compliance

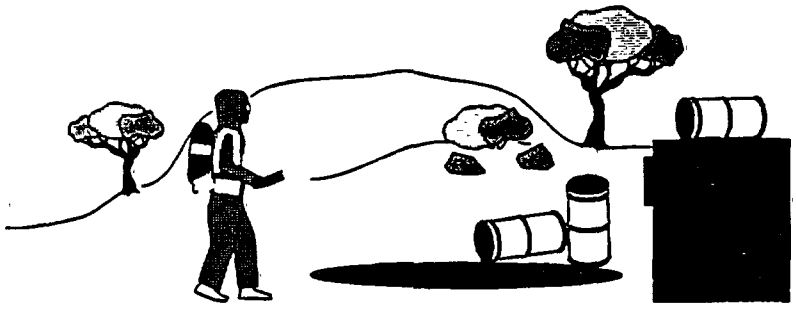
13. Describe the chemical protective equipment program mandated by 1910.120 Paragraph Q

14. Describe how the requirements mandated by 1910.120 Paragraph Q impact decisions regarding post-emergency operations.

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

NOTES

REGULATORY OVERVIEW
29 CFR 1910.120 (Q)



S-1

SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986

SARA

S-2

SUPERFUND AMMENDMENTS AND REAUTHORIZATION ACT OF 1986

I. Provisions relating primarily to reponse and liability

II. Miscellaneous provisions

III. Emergency planning and community right to know

IV. Radon gas and indoor air quality research

S-3

NOTES

SARA (cont.)

- Worker Protection Standards
  - Title I, Section 126, SARA
  - Codified in 29 CFR 1910.120

S-4

SARA (cont.)

- Emergency planning and community right to know, Title III SARA
  - State Emergency Response Commissions (SERC)
  - Local Emergency Response Committees (LEPC)

S-5

SARA (cont.)

- Emergency planning and community right to know, Title III SARA
  - Industry reporting of stored and used hazardous substances
  - Develop emergency response plans

S-6

NOTES

PARAGRAPH Q 29 CFR 1910.120

- Agencies engaged in emergency response to hazardous substance incidents regardless of location
- Section 303 of SARA
  - Comprehensive emergency response plan

S-7

EMERGENCY RESPONSE PLAN

- Develop and implement as a minimum
  - Pre-emergency planning
  - Personnel roles, lines of authority training, and communications
  - Emergency recognition and prevention
  - Safe distances
  - Site security

S-8

EMERGENCY RESPONSE PLAN (cont.)

- Evacuation procedures
- Decontamination procedures
- Emergency medical treatment
- Personal protective equipment
- Critique and response follow-up

S-9

NOTES

EMERGENCY RESPONSE PROCEDURES

- Incident command employed
- Incident commander required to:
  - Identify chemical and physical hazards
  - Address site analysis
  - Use engineering controls

S-10

EMERGENCY RESPONSE PROCEDURES (cont.)

- Incident commander required to:
  - Establish maximum exposure limits
  - Establish hazardous substance handling procedures
  - Use new technologies

S-11

INCIDENT COMMANDER

- Ensure:
  - Proper protective equipment used
  - When required, positive pressure breathing apparatus is used
  - Response personnel on scene kept to a minimum

S-12

NOTES

INCIDENT COMMANDER (cont.)

- Ensure:
  - "Buddy system" used on scene (two or more personnel)
  - Back-up personnel on standby
  - Advanced first aid personnel on scene with transportation

S-13

SAFETY OFFICIAL

- Incident commander appoints
- Safety official must identify and evaluate hazards
- Authority to alter, suspend, or terminate scene activities
  - Inform incident commander immediately; provide direction

S-14

INCIDENT COMMANDER

- Ensure:
  - Implement appropriate decontamination procedures
  - Exchange of SCBA air cylinders

S-15

NOTES

SKILLED SUPPORT PERSONNEL

- Specialized equipment operators
- Temporary support work
- Training requirements

S-16

SKILLED SUPPORT PERSONNEL (cont.)

- Initial briefing required
  - Use of personal protective clothing
  - Chemical hazards
  - Duties to be performed

S-17

SPECIALIST EMPLOYEES

- Work with specific hazardous substances
- Provide technical advice
- Demonstrate competency

S-18

NOTES

TRAINING

- Based on duties and functions
- Personnel hired after March 6, 1990

S-19

FIRST RESPONDER AWARENESS LEVEL

- Discover or witness incident
- Notify proper authorities

S-20

FIRST RESPONDER AWARENESS LEVEL (cont.)

- Sufficient training and experience to objectively demonstrate:
  - Understanding of hazardous materials and risks during response
  - Potential outcomes of response

S-21

NOTES

FIRST RESPONDER AWARENESS LEVEL (cont.)

- Recognize presence of hazardous materials
- Ability to identify hazardous materials
- Understanding of responder's role
- Recognize need for additional resources

S-22

FIRST RESPONDER OPERATIONS LEVEL

- Protection of nearby persons, property, or the environment
- Defensive response
- Confinement of release from safe distance

S-23

FIRST RESPONDER OPERATIONS LEVEL (cont.)

- At least 8 hours of training
- Sufficient experience to objectively demonstrate compentency of Awareness Level training

S-24

NOTES

FIRST RESPONDER OPERATIONS LEVEL (cont.)

- Agency to certify:
  - Knowledge of basic hazard and risk assessment
  - Selection and use of PPE
  - Basic hazardous materials terminology

S-25

FIRST RESPONDER OPERATIONS LEVEL (cont.)

- Perform basic control techniques
- Implement basic decontamination procedures
- Relevant standard operating procedures, and termination procedures

S-26

HAZARDOUS MATERIALS TECHNICIAN

- Respond to stop a release
- Perform advance control techniques
- Received at least 24 hours of training equal to Operations Level

S-27

NOTES

HAZARDOUS MATERIALS TECHNICIAN (cont.)

- Agency shall certify that the technician has the ability to:
  - Implement the agencies' emergency response plan
  - Use field instruments to classify, identify, or verify known or unknown materials present
  - Function within an assigned role in the agencies' ICS

S-28

HAZARDOUS MATERIALS TECHNICIAN (cont.)

- Agency shall certify that the technician has the ability to:
  - Select and use proper specialized personal protective equipment
  - Understand hazard and risk assessment techniques
  - Perform advance control, containment, or confinement techniques

S-29

HAZARDOUS MATERIALS TECHNICIAN (cont.)

- Understand and implement decontamination procedures
- Understand termination procedures
- Understand basic chemical and toxicological terminology and behavior

S-30

NOTES

HAZARDOUS MATERIALS SPECIALIST

- Support technicians
- Specific knowledge of various substances
- Act as liaison with local, state, and federal government officials
- Shall have minimum of 24 hours training equal to Technician Level

S-31

HAZARDOUS MATERIALS SPECIALIST (cont.)

- Agency shall certify the specialist has the ability to:
  - Implement the local emergency response plan
  - Use advanced survey instruments and equipment to classify, identify, and verify known and unknown materials onsite

S-32

HAZARDOUS MATERIALS SPECIALIST (cont.)

- Agency shall certify the specialist has the ability to:
  - Know the state emergency response plan
  - Select and use specialized chemical personal protective equipment
  - Understand in-depth hazard and risk assessment techniques

S-33

NOTES

HAZARDOUS MATERIALS SPECIALIST (cont.)

- Agency shall certify the specialist has the ability to:
  - Perform specialized control, containment, and confinement operations
  - Implement decontamination procedures
  - Develop a site safety and control plan
  - Understand chemical, radiological, and toxicological terminology and behavior

S-34

ON-SCENE INCIDENT COMMANDER

- Training for those who control scene beyond Awareness Level response
- Shall receive a minimum 24 hours of training equal to Operations Level

S-35

ON-SCENE INCIDENT COMMANDER (cont.)

- Must have competency in the following areas:
  - Know and implement agencies' ICS
  - Implement the agencies' ERP
  - Know the risks and hazards of employees working in chemical protective clothing
  - Implement the local ERP

S-36

NOTES

ON-SCENE INCIDENT COMMANDER (cont.)

- Must have competency in the following areas:
  - Knowledge of the state ERP
  - Knowledge of the federal regional response team
  - Know and understand the importance of decontamination procedures

S-37

TRAINERS

- Trainers of employees in categories Q-6 of the standard shall:
  - Satisfactorily complete training course
  - Have training or academic credentials
  - Possess a good command of subject matter

S-38

REFRESHER TRAINING

- Training pursuant to Q-6:
  - Sufficient content and duration to maintain competency
  - Employee to demonstrate competency at least yearly
  - Agency to make a written statement of the training or competency
  - Record of methodology

S-39

NOTES

MEDICAL SURVEILLANCE

- Members of organized and designated hazardous material teams
- Hazardous materials specialist
- Paragraph (f) of standard

S-40

MEDICAL SURVEILLANCE (cont.)

- Prior to response
- Every 12 months, unless physician approves longer interval
- Reassignment of duties or termination of employment
- Agency to provide examinations at no cost to employees

S-41

MEDICAL SURVEILLANCE (cont.)

- Signs or symptoms of possible overexposure to a substance or health hazard
- Injured or exposed above the PEL
- More frequent intervals as determined by physician

S-42

NOTES

CHEMICAL PROTECTIVE CLOTHING

- Compliance with Paragraph (g-35) of the standard
  - Selection based on known or potential hazards
  - Positive-pressure SCBA

S-43

CHEMICAL PROTECTIVE CLOTHING (cont.)

- Compliance with Paragraph (g-35) of the standard
  - Level A suits to be used when skin absorption possible
  - Level of protection to vary with conditions
  - Level A suit to protect from hazards

S-44

CHEMICAL PROTECTIVE CLOTHING (cont.)

- Personal protective equipment program
  - Equipment selection
  - Use and limitations of equipment
  - Work mission duration
  - Maintenance and storage

S-45

NOTES

CHEMICAL PROTECTIVE CLOTHING (cont.)

- Personal protective equipment program
  - Decontamination and disposal
  - Training and proper fitting
  - Donning and doffing procedures
  - Inspection procedures prior to, during, and after use

S-46

CHEMICAL PROTECTIVE CLOTHING (cont.)

- Personal protective equipment program
  - Evaluation of program
  - Limitations during temperature extremes, heat stress, appropriate medical considerations

S-47

POST-EMERGENCY RESPONSE

- Institute termination procedures
- Cleanup and removal of materials from scene; mandatory compliance with paragraphs (b) through (o) of standard
- Incident at facility

S-48

NOTES

WORKER PROTECTION STANDARDS

- Standard enforced by both OSHA and U.S. EPA
- Professional response

S-49

REGULATORY OVERVIEW

TITLE III - EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW

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B. EMERGENCY NOTIFICATION (SECTION 304) 3

C. COMMUNITY RIGHT-TO-KNOW REPORTING REQUIREMENTS (SECTION 311-312) 4

D. TOXIC CHEMICAL RELEASE REPORTING (SECTION 313) 5

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V. SUMMARY 7

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REGULATORY OVERVIEW

TITLE III - EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW

I. INTRODUCTION

Responding to a hazardous material emergency (or incident) requires executing many different activities in order to control the emergency and prevent or reduce loss of life, injury, property damage, or adverse environmental effects. The number of responders (and resources) needed varies considerably. From a few responders for a minor spill to many, representing local, state, and federal agencies as well as private industry, for a major incident. Regardless of the number needed, whether they can effectively achieve the goal of mitigating undesirable effects depends upon a number of factors. To a large degree, one factor primarily determines the success of a response - having a preestablished hazardous material emergency response plan.

A comprehensive, well-written plan, periodically reviewed and tested, helps prevent much of the confusion and chaos inherent in responding to incidents for which no preplanning exists. A plan allows required activities to commence without unnecessary delays caused by lack of organization, structure, leadership, resources, assistance, or technical expertise.

In addition to existing state and local laws and regulations concerning hazardous material emergencies, a relatively new federal environmental law, the Emergency Planning and Community Right-To-Known Act of 1986, known a Title III, requires the states to develop and coordinate state and local response organizations and preparedness plans for responding to hazardous material emergencies.

Four provisions of Title III are especially important to local responders.

- A planning committee comprised of representatives from the local community must be established to develop plans and organize resources for responding to chemical accidents.

- Facilities that manufacture, use, store, or otherwise possess quantities of designated chemicals above minimum levels must identify and give information concerning the hazardous properties of these substances to the local emergency planning committee and to the fire department.

- Facilities must immediately notify local and state authorities of a release of more than a predetermined amount of designated chemicals.

- Upon request of the fire department, the owner/operator of a facility must permit access to the facility by the fire department to conduct on-site inspections of the facility.

II. SUPERFUND REAUTHORIZATION AND AMENDMENTS ACT

In 1986, the Superfund Reauthorization and Amendments Act, (SARA) was passed. SARA reauthorized and amended the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, the major law establishing the role and responsibilities of the federal agencies for responses to hazardous materials accidents and clean-up of abandoned, hazardous waste sites. The reauthorization of CERCLA provided for the continuation and revision of the federal government's own plan for responding to hazardous material emergencies - the Oil and Hazardous Substances Contingency Plan. Also included in SARA were five titles (each a free-standing statutory provision or law). Of these, Title III has a direct impact on state and local emergency response planning for hazardous material emergencies.

III. TITLE III - EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT OF 1986

Title III mandates that state and local governments establish an organization, prepare emergency plans, identify resources, and provide training for emergency responders. Its intent is to improve the local and state capability for planning, preparing, and responding to chemical emergencies and to provide for a more coordinated local, state, federal approach to hazardous material emergency response.

Title III has four major sections:

A. Emergency Planning (Section 301-302)

The Governor of each state must designate a State Emergency Response Commission (SERC) which should have broad based representation from state agencies, the public as well as the private sector. The SERC is to designate emergency planning districts and appoint Local Emergency Planning Committees (LEPC). Membership of the LEPC must include elected State and local officials, police, fire, civil defense, public health professionals, environmental, hospital, and transportation officials as well as representatives of facilities subject to the emergency planning requirements, community groups, and the media.

It is the responsibility of the SERC to coordinate local planning efforts and to insure that facilities and the local community comply with Title III requirements.

The LEPC is responsible for preparing an emergency response plan which must, as a minimum:

- Identify facilities and extremely hazardous substances transportation routes.
- Designate a Local Emergency Coordinator and facility coordinators(s).

- Establish emergency notification procedures.
- Provide emergency response training to local personnel who may be called upon to mitigate a chemical release.
- Provide methods for determining the occurrence of releases and the probable area affected area and population.
- Describe the community's and industry's emergency equipment and facilities and identifying the persons responsible for them.
- Prepare evacuation plans.
- Develop methods and schedules for exercising emergency response plans.

B. Emergency Notification (Section 304)

Facilities must immediately notify the LEPC and the SERC if there is a release of a listed hazardous substance that exceeds the reportable quantity for that substance. Substances subject to this requirement are:

- Substances listed on the list of Extremely Hazardous Substances (EHS) (See Appendix I).
- Substances subject to the emergency notification requirement Of CERCLA, Section 303(a).

The initial notification requirement can be by telephone, radio, or in person. Transportation incidents are reported by dialing the local emergency number (911) or the local operator.

Emergency notification needs to include:

- The chemical name
- An indication of whether the substance is extremely hazardous
- An estimate of the quantity released into the environment
- The time and duration of the release
- The media into which the release occurred
- Any known or anticipated acute or chronic health risk associated with the emergency, and where appropriate, advise regarding medical attention necessary for exposed individuals

- Proper precautions, such as evacuation
- Name and telephone number of contact person

A follow-up written notice is required after the emergency which is to include:

- Updated information included in the initial verbal notification
- Additional information on:
  - -- Actual response actions taken
  - -- Any known or anticipated data or chronic health risks associated with the release
  - -- Advise regarding medical attention necessary for exposed individuals

C. Community Right-to-Know Reporting Requirements (Section 311-312)

Facilities required to prepare Material Safety Data Sheets (MSDSs), by the U.S. Occupational Health and Safety Administration (OSHA) in their Worker Right-To-Know regulations, must submit, if they meet the threshold limit quantities, this information to the SERC, the LEPC, and the local fire department Facilities may submit a list of the chemicals they have instead of the MSDS. (See Sample MSDS, Appendix II). If so done, the list must include the chemical or common name and any hazardous components as provided on the MSDS. If requested by the LEPC, facilities must submit MSDS for the chemicals on their list to the LEPC.

The chemicals on the list must be organized into health and physical hazards as set forth by OSHA regulations. OSHA originally used 23 separate categories of health hazards. EPA has condensed this into five groups. Two health - acute and chronic toxicity, and three physical hazard groups - pressure release (which can include anything from compressed gases to explosives), flammable and reactive.

The reporting requirements also include submission of an emergency and hazardous chemical inventory form to the LEPC, the SERC, and to the local fire department. EPA has established a two-tier requirement for facilities to report chemical information to local and state authorities.

- Tier I Information

  This is general information about the facility and the identity and an estimate (in ranges) of the maximum amount of chemicals for each category present at the facility during the previous calendar year. Also required is an estimate (a range) of the average daily amount of chemicals in each category and the general location in the facility where they are stored.

- Tier II Information

  Upon the request of the LEPC, SERC, or fire department, the facility must provide the following information:

  -- Essentially the same information as required by Tier I, but in more detail. Additional information includes a brief description of the manner of storage, the location of the chemicals in the facility, and an indication of whether the owner wishes to withhold information on the basis of trade secrecy.

  -- Tier I information must be made available to the public during normal working hours by the SERC or LEPC. Tier II information is to be made available by the SERC provided a written request substantiates a legitimate need to know.

Of particular importance to emergency responders is the section which gives the senior fire official or his designated representative access to the facility to conduct inspections for compliance with these regulations. Local authorities can also designate additional personnel such as environmental health or health department inspectors to assist in conducting these facility inspections.

D. Toxic Chemical Release Reporting (Section 313)

Requires EPA to establish an inventory of toxic chemical emissions from certain facilities. Facilities subject to this reporting requirement are required to complete a toxic chemical release form for each specific chemical meeting threshold requirements.

The reporting requirement applies to owners and operators of facilities that have ten or more full-time employees and that manufacture, process, or otherwise use a listed toxic chemical in excess of specified threshold quantities. They must report annually on all releases to air, water, and land.

There are over 300 chemicals and categories of chemicals that are subject to the reporting requirements. Facilities using listed chemicals in quantities over 10,000 pounds per year are subject to reporting requirements.

Other Title III Provisions

Section 322 addresses the authority for a facility to withhold information based upon trade secrecy. In general, for the specific identity of a chemical to be withheld from disclosure four criteria must be met:

1. The information withheld cannot have been divulged to another person. Essentially if others not directly involved in the processing or operation are aware of the chemical identity, it cannot be considered a secret any longer.

2. The information is not required to be disclosed by other federal laws.

3. The disclosure of the information would cause a substantial competitive disadvantage to the firm in the commercial marketplace.

4. The identity of the chemical is not readily discernable through reverse engineering.

Even for chemicals whose specific identity can be withheld as a trade secret the generic category the chemical falls in must still be submitted as well as any significant health and safety hazards it possesses.

In this subtitle, there is an exception to the trade secret provision. Upon written request by health practitioners, information must be made available for the diagnosis and treatment of chemical injury. During a medical emergency a written confidentiality statement by the physician is not needed, but the provider of the chemical information, under the trade secrecy provision, may subsequently request a written confidentiality agreement from health professionals. If information is needed for any reason other than a bonafide emergency, a written confidentiality agreement must be provided along with a specific statement of need for the information by the local medical authority.

Section 305(a) Provides up to $5,000,000 annually to states to enhance their training efforts in the area of planning and responding to chemical incidents.

Section 305(b) requires EPA to review emergency systems for monitoring, detecting, and preventing releases of extremely hazardous substances at representative facilities that produce, use, or store these substances.

IV. THE NATIONAL RESPONSE PLAN

The federal government's role and responsibilities for responding to releases or potential releases of oil or hazardous substances is contained in the National Oil and Hazardous Substances Contingency Plan (NCP). The NCP establishes a National Response Team (NRT), comprised of representatives from 14 federal agencies. Each signatory agency is assigned certain response functions, generally parallel to the agency's legislative responsibilities, and is required to develop and organize their agencies capabilities for responding to chemical emergencies.

The National Response Team's primary function is to organize and manage the NCP; to review it, keep it current, and to make sure that individual agencies discharge their responsibility. Lead roles in the NCP are assigned to the U.S. EPA and the U.S. Coast Guard (USCG).

The NCP also establishes Regional Response Teams (RRT) and requires that they develop appropriate regional mechanisms for planning and preparedness activities. Regional Contingency Plans (RCP) are to include provisions for communications, planning, coordination, training, evaluation, preparedness, and other such matters on a region-wide

basis. The NCP calls for ten Regional Response Teams with jurisdiction corresponding to the ten standard federal geographical regions. The RRT's are responsible for developing and preparing Regional Response Plans (RRP).

Regional Response Teams are comprised of regional representatives from each of the 14 federal agencies on the NRT. It also includes a representative from each of the States within that region. When the Regional Response Plan is activated, due to an incident within the region, a representative from the locally effected area automatically becomes a voting member of the committee. The RRP also preestablishes a federal manager - On-Scene-Coordinator (OSC) - either from the EPA or the USCG for any incident that occurs.

Title III requires Regional Response Teams, when requested, to assist SERCs and LEPCs in the development and implementation of their emergency preparedness plans. It also requires the NRT to publish guidance documents concerning the preparation and planning of emergency response plans.

V. SUMMARY

Responses to hazardous materials incidents are more effective when preplanning has been done and emergency response plans prepared in advance. Emergency response plans must be prepared by each level of government - local, state, federal - which has responsibilities for response activities. Title III and the NCP provide a mechanism for integrated, coordinated preparedness planning and emergency response.

APPENDIX I

29CFR 1910.120 PARAGRAPH (q) EMERGENCY RESPONSE TO HAZARDOUS SUBSTANCE RELEASES.

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

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

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

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

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

(iii) Emergency recognition and prevention.

(iv) Safe distances and places of refuse.

(v) Site security and control.

(vi) Evacuation routes and procedures.

(vii) Decontamination.

(viii) Emergency medical treatment and first aid.

(ix) Emergency alerting and response procedures.

(x) Critique of response and follow-up.

(xi) PPE and Emergency equipment.

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

(3) Procedures for handling emergency response.

(i) The senior emergency response official responding to an emergency shall become the individual in charge of a site-specific Incident Command System (ICS). All emergency responders and their

communications shall be coordinated and controlled through the individual in charge of the ICS assisted by the senior official present for each employer.

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

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

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

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

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

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

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

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

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

(x) When deemed necessary for meeting the tasks at hand, approved self-contained

compressed air breathing apparatus may be used with approved cylinders from other approved self-contained compressed air breathing apparatus provided that such cylinders are of the same capacity and pressure rating. All compressed air cylinders used with self-contained breathing apparatus shall meet U.S. Department of Transportation and National Institute for Occupational Safety and Health criteria.

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

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

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

(i) **First responder awareness level.** First responders at the awareness level are individuals who are likely to witness or discover a hazardous substance release and who have been trained to initiate an emergency response sequence by notifying the proper authorities of the release. They would take no further action beyond notifying the authorities of the release. First responders at the awareness level shall have sufficient training to have had sufficient experience to objectively demonstrate competency in the following areas.

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

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

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

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

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

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

(ii) **First responder operations level.** First responders at the operations level are individuals who respond to releases or potential releases of hazardous substances as part of the initial response to the site for the purpose of protecting nearby persons, property, or the environment from the effects of the release. They are trained to respond in a defensive fashion without actually trying to stop the release. Their function is to contain the release from a safe distance, keep it from spreading, and prevent exposures. First responders at the operational level shall have received at least eight hours of training or have had sufficient experience to objectively demonstrate competency in the following areas in addition to those listed for the awareness level and the employer shall so certify:

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

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

(c) An understanding of basic hazardous materials terms.

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

(e) Know how to implement basic decontamination procedures.

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

(iii) **Hazardous materials technician.** Hazardous materials technicians are individuals who respond to releases or potential releases for the purpose of stopping the release. They assume a more aggressive role than a first responder at the operations level in that they will approach the point of release in order to plug, patch or otherwise stop the release of a hazardous substance. Hazardous materials technicians shall have received at least 24 hours of training equal to the first responder operations level and in addition have competency in the following areas and the employer shall so certify:

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

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

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

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

(e) Understand hazard and risk assessment techniques.

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

(g) Understand and implement decontamination procedures.

(h) Understand termination procedures.

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

(iv) **Hazardous materials specialist.** Hazardous materials specialists are individuals who respond with and provide support to hazardous materials technicians. Their duties parallel those of the hazardous materials technician, however, those duties require a more directed or specific knowledge of the various substances they may be called upon to contain. The hazardous materials specialist would also act as the site liaison with Federal, state, local and other government authorities in regards to site activities. Hazardous materials specialists shall have received at least 24 hours of training equal to the technical level and in addition have competency in the following areas and the employer shall so certify:

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

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

(c) Know of the state emergency response plan.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

(8) **Refresher training.**

(i) Those employees who are trained in

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

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

(9) Medical surveillance and consultation.

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

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

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

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

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

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

APPENDIX II

29CFR 1910.120 PARAGRAPH (f) MEDICAL SURVEILLANCE

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

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

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

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

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

(iv) Members of HAZMAT teams.

(3) Frequency of medical examinations and consultations.

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

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

(a) Prior to assignment;

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

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

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

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

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

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

(b) At additional times, if the examining physician determines that follow-up

examinations or consultations are medically necessary.

(4) Content of medical examinations and consultations.

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

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

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

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

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

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

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

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

(v) Information required by §1910.134

(7) Physician's written opinion.

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

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

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

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

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

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

(8) Recordkeeping.

(i) An accurate record of the medical surveillance required by paragraph (f) of this section shall be retained. This record shall be retained for the period specified and meet the criteria of 29 CFR 1919.20

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

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

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

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

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

APPENDIX III

Material Safety Data Sheet
May be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Standard must be consulted for specific requirements.

U.S. Department of Labor
Occupational Safety and Health Administration
(Non-Mandatory Form)
Form Approved
OMB No. 1218-0072

IDENTITY (As Used on Label and List)

Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.

Section I

Manufacturer's Name	Emergency Telephone Number
Address (Number, Street, City, State, and ZIP Code)	Telephone Number for Information
	Date Prepared
	Signature of Preparer (optional)

Section II — Hazardous Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optional)

Section III — Physical/Chemical Characteristics

Boiling Point		Specific Gravity (H_2O = 1)	
Vapor Pressure (mm Hg.)		Melting Point	
Vapor Density (AIR = 1)		Evaporation Rate (Butyl Acetate = 1)	

Solubility in Water

Appearance and Odor

Section IV — Fire and Explosion Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL

Extinguishing Media

Special Fire Fighting Procedures

Unusual Fire and Explosion Hazards

APPENDIX III

Section V — Reactivity Data

Stability	Unstable		Conditions to Avoid
	Stable		

Incompatibility (*Materials to Avoid*)

Hazardous Decomposition or Byproducts

Hazardous Polymerization	May Occur		Conditions to Avoid
	Will Not Occur		

Section VI — Health Hazard Data

Route(s) of Entry: Inhalation? Skin? Ingestion?

Health Hazards (*Acute and Chronic*)

Carcinogenicity: NTP? IARC Monographs? OSHA Regulated?

Signs and Symptoms of Exposure

Medical Conditions
Generally Aggravated by Exposure

Emergency and First Aid Procedures

Section VII — Precautions for Safe Handling and Use

Steps to Be Taken in Case Material is Released or Spilled

Waste Disposal Method

Precautions to Be Taken in Handling and Storing

Other Precautions

Section VIII — Control Measures

Respiratory Protection (*Specify Type*)

Ventilation	Local Exhaust	Special
	Mechanical (General)	Other

Protective Gloves	Eye Protection

Other Protective Clothing or Equipment

Work/Hygienic Practices

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APPENDIX III

SAMPLE OF COMPLETED MATERIAL SAFETY DATA SHEET	
Manufacturer's Name & Address XYZ Chemical, Inc. 4400 Carin Alley Elizabeth, NJ 07231	**Emergency Contact** John H. Doe (615/211-2233)
Prepared By **Date Prepared** Susan S. Smith 2/18/87	**Information Contact** Susan S. Smith (615/211-2234)
Chemical Identity Vinyl chloride monomer CAS #75-01-4 $CH_2 = CHCl$	**Synonyms, Trade and Common Names** VCM; Vinyl chloride, inhibited; Chloroethylene; Chlorethene; Monochloroethylene; Ethylene monochloride
OSHA PEL 1 ppm (8hr. TWA); 0.5 ppm (8 hr. TWA) action level; 5 ppm ceiling concentration.	
ACGIH TLV 5 ppm (8 hr. TWA); Human carcinogen.	
Other Limits Recommended NIOSH - Lowest detectable (NIOSH Recommended Exposure Level, REL)	
Hazardous Components/Ingredients Vinyl chloride monomer 99.9% Contaminants may include acetaldehyde, acetylene, iron, hydrogen chloride. An inhibitor (e.g., approx. 50 ppm phenol) may be added to prevent polymerization during storage.	

SAMPLE OF COMPLETED MATERIAL SAFETY DATA SHEET CONT'D

Physical/Chemical Characteristics

Boiling Point:	7°F (-14°C)
Specific Gravity (H^2O = 1):	0.91
Vapor Pressure:	230 mm Hg at 20°C
Solubility in Water:	Negligible (0.1% at 25°C)
Appearance and Odor:	Colorless, sweet-smelling gas at room temperature. Readily liquefies below -14°C or at increased pressures.
Vapor Density (Air = 1):	2.2
Melting Point:	-245°F (-160°C)
Evaporation Rate: (Butyl acetate = 1)	Information not available

Fire and Explosion Information

Flash Point (Method Used):	108°F/-77°C (COC)
Flammable Limits in Air (% by volume):	Lower (LEL) 3.6% Upper (UEL) 33%
Extinguishing Media:	Dry chemical or carbon dioxide for small fires. Heavy water spray, fog or alcohol foam for larger fires to cool containers and protect response workers (ineffective extinguishing material).
Special Firefighting Recommendations:	Stop flow of gas if possible; if flow cannot be stopped, fight fires from a distance or allow to burn. If possible, remove container from fire area and/or isolate from other flammable materials.
Unusual Fire and Explosion Hazards:	Heavier than air - can flow along surfaces to distant sources of ignition and flashback. VCM is highly flammable and can form explosive mixtures in air. If heated or exposed to light, air or catalyst, it can undergo violent exothermic reaction.

APPENDIX III

SAMPLE OF COMPLETED MATERIAL SAFETY DATA SHEET CONT'D

Reactivity Data

Stability:	Inhibited VCM is stable at room temperature.
Conditions to Avoid:	Heat, sparks, or other sources of ignition can result in a flashback fire and/or explosion. Exposure to heat, light, air, oxidizing agents, copper, or aluminum can result in vigorous reaction.
Hazardous Polymerization:	_X_may occur ___does not occur
Hazard Decomposition Products:	Hydrogen chloride, carbon monoxide, phosgene.

Health Hazard Data

Main Route(s) of Exposure:	Inhalation, Skin, Eye contact
Signs and Symptoms of Overexposure:	
Acute:	Central Nervous System (CNS) disturbances (e.g., headache, nausea, drunkenness, drowsiness, narcolepsy, unconsciousness, respiratory paralysis, euphoria, cardiac arrest); asphyxia, pulmonary damage; liver and kidney damage; dimmed vision; skin irritation, redness, frostbite and pain; nonpermanent corneal injury with eye contact.
Chronic:	Cancer; CNS and automonic nervous system effects; peripheral circulation disturbances (Raynaud's phenomenon), skeletal and skin changes, immunosuppression.
Carcinogenicity:	NTP - Yes OSHA - Yes (29 CFR 1910.1017) IARC Human - Yes Animal - Yes
Medical Conditions Aggravated by Exposure:	No information available

APPENDIX III

SAMPLE OF COMPLETED MATERIAL SAFETY DATA SHEET CONT'D	
Emergency and First-Aid Procedures	
Inhalation:	Promptly take victim to uncontaminated, well-ventilated area. Resuscitate if necessary (oxygen may be necessary). GET MEDICAL ATTENTION IMMEDIATELY.
Skin Contact:	Promptly remove contaminated shoes and clothing and thoroughly wash affected areas with large amounts of warm water. If frostbite occurs, warm affected parts by wrapping. Gently exercise affected parts to restore circulation.
Eye Contact:	Immediately flush eyes with large amounts of water with lids lifted, for no less than 15-20 minutes. GET IMMEDIATE MEDICAL ATTENTION.
Precautions for Safe Handling and Use	
Storage and Handling Precautions:	Store in a cool, well-ventilated area isolated from ignition sources or oxidizing agents. Cylinders must be protected from physical damage.
Other Precautions:	VCM is a cancer hazard and must be stored in a designated regulated area with controlled and limited access. Where workers may be exposed, storage and other areas must be monitored periodically for levels above the 0.5 ppm action level.
Spill and Leak Procedures:	Immediately remove and/or turn off all sources of ignition. Evacuate and isolate area until leak has been stopped and area well-ventilated. Stop leak if possible and spray area with large amounts of water to suppress vapors and reduce temperatures. Response personnel must use appropriate personal protective clothing and equipment to prevent breathing contaminated air or coming into contact with liquid VCM.
Waste Disposal Method:	High temperature incineration in accordance with EPA guidelines.

SAMPLE OF COMPLETED MATERIAL SAFETY DATA SHEET CONT'D

Control Measures

Ventilation:	Local Exhaust, explosion-proof. Process enclosure, if possible. General ventilation must also be explosion-proof.
Respiratory Protection (Specific Type):	
Up to 10 ppm:	1) Combination Type C supplied air respirator (SAR), demand-type with half-mask facepiece and auxiliary self-contained air supply; or 2) Type C SAR, demand type with half-mask facepiece; or 3) Any chemical cartridge respirator with an organic vapor cartridge that has at least a one-hour service life in concentrations of vinyl chloride up to 10 ppm. (See 29 CFR 1910.1017(g)(4) for the required selection of respirators at higher concentrations.)
Protective Gloves:	Neoprene or other VCM-impermeable material.
Eye Protection:	Chemical-protective goggles or faceshield, as needed. Eyewash station must be in working order and readily accessible for emergency use.
Other Protective Clothing/Equipment:	Chemical-protective clothing and boot covers.
Work/Hygienic Practices:	Safety showers and eyewash stations must be in working order and readily accessible in the work areas.

DIRECT-READING INSTRUMENTS AND RADIATION SURVEY INSTRUMENTS

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. List two reasons why air monitoring with direct-reading instruments is important at an incident involving hazardous materials

2. Identify three limitations of each of the following:

   - Combustible gas indicators
   - Oxygen indicators
   - Colorimetric tubes

3. Identify four desirable characteristics in a field monitoring instrument

4. Recognize the inherent safety classifications

5. Identify three instrument rating definitions

6. Explain the following terms:

   - Perimeter monitoring
   - Plume modeling
   - Internal sensor/external sensor
   - Automatic pump/manual pump

7. Explain the two values colorimetric tubes are read in

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

PERFORMANCE OBJECTIVES (Continued)

8. Describe the Wheatstone Bridge Circuit

9. Define "operating temperature range" in relation to instruments and colorimetric tubes

10. Identify the characteristics associated with the following types of radiation:

    - Alpha
    - Beta
    - Gamma

11. Explain the difference between Geiger-Mueller tubes and scintillation media detectors

12. Identify the action level for ionizing radiation

13. Describe the relationships between microroentgen, milliroentgen, and roentgen

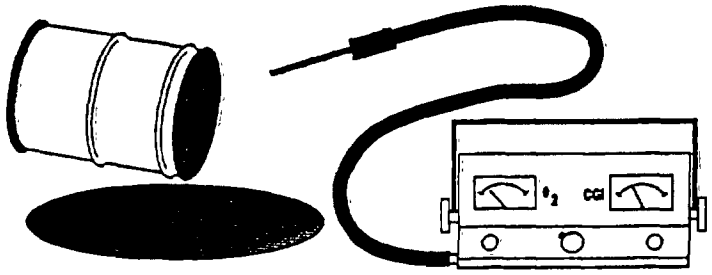
14. Identify the maximum radiation level allowed in a rescue situation

15. Identify at least three common sources of radiation in the community

16. Describe background radiation.

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

NOTES



DIRECT-READING INSTRUMENTS

S-1

AIR MONITORING INSTRUMENTS

- Collection of "real time" data to aid in decisions concerning:
  - Hazards and risks to personnel and public
  - Personal protective equipment
  - Mitigative actions

S-2

FIELD INSTRUMENT CHARACTERISTICS

- Portability
- Ease of operation
- Reliable and useful results
- Inherent safety

S-3

NOTES

INHERENT SAFETY

- Instrument testing and certification
  - Factory Mutual (FM)
  - Underwriters Laboratories (UL)
  - Approval markings

S-4

INHERENT SAFETY APPROVAL

- National Fire Protection Association (NFPA)
  - National Fire Codes
- National Electrical Code (NEC)
  - Chapter 5. Special Occupancies
    Article 500: Hazardous Locations

S-5

INHERENT SAFETY APPROVAL (cont.)

- Equipment approved for:
  - Class of location
  - Explosive, combustible, or ignitable properties of the specific gas, vapor, dust, fiber, or flyings present

S-6

NOTES

HAZARD LOCATION

- Class
  - I - Flammable gases or vapors
  - II - Combustible dusts
  - III - Ignitable fibers or flyings

S-7

HAZARD LOCATIONS (cont.)

- Division 1 -

  Hazardous concentrations exist continuously, intermittently, or periodically under normal working conditions

S-8

HAZARD LOCATIONS (cont.)

- Division 2 -

  Locations in which hazardous concentrations do not normally exist under normal working conditions

S-9

NOTES

HAZARD LOCATIONS (cont.)

- Groups
  - Groups A, B, C, and D
    Gases or vapors found in Class I atmospheres
  - Groups E, F, and G
    Dusts found in Class II atmospheres

S-10

INSTRUMENT PROTECTION CRITERIA

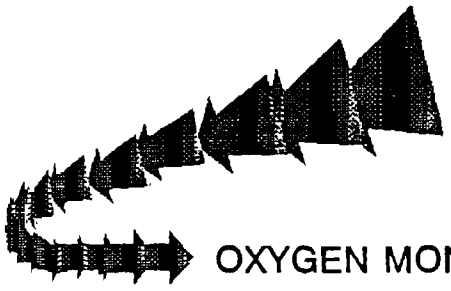
- Class I, Division 1, Groups A, B, C, and D
  - Intrinsically safe
  - Explosion proof
  - Purged system

S-11

INSTRUMENT PROTECTION CRITERIA (cont.)

- Class I, Division 2, Groups A, B, C, and D
  - Nonincendive
- Class II, Divisions 1 and 2, Groups E, F, and G
  - Dust-ignition proof

S-12



1

OXYGEN MONITORING

S-13

OXYGEN MONITORING

- Monitor to determine:
  - Respiratory protection
  - Increased flammability risk
  - CGI operation
  - Presence of contaminants

S-14

OXYGEN INDICATORS

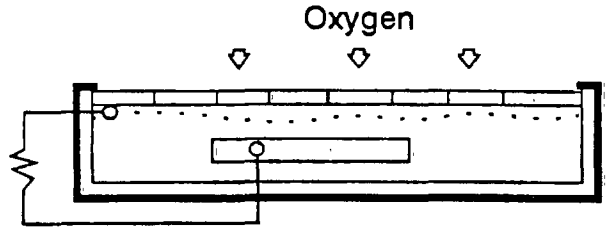
- Exterior sensor
- Interior sensor
  - Manual pump
  - Automatic pump
- Combination units

S-15

NOTES

THEORY OF OPERATION

- Oxygen diffusion into detector cell
- Chemical reaction establishes current proportional to oxygen concentration



S-16

INTERPRETATION OF DATA

- Instantaneous results
- Specific, quantitative results
  - 0 - 25%
  - 0 - 100%
- Calibrate to ambient air

S-17

LIMITATIONS AND PRECAUTIONS

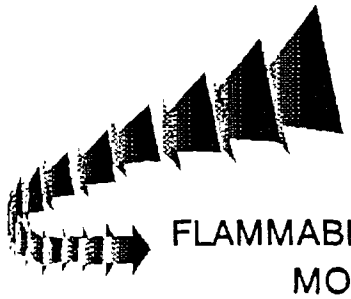
- Atmospheric pressure (altitude)
- Interfering gases
- Ambient temperature

S-18

NOTES

Altitude	O_2	Altitude	O_2
-1000	21.6%	6000	16.7%
-500	21.2%	7000	16.1%
Sea level	20.8%	8000	15.4%
500	20.4%	9000	14.9%
1000	20.1%	10,000	14.3%
3000	18.6%		
4000	18.0%	Calibrate	
5000	17.3%	Calibrate	

S-19



2

FLAMMABLE ATMOSPHERE MONITORING

S-20

FLAMMABLE ATMOSPHERE MONITORING

- Monitor to determine:
  - Risk of explosion or fire
  - Work zones

S-21

NOTES

COMBUSTIBLE GAS INDICATOR

- External sensor
- Internal sensor
  - Manual pump
  - Automatic pump
- Supersensitive unit
- Combination units

S-22

THEORY OF OPERATION

- Wheatstone Bridge
  - Heated catalytic filament
  - Increase in operating temperature
  - Increase in electrial resistance
  - Imbalance in Wheatstone Bridge
  - Needle deflection

S-23

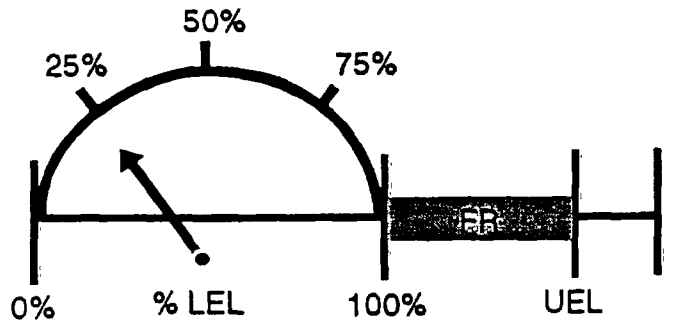
DATA INTERPRETATION

- Rapid response of instrument
- Nonselective quantitative results
- Needle deflection indicates 0 - 100% lower explosive limit

S-24

NOTES

DATA INTERPRETATION

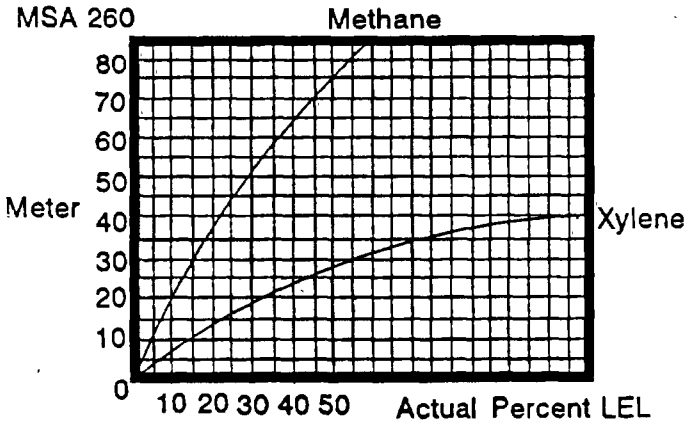


S-25

INSTRUMENT LIMITATIONS

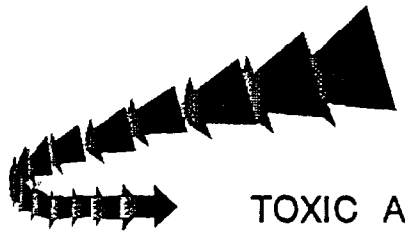
- Oxygen requirements
- Filament damage or destruction
- Temperature
- Relative response
- Accuracy

S-26



S-27

NOTES



3

TOXIC ATMOSPHERE MONITORING

S-28

TOXIC ATMOSPHERE MONITORING

- Used to determine:
  - Health risks to personnel and public
  - Appropriate levels of protection
  - Work zones

S-29

TOXIC ATMOSPHERE MONITORS

- Detector tube systems
- Specific toxic agent monitors
- Total vapor analyzers
- Gas chromatographs

S-30

NOTES

DETECTOR TUBE SYSTEMS

- Bellows pump
- Piston pump

S-31

TUBE SELECTION

- Specific chemicals
- Classes of chemicals
- Concentration ranges

S-32

THEORY OF OPERATION

- Specific volume of air
- Length of tube stain
- Concentration of contaminant

S-33

NOTES

DATA INTERPRETATION

- Sometimes tedious and slow
- Know suspect chemical
  - Polytest
- Specific quantitative results
  - ppm or % by volume

S-34

LIMITATIONS/PRECAUTIONS

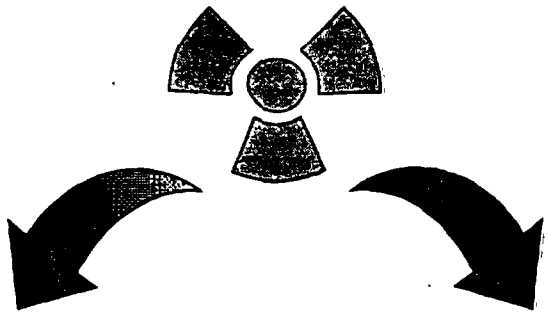
- Chemical group
- Tube lot number
- Expiration date
- Pump strokes
- Color change

S-35

LIMITATIONS / PRECAUTIONS (cont.)

- Temperature
- Humidity
- Atmospheric pressure
- Reusable
- Accuracy

S-36



RADIATION MONITORING

S-37

MONITORING FOR RADIATION

- Ionizing radiation
- Gamma radiation

S-38

USE OF RADIATION INSTRUMENTS

- Principles of operation
  - Ionization in detection media
  - Ions produced counted electronically
  - Relationship established between ionizing events and the quantity of radiation present

S-39

NOTES

TYPES OF RADIATION

Radiation	Distance	Shielding
Alpha	<1 inch	Sheet of Paper
Beta	Inches	1/16 inch aluminum foil
Gamma	Hundreds of feet	2 feet aluminum

S-40

PROTECTION FACTORS

- Time
- Distance
- Shielding

S-41

RADIATION INSTRUMENTS

- Activity meters
- Exposure meters

S-42

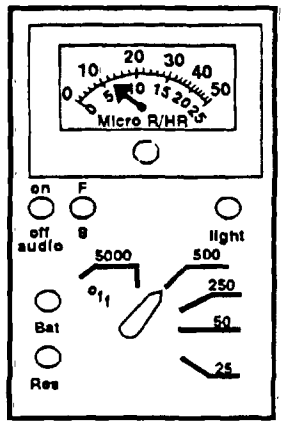
NOTES

EXPOSURE METERS

- Geiger-Mueller detection tube
- Scintillation detection media
  - Roentgens per hour
  - Milliroentgens per hour
  - Microroentgens per hour

S-43

LUDLUM
MODEL - 19
MICRO R METER*



Measurements, Inc.
Sweetwater, Texas

S-44

RADIATION SURVEY

- Check instrument calibration
- Check instrument battery
- Obtain background reading

S-45

* "Reprinted from Ludlum Measurements instruction manual, May 1982,with permission of Ludlum Measure

NOTES

PRELIMINARY SURVEY

- Select "fast" setting for needle response switch
- Select lowest setting on range selector switch
- Carry detector waist high
- Compare readings with background

S-46

DIRECT-READING INSTRUMENTS AND RADIATION SURVEY INSTRUMENTS

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DIRECT-READING INSTRUMENTS AND RADIATION SURVEY INSTRUMENTS

I. INTRODUCTION

Airborne contaminants can present a significant threat to human health. Identifying and quantifying these contaminants by air monitoring is an essential component of a health and safety program at a hazardous waste site. Air monitoring data is useful to:

- Assess the health risks to the public and response workers.
- Select personal protective equipment.
- Delineate areas where protection is needed.
- Determine actual or potential effects on the environment.
- Select actions to mitigate the hazards safely and effectively.

Direct-reading instruments were developed as early warning devices for use in industrial settings, where leaks or an accident could release a high concentration of a known chemical. Today, some direct reading instruments can detect low concentrations of contaminants as little as one part contaminant per million parts of air (ppm). Direct-reading instruments provide information at the time of sampling and do not require sending samples to a laboratory for subsequent analysis. This characteristic of direct-reading instruments enables rapid decision-making.

Many of the common types of monitoring equipment discussed in this part are listed in tabular form in **APPENDIX I**.

II. CHARACTERISTICS OF AIR MONITORING INSTRUMENTS

To be useful air monitoring instruments must be:

- Portable and rugged.
- Easy to operate.
- Inherently safe.
- Able to generate reliable and useful results.

A. Portability

A prime consideration for field instruments is portability. Transportation shock resulting from the movement from one place to another, together with unintentional abuse, shortens the usable life of an instrument. To reduce the effects of this trauma, instruments should be selected that have reinforced shells or frames, shock-mounted electronic packages, or padded containers for shipment.

Exposure to the elements and to the test atmosphere itself is of concern for those instruments repeatedly used in adverse conditions or as long-term monitors. Anodized or coated finishes, weather resistant packaging and remote sensors are effective in reducing downtime and increasing portability.

An internal power supply is important for portability. Some instruments use replaceable or rechargeable batteries and some do not require a power supply.

An instrument should not be so heavy or bulky that it is difficult for a response worker to carry.

B. Ease Of Operation

Because many of these instruments were designed for industrial use, allowances may not have been made for using the instrument while wearing protective equipment. One must consider how easy it is to use the instrument while wearing gloves or how difficult it is to read the meter while wearing a respirator. Also, how quickly a worker can learn to operate the instrument correctly should be considered.

Preparation time for use of the instrument should be short. Rapid warm-up, easy attachment of accessories, and quick instrument checks shorten preparation time.

C. Inherent Safety

The portable instrumentation used to characterize hazardous material spills or waste sites must be safe to use. Electrical devices, including instruments, must be constructed in such a fashion as to prevent the ignition of a combustible atmosphere. The sources of this ignition could be: an arc generated by the power source itself or the associated electronics, or a flame or heat source necessary for function of the instrument. Several engineering, insurance, and safety organizations have standardized test methods, established inclusive definitions, and developed codes for testing electrical devices used in hazardous locations. The National Fire Protection Association (NFPA) has created minimum standards in its National Electrical Code (NEC) published every 3 years. This code spells out types of areas in which hazardous atmospheres can be generated and the types of materials that generate these atmospheres, and design safeguards acceptable for use in hazardous atmospheres.

1. Hazardous Atmospheres

Depending upon the response worker's background, the term "hazardous atmosphere" conjures up situations ranging from toxic air contaminants to flammable atmospheres. For NEC purposes, an atmosphere is hazardous if it meets the following criteria:

- It is a mixture of any flammable material in air whose concentration is within the material's flammable range (i.e. between the material's lower flammable limit and its upper flammable limit).

- There is the potential for an ignition source to be present.
- The resulting exothermic reaction could propagate beyond where it started.

To adequately describe hazardous atmospheres, the NEC categories them according to their Class, Group, and Division.

a. Class and Group

Class is a category describing the type of flammable material that produces the hazardous atmosphere:

- Class I is flammable vapors and gases, such as gasoline and hydrogen. Class I is further divided into groups A, B, C, and D on the basis of similar flammability characteristics (**Table 1**).
- Class II consists of combustible dusts like coal or grain and is divided into groups E, F, and G (**Table 2**).
- Class III is ignitable fibers such as produced by cotton milling.

b. Division

Division is the term describing the "location" of generation and release of the flammable material.

- Division 1 is a location where the generation and release are continuous, intermittent, or periodic into an open, unconfined area under normal conditions.
- Division 2 is a location where the generation and release are only from ruptures, leaks or other failures from closed systems or containers.

TABLE 1
SELECTED CLASS I CHEMICALS BY GROUPS

Group A **Atmospheres acetylene**

Group B **Atmospheres (not sealed in conduit 1/2 inch of larger)**

1,3-Butadiene
Ethylene oxide
Formaldehyde (gas)
Hydrogen
Manufactured gas (containing greater than 30% H_2 by volume)
Propylene oxide
Propyl nitrate
Allyl glycidyl ether
N-Butyl glycidyl ether

Group C **Atmospheres (selected chemicals)**

Acetaldehyde	Epichlorohydrin	Tetrahydrofuran
Carbon monoxide	Ethylene	Triethylamine
Crotonaldehyde	Ethyl mercaptan	Ethylene glycol
Dicyclopentadiene	Hydrogen cyanide	Monoethyl ether
Diethyl ether	Hydrogen selenide	Hydrazine
Di-isobutyl amine	Hydrogen sulfide	Chloroaldehyde
Methylacetylene	Morpholine	Tetraethyl lead
Ethylene glycol	Monoethyl	(39 others)
Ether acetate	Nitropropane	

Group D **Atmospheres (selected chemicals)**

Acetone	Methane	Acetonitrile
Methanol	Acrylonitrile	Methyl ethyl ketone
Ammonia	Naphtha	Benzene
Propane	Butane	Styrene
Chlorobenzene	Vinyl chloride	

Source: Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (classified) Locations, 1991 National Fire Protection Association ANSI/NFPA 497M.

TABLE 2 SELECTED CLASS II DUSTS BY GROUPS
Group E Selected metalic dusts (Conductive) Atmospheres containing metal dusts, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics.
Group F Selected Carbonaceous dusts (Semi-Volatile) Atmospheres containing carbon black, coal or coke dust with more than 8% volatile material.
Group G Selected other dusts Atmospheres containing flour, starch, grain, carbonaceous, chemical thermoplastic, thermosetting and molding compounds.

NOTE: Mixtures of dusts in any of the groups is considered to be a hybrid dust.

Source: Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (classified) Locations, 1986 National Fire Protection Association ANSI, NFPA 497M, (Sec 5, Article 500, National Electrical Code)

2. Using this system

A hazardous atmosphere can be routinely and adequately defined. As an example, an abandoned waste site containing intact closed drums of methyl ethyl ketone, toluene and xylene would be considered a Class I, Division 2, Group D environment. However, when transferring of the flammable liquids takes place at the site, or if releases of flammable gases/vapors is considered normal, the areas would be considered Class I, Division 1.

3. Controls

The following three methods of construction exist to prevent a potential source from igniting a flammable atmosphere:

- Explosion-proof: Explosion-proof instruments allow the flammable atmosphere to enter. If an arc is generated, the ensuing explosion is contained within the specially built enclosure. Within it, any flames or hot gases are cooled prior to exiting into the ambient flammable atmosphere so that the explosion does not spread into the environment.

- Intrinsically Safe: The potential for arcing among components is reduced by encasing them in a solid insulating material. Also, reducing the instrument's operational current and voltage below the energy level necessary for ignition of the flammable atmosphere provides protection. An "intrinsically safe" device, as defined by the National Electrical Code, is incapable "of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignited concentration. Abnormal conditions shall include accidental damage to any wiring, failure of electrical components, application of over-voltage, adjustment and maintenance operations and other similar conditions".

- Purged: The arcing or flame-producing device is metallic from the flammable atmosphere with an inert gas. In a pressurized or "purged" system, a steady stream of, nitrogen or helium is passed by the potential arcing device, keeping the flammable atmosphere from the ignition source. This type of control, however, does not satisfactorily control analytical devices that use flame or heat for analysis, such as a combustible gas indicator (CGI). It also requires a source of gas which would reduce instrument portability.

4. Certification

If a device is certified as explosion-proof,intrinsically safe, or purged for a given class, division, and group, and is used, maintained, and serviced according to the manufacturer's instructions, it will not contribute to ignition. The device is not, however, certified for use in atmospheres other than those indicated. All certified devices must be marked to show class, division, and group (**Figure 1**). Any manufacturer wishing to have an electrical device certified must submit a prototype to a laboratory for testing. If the unit passes, it is certified as submitted. However, the manufacturer agrees to allow the testing laboratory to randomly check the manufacturing plant at any time, as well as any marketed units. Furthermore, any change in the unit requires the manufacturer to notify the test laboratory, which can continue the certification or withdraw it until the modified unit can be retested. NFPA does not do certification testing. Testing is done by such organizations as Underwriters' Laboratory Inc. (UL) or Factory Mutual Research Corp. (FM). Currently, these are the only two testing labs recognized by OSHA.

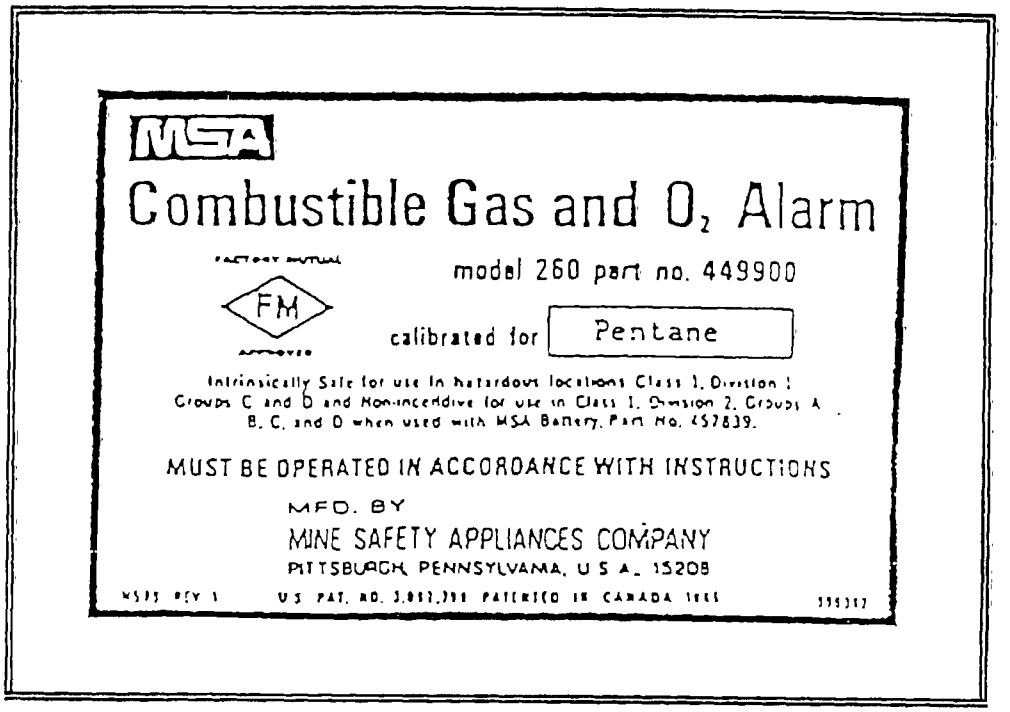

FIGURE 1
CERTIFICATION LABEL FROM MSA MODEL 260
COMBUSTIBLE GAS AND O_2 INDICATOR

To ensure personnel safety, it is recommended that only approved instruments be used on-site and only in atmospheres for which they have been certified. When investigating incidents involving unknown hazards, the monitoring instruments should be rated for use in the most hazardous locations. The following points will assist in selection of equipment that will not contribute to ignition of a hazardous atmosphere:

- The mention of a certifying group in the manufacturer's equipment literature does not guarantee certification.

- Some organizations test and certify instruments for locations different from the NEC classification. The Mine Safety and Health Administration (MSHA) tests instruments only for use in methane-air atmospheres and in atmospheres containing coal dust.

- In an area designated Division 1, there is a greater probability of generating a hazardous atmosphere than in Division 2. Therefore, the test protocols for Division 1 certification are more stringent than those for Division 2. Thus a device approved for Division 1 is also permitted for use in Division 2, but not vice versa. For most response work this means that devices approved for Class I (vapors, gases), Division 1 (areas of ignitable concentrations), Groups A, B, C, D should be chosen whenever possible. At a minimum, an instrument should be approved for use in Division 2 locations.

- There are so many groups, classes, and divisions that it is impossible to certify an all-inclusive instrument. Therefore, select a certified device based on the chemicals and conditions most likely to be encountered. For example, a device certified for a Class II, Division 1, Group E (combustible metal dust) would offer little protection around a flammable vapor or gas.

D. Reliable and Useful Results

The response time, sensitivity, selectivity, accuracy and precision of an instrument are important in evaluating the reliability and usefulness of the data the instrument generates.

Response time, the interval between an instrument "sensing" a contaminant and generating data, is important to producing reliable and useful results in the field. Response time depends on: test(s) to be performed, dead time between sample periods (the time for analysis, data generation, and data display), and the sensitivity of the instrument. Response times for direct-reading instruments may range from a few seconds to several minutes.

Sensitivity is important when slight concentration changes can be dangerous. Sensitivity is defined as the ability of an instrument to accurately measure changes in concentration. Sensitive instruments can detect small changes in concentration. The lower detection limit is the lowest concentration to which instrument will respond to. The operating range is the lower and upper use limits of the instrument. It is defined by the lower detection limit at one end and the saturation concentration at the other end. It is important to use an instrument with an operating range that will accurately measure the concentration in the range of concern.

Amplification, a term often used synonymously (and incorrectly) with sensitivity, is the instrument's ability to increase very small electronic signals emanating from the detector to the readout. Changing the amplification of the detector does not change its sensitivity. However, it may be useful in calibration. Instruments with amplifier circuits can be effected by radio frequency from pulsed DC or AC power lines, transformers, generators, and radio wave transmitters.

Accuracy is defined as the relationship between a true value and the instrument reading. Precision is the indication of the reproduceability. These factors can be indicated by the error factor. For example, some detector tubes may have an error factor of $\pm 35\%$ of the true value; meaning the actual concentration of the chemical being measured is within a range of 35% higher or lower than the tube reading.

Selectivity is the ability of an instrument to detect and measure a specific chemical or group of similar chemicals. Additionally, selectivity is dependent upon interfering compounds which may produce a similar response. Selectivity and sensitivity must be reviewed and interpreted together. Interferences can affect the accuracy of the instrument reading.

Another consideration is that the instrument must give results that are immediately useful. Instruments should be direct reading, with little or no need to interpolate, integrate, or compile large amounts of data.

When selecting an instrument, compare the desired sensitivity, range, accuracy, selectivity, and ability to vary amplification of detector signals with the available instrument characteristics.

III. CALIBRATION AND RELATIVE RESPONSE

For an instrument to function properly in the field, it should be calibrated prior to use. Calibration is the process of adjusting the instrument readout so that it corresponds to the actual concentration. Calibration involves checking the instrument results with a known concentration of a gas or vapor to see that the instrument gives the proper response. For example, if a combustible gas meter is calibrated with a gas that is 20% of the lower explosive limit (LEL), then the instrument should read 20% of the LEL. If it does not read accurately, it is out of calibration and should be adjusted until accurate readings are obtained. Although an instrument is calibrated to give a one-to-one response for a specific chemical (the calibration gas), its response to other chemicals may be different. This variability is called relative response. A combustible gas indicator calibrated to pentane will give a higher instrument reading for Methane than the actual concentration (**Table 3**). The relative response of an instrument to different chemicals can be calculated by dividing the instrument reading by the actual concentration and is expressed as a ratio or a percent. Note that for the calibration standard the relative response should be 1.00 or 100%.

If the instrument is being used for a chemical that is not the calibration standard, then it may be possible to look at the manufacturer's information to get the relative response of that instrument for the chemical. Then the actual concentration can be calculated. For example, if the instrument's relative response for Xylene is .27 (27%) and the reading is 100 ppm (parts per million), then the actual concentration is 370 ppm (.27 x actual concentration = 100 ppm, then actual concentration = 100/.27 = 370 ppm). If there is no relative response data for the chemical in question, it may be possible to recalibrate the instrument. If the instrument has adjustable settings and a known concentration is available, the instrument may be adjusted to read directly for the chemical. As recalibration takes time, this is usually done only if the instrument is going to be used for many measurements of the special chemical.

TABLE 3 RELATIVE RESPONSE FOR A COMBUSTIBLE GAS INDICATOR CALIBRATED TO PENTANE			
Chemical	Concentration (% LEL)	Meter Response (% LEL)	Relative Response
Methane	50	85	170%
Acetylene	50	60	120%
Pentane	50	53	106%
1,4-Dioxane	50	37	74%
Xylene	50	27	54%

Source: Portable Gas Indicator, Model 250 & 260, Response Curves, Mine Safety Appliances Company, Pittsburgh, PA.

IV. TYPES OF DIRECT-READING INSTRUMENTS

A. Introduction

Many hazards may be present when responding to hazardous materials spills or uncontrolled waste sites. There are several types of instrumentation for detecting hazardous atmospheres. This section will discuss Oxygen indicators, combustible gas indicators, and toxic atmosphere monitors.

B. Oxygen Indicators

Oxygen indicators are used to evaluate an atmosphere for the following:

- Oxygen content for respiratory purposes. Normal air is 20.9% Oxygen. Generally, if the Oxygen content decreases below 19.5% it is considered Oxygen deficient and special respiratory protection is needed.

- Increased risk of combustion. Generally, concentrations above 25% are considered Oxygen-enriched and increase the risk of combustion.

- Use of other instruments. Some instruments require sufficient oxygen for operation. For example, some combustible gas indicators do not give reliable results at oxygen concentrations below 10%. Also, the inherent safety approvals for instruments are for normal atmospheres and not for Oxygen enriched ones.

- Presence of contaminants. A decrease in oxygen content can be due to the consumption (by combustion or a reaction such as rusting) of oxygen or the displacement of air by a chemical. If it is due to consumption then the concern is the lack of oxygen. If it is due to displacement then there is something present that could be flammable or toxic.

Oxygen deficient atmospheres may occur in unventilated areas or may by due to terrain variations in cases where heavier than air vapors may collect. Most indicators have meters which display the oxygen concentration from 0-25%. There are also oxygen indicators available which measure concentrations from 0-5% and 0-100%. The most useful range for response is the 0-25% oxygen content readout since decisions involving air-supplying respirators and the use of combustible gas indicators fall into this range.

Many instrument manufacturers make oxygen meters. They can be small hand-held units with or without pumps to draw the sample across the detector cell. Some pumps are single aspirating (hand-squeeze) bulbs, others are battery powered diaphragm pumps. Units that combine O_2 meters and combustible gas indicators into one instrument are available from a number of manufacturers. Also, flashing and audible alarms can be found on many instruments. These alarms go off at a pre-set oxygen concentration to alert the users even if they are not watching the meter. Manufacturers of oxygen indicators are found at the end of this manual section.

1. Principle of Operation

Oxygen indicators have two principle components for operation. These are the oxygen sensor and the meter readout. In some units air is drawn into the oxygen detector with an aspirator bulb or pump; in other units, the ambient air is allowed to diffuse to the sensor. The oxygen detector uses an electrochemical sensor to determine the oxygen concentration in air. A typical sensor consists of: two electrodes; a housing containing a basic electrolytic solution; and a semipermeable Teflon membrane (**Figure 2**).

Oxygen molecules (O_2) diffuse through the membrane into the solution. Reactions between the oxygen, the solution and the electrodes produce a minute electric current proportional to the oxygen content. The current passes through the electronic circuit. The resulting signal is shown as a needle deflection on a meter or digital reading.

2. Limitations and Considerations

The operation of oxygen meters depends on the absolute atmospheric pressure. The concentration of natural oxygen (to differentiate it from manufactured or generated oxygen) is a function of the atmospheric pressure at a given altitude. While the actual percentage of oxygen does not change with altitude, at sea level the weight of the atmosphere above is greater, and more O_2 molecules (and the other components of air) are compressed into a

given volume than at higher elevations. As elevation increases, this compression decreases, resulting in fewer air molecules being "squeezed" into a given volume. Consequently, an O_2 indicator calibrated at sea level and operated at an altitude of several thousand feet will falsely indicate an oxygen deficient atmosphere because less oxygen is being "pushed" into the sensor. Therefore, it is necessary to calibrate at the altitude the instrument is used.

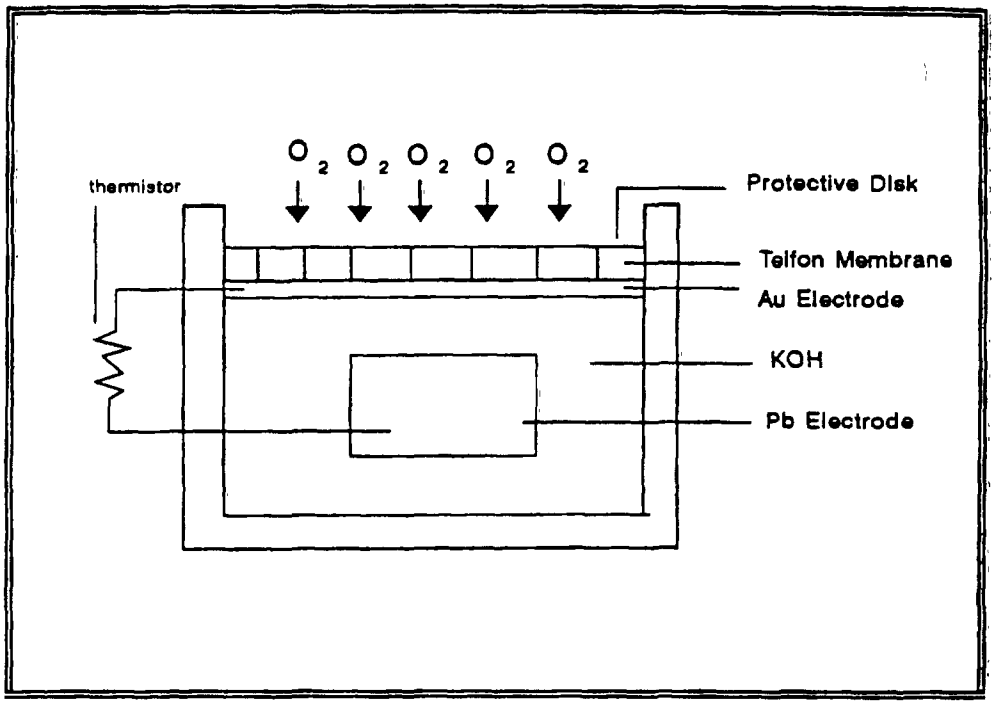

FIGURE 2
SCHEMATIC OF OXYGEN SENSOR
Selection from Product Literature, Rexnard Electronic Products Division, Biomarine Oxygen Sensor, by Rexnard, Inc., reprinted with permission of publisher.

High concentrations of carbon dioxide (CO_2) shorten the useful life of the oxygen sensor. As a general rule, the unit can be used in atmospheres greater than 0.5% CO_2 only with frequent replacing or rejuvenating of the sensor. Lifetime in a normal atmosphere (0.04% CO_2) can be from one week to one year depending on the manufacturer's design.

Temperature can affect the response of oxygen indicators. The normal operating range for them is between 32°F and 120°F. Between 0°F and 32°F the response of the unit is slower. Below 0°F the sensor may be damaged by the solution freezing. The instrument should be calibrated at the temperature at which it will be used.

Strong oxidizing chemicals, like ozone and chlorine, and bromine can cause increased readings and indicate high or normal O_2 content when the actual content is normal or even low.

C. Combustible Atmosphere Indicators

Combustible gas indicators (CGIs) measure the concentration of a flammable vapor or gas in air, indicating the results as a percentage of the lower explosive limit (LEL) of the calibration gas.

The LEL (or LFL - lower flammable limit) of a combustible gas or vapor is the minimum concentration of the material in air which will propagate flame on contact with an ignition source. The upper explosive limit (UEL) is the maximum concentration. Above the UEL, the mixture is too "rich" to support combustion so ignition is not possible. Below the LEL there is insufficient fuel to support combustion.

CGI's are available in many styles and configurations. All units have some type of pump to draw the air sample into the detector. The pumps are either hand operated square bulbs or automatic (battery-powered) diaphragm types. Many units are "combination meters". This means they have an O_2 meter and CGI (and sometimes one or two specific gas indicators) combined in the same instrument. Flashing and audible alarms are options on many units. The alarms go off at a pre-set concentration to warn the instrument operator of potentially hazardous concentrations. Other options such as larger sampling lines, moisture taps, all dust filters are also available. Manufacturers of CGIs are listed at the end of this manual section.

Concentrations between the LEL and the UEL are considered flammable.

1. Principle of Operation

Combustible gas indicators use a combustion chamber containing a catalytic filament or bead that combusts the flammable gas. To facilitate combustion the filament is heated or is coated with a catalyst (like Platinum or Palladium), or both. The filament is part of a balanced resistor circuit called a Wheatstone Bridge. The hot filament combusts the gas on the immediate surface of the element, thus raising the temperature of the filament. As the temperature of the filament increases so does its resistance. This change in resistance causes an imbalance in the Wheatstone Bridge.

This is measured as the ratio of combustible vapor present compared to the total required to reach the LEL. For example, if the meter reads 0.5 (or 50%, depending upon the readout), this means that 50% of the concentration of combustible gas needed to reach a flammable or combustible situation is present. If the LEL for the gas is 5% then the meter indicates that a 2.5%

concentration is present. Thus, the typical meter readout indicates concentration up to the LEL of the gas (**Figure 3**).

If a concentration greater than LEL and lower than the UEL is present, then the meter needle will stay beyond the 1.0 (100%) level on the meter (**Figure 3**). This indicates that the ambient atmosphere is readily combustible. When the atmosphere has a gas concentration above the UEL the meter needle will usually rise above the 1.0 (100%) mark and then return to zero (**Figure 3**). This occurs because the gas mixture in the combustion cell is too rich to burn. This permits the filament to conduct a current just as if the atmosphere contained no combustibles at all. Some instruments have a lock mechanism that prevents the needle from returning to zero when it has reached 100% and must be reset in an atmosphere below the LEL.

2. Metal Oxide Semiconductor

This solid state sensor is used for both combustible gas and toxic gas detection. The solid state of the MOS unit is still a connection through the wheatstone bridge circuit for detection of imbalance in the circuit. The major difference is that the MOS works on decreased resistance and the filament or bead works on increased resistance.

Principle of Operation:

A small ceramic stone is coated with a metal oxide, usually zinc or tin. The ceramic is heated to a preset temperature and gives off a certain number of O_2 Ions. The material that is being drawn through the ceramic stone strips these ions in relation to its own valence shell.

As the ions are stripped they result in a cooling of the stone and the imbalance is recorded through the circuitry to the meter face. The sensor cannot discriminate between a variety of materials, particularly hydrocarbons. It cannot identify a particular material which elicits a meter response unless it is the only material which is present. Another drawback of this type of sensor is that it may not purge all gases immediately, thus causing false positives. This purge can sometimes take as long as 2-6 hours for complete clearing.

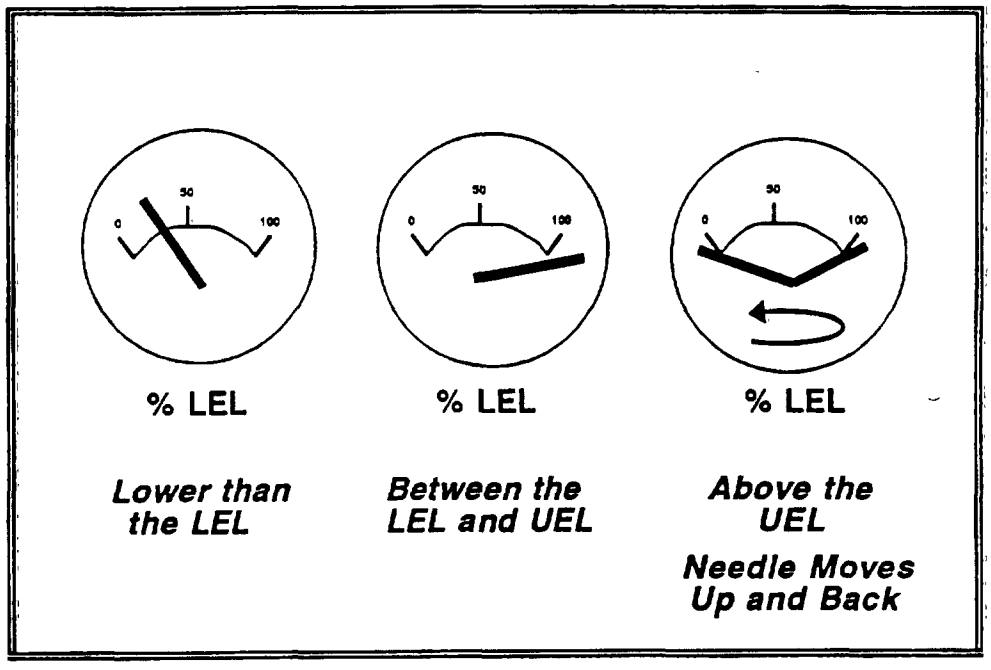

FIGURE 3
COMPARISON OF METER READINGS TO COMBUSTIBLE GAS CONCENTRATIONS

3. Limitations and Considerations

The response of the instrument is temperature dependent. If the temperature at which the instrument is zeroed differs from the ambient temperature, the accuracy of the reading is affected. Hotter temperatures raise the temperature of the filament and produce a higher than actual reading. Cooler temperatures will reduce the reading. This works exactly opposite in the MOS instrument. It works best to calibrate and zero the instrument at the ambient temperature.

The instruments are intended for use only in normal oxygen atmospheres. Oxygen-deficient atmospheres will produce lowered readings. Also the safety guards that prevent the combustion source from igniting a flammable atmosphere are not designed to operate in an oxygen-enriched atmosphere.

Organic lead vapors (e.g. gasoline vapors), sulfur compounds, and Silicone compounds will foul the filament. Acid gases (e.g. hydrogen chloride and hydrogen fluoride) can corrode the filament. Most units have an optional filter that protects the sensor from leaded vapors.

There is no differentiation between petroleum vapors and combustible gases. If the flammability of the combined vapors and gases in an atmosphere is the concern this is not a problem. However, if the instrument is being used to

detect the presence of a released flammable liquid - like gasoline - in a sewer system where methane may be present, the operator can't tell if the reading is the contaminant or the methane. A pre-filter can be used to remove the vapors but will not remove the methane. Thus, if readings are made with and without the filter, the user can compare the readings and can conclude that differences in the values indicate that a petroleum vapor (i.e. the contaminant) is present.

D. Toxic Atmosphere Monitors

Along with oxygen concentration and flammable gases or vapors, there is a concern about chemicals present at toxic concentrations.

This usually involves measurements at concentrations lower than would be indicated by oxygen indicators or combustible gas indicators. There is a need to determine if toxic chemicals are present and identify them so the environmental concentration can be compared to exposure guidelines. Toxic atmosphere monitoring is done to:

- identify airborne concentrations that could pose a toxic risk to response workers and the public.
- evaluate the need for and type of personal protective equipment.
- set up work zones or areas where contaminants are or are not present.

There are several different groups of instruments that can be used for these functions.

1. Colorimetric Indicator Tubes (Detector Tubes)

a. Principle of Operation

Colorimetric indicator tubes consist of a glass tube impregnated with an indicating chemical (**Figure 4**). The tube is connected to a piston- or bellows- type pump. A known volume of contaminated air is pulled at a predetermined rate through the tube by the pump. The contaminant reacts with the indicator chemical in the tube, producing a change in color whose length is proportional to the contaminant concentration.

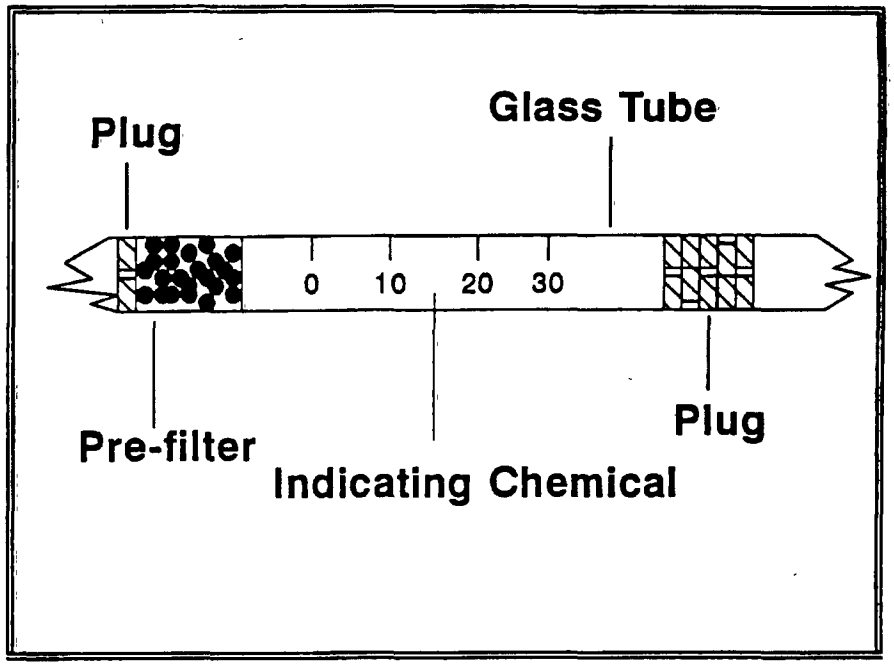

FIGURE 4
DIRECT-READING COLORIMETRIC INDICATOR TUBE

Detector tubes are normally chemical specific. There are different tubes for different gases; for example, chlorine detector tube for chlorine gas, acrylonitrile tube for acrylonitrile gas, etc. Some manufacturers do produce tubes for groups of gases, e.g. Aromatic hydrocarbons, alcohols. Concentration ranges on the tubes may be in the ppm or percent range. A preconditioning filter may precede the indicating chemical to:

- remove contaminants (other than the one in question) that may interfere with the measurement. Many have a prefilter for removing humidity.
- react with a contaminant to change it into a compound that reacts with the indicating chemical.

"Haz-mat kits are available from at least two manufacturers. These kits identify or classify the contaminants as a member of a chemical group such as acid gas, halogenated hydrocarbon, etc. This is done by sampling with certain combinations of tubes at the same time by using a special multiple tube holder or by using tubes in a specific sampling sequence. Detector tube manufacturers are listed at the end of this manual section.

b. Limitations and Considerations

Detector tubes have the disadvantage of poor accuracy and precision. In the past, the National Institute for Occupational Safety and Health (NIOSH) tested and certified detector tubes that were submitted to them. For the tubes they tested they certified the accuracy to be $\pm 35\%$ at concentrations at 1/2 the OSHA Permissible Exposure Limit (PEL) and $\pm 25\%$ at 1 to 5 times the PEL. NIOSH has discontinued testing and certification. Special studies have reported error factors of 50% and higher for some tubes.

The chemical reactions involved in the use of the tubes are affected by temperature. Cold weather slows the reactions and thus the response time. To reduce this problem it is recommended that the tubes be kept warm (for example, inside a coat pocket) until they are used if the measurement is done in cold weather. Hot temperatures increase the reaction and can cause a problem by discoloring the indicator when a contaminant is not present. This can happen even in unopened tubes. Therefore, the tubes should be stored at a moderate temperature or even refrigerated during storage.

Some tubes do not have a prefilter to remove humidity and may be affected by high humidity. The manufacturer's instructions usually indicate if humidity is a problem and list any correction factors to use if the tube is affected by humidity.

The chemical used in the tubes deteriorates over time. Thus the tubes are assigned a shelf life. This varies from 1 to 3 years. Shelf life can be extended by refrigeration but the tube should equilibrate to ambient temperature before use.

An advantage that detector tubes have over some other instruments is that it is possible to select a tube that is specific to a chemical. However, some tubes will respond to interfering compounds. Fortunately, the manufacturers provide information with the tubes on interfering gases and vapors.

Interpretation of results can be a problem. Since the tube's length of color change indicates the contaminant concentration, the user must be able to see the end of the stain. Some stains are diffused and are not clear cut; others may have an uneven endpoint. When in doubt use the highest value that would be obtained from reading the different aspects of the tube.

The total volume to be drawn through the tube varies with the tubes. The volume needed is given as the number of pump strokes needed, i.e. the number of times the piston or bellows is manipulated. Also, the air does not instantaneously go through the tube. It may take 1 to 2 minutes for each volume (stroke) to be completely drawn.

Therefore, sampling times can vary from 1 to 30 minutes per tube. This can make the use of detector tubes time consuming.

Due to these many considerations, it is very important to read the instructions that are provided with and are specific to a set of tubes. The information includes the number of pump strokes needed, time for each pump stroke, interfering gases and vapors, effects of humidity and temperature, shelf life, proper color change and whether the tube is reusable.

While there are many limitations and considerations for using detector tubes, detector tubes allow the versatility of being able to measure a wide range of chemicals with a single pump. Also, there are some chemicals for which detector tubes are the only direct-reading indicators.

2. Specific Chemical Monitors

There are several gas monitors which utilize electrochemical cells or metal oxide semi-conductors (MOS) for detecting specific chemicals. MOS detectors change conductivity when exposed to certain gases or vapors. They can be designed to respond to a large group of chemicals or to a specific chemical. The most common monitors are used to detect carbon monoxide or hydrogen sulfide but there are also monitors available for hydrogen cyanide, ammonia and chlorine. They are more accurate than detector tubes but there are only about a dozen different chemicals they can monitor.

V. RADIATION

There are three primary categories of radiation that might be encountered in a field survey: (1) alpha, (2) beta, and (3) gamma. Each of these has unique characteristics that must be considered in selecting an instrument for use. Alpha radiation is particulate and is simply the nucleus of an helium ion (2 protons, 2 neutrons, and no electrons). Because of their large size (mass or 4), and high charge (double positive), they readily interact with any thing they come into contact with and will not penetrate through much matter. Alpha particles only travel about an inch in air, and can normally be stopped by a sheet of paper. Beta radiation is also particulate, but is relatively small in size (mass of .00055) as compared to alpha radiation. Beta particles can have a positive or negative charge (depending on the decay scheme), and are more penetrating than alpha particles. They can travel up to about a meter in air, and can normally be stopped by a few millimeters of material such as plastic or aluminum. Gamma radiation is not particulate and is simply high energy light (photons). It is the most penetrating of the radiation types. Very high energy gamma radiation can penetrate through several centimeters of most materials, so thick, dense, heavy materials such as lead and iron are needed to stop gamma radiation.

There are hazards associated with exposure of humans to radiation, but if the exposure is limited to low levels, that hazard is not very serious. In fact, humans are exposed to natural

background radiation every day. Naturally occurring radioactive materials can be found in the soil, building materials, certain foods, and even the human body. The unit used to quantify the radiation dose received by an individual is the roentgen equivalent man (rem). The average dose, due to natural background radiation and natural radioactive materials in the environment, to an individual in the United States is about 0.2 rem/year.

The actual health risk from low-levels of radiation is quite small. There is no direct evidence that low doses of radiation can injure the health of humans. All of the estimates of the health risks associated with radiation have been extrapolated from studies of people who have received doses equivalent to hundreds of rem. It has been assumed that very low levels of radiation would affect the body in the same way as these very high doses, only with proportionately less damage. As radiation passes through matter, it may interact and lose energy. The damage done by radiation as it interacts with the body results from the way it affects molecules essential to the normal functioning of human cells. One of four things may happen when radiation strikes a cell: (1) the radiation may pass through the cell without doing any damage, (2) the cell may be damaged but repairs itself, (3) the cell may be damaged so that it not only fails to repair itself, but reproduces in damaged form over a period of years, or (4) the cell may be killed. The death of a single cell may not be harmful because the body can readily replace most cells, but problems will occur if so many cells are killed that the body cannot properly function. Incompletely or imperfectly repaired cells can lead to delayed health effects such as cancer, genetic mutations, or birth defects. Again, it is important to recognize that the risks from radiation are small. For example, the statistical risk of a cancer death from 7 millirem of radiation is equivalent to that associated with smoking a single cigarette.

Radiation cannot be detected by any of the human senses. We cannot taste, smell, feel, see or hear it. Because of this, we must rely upon instruments that respond to an interaction between the radiation and the instrument itself. Radiation is nothing more than energetic particles or photons.

As the radiation passes through matter, it interacts with the material's electrons to lose some of the energy. This energy results in either excitation or ionization of atoms. Depending upon the type of detector, either the excitation or the ionization is sensed, quantified, and the instrument produces a response that is proportional to the total amount of radiation that is present in the area being monitored or surveyed.

Portable survey instruments are calibrated to read out in either counts per minute (CPM), in direct units or radiation intensity, such as milli-Roentgen/hour (mR/hr) or micro-Roentgen/hour (μR/hr). Instruments reading out in mR/hr and μR/hr are used to measure extended radiation fields such as that experienced in the vicinity of radioactive materials' storage or disposal sites. Instruments that read out in CPM are usually used to monitor for low-level surface contamination, particularly on hard, nonporous surfaces.

One of the difficulties in measuring radiation is that there is always some background level of radiation present. This background will vary with location; some regions of the country will have higher background than others, brick buildings will have higher backgrounds than wooden buildings, etc. Because of this variation, when any survey instrument is used, a

determination of local background must be made in an area that is not believed to contain any radioactive materials. Any reading significantly above the background (two to three times background) is indicative of the presence of radioactive materials. Background levels throughout the United States will typically range between 5 and 100 μR/hr. The United States Environmental Protection Agency limits the radiation exposure to workers to 1 mR/hr above background. This action level is specified in the EPA's *Standard Operating Safety Guides*.

The detectors used in most portable survey instruments are gas-filled or scintillation devices. The gas-filled detectors measure the amount of ionization in the gas that is caused by radiation entering the detectors. This is accomplished by establishing a voltage potential across a volume of gas. When the gas is ionized, the current that flows between the electrodes producing the potential can be measured. The amount of current is directly proportional to the amount of radiation that enters the detector. Scintillation detectors depend upon light that is produced in a crystal plastic, of certain compounds, when the material's atoms are excited by interactions with radiation. The amount of light produced is measured and converted to an easily monitored electrical signal by a photomultiplier tube. There are gas-filled and scintillation detectors designed to detect all three of the radiation types of interest in field surveys.

The most obvious difference in detectors used for different radiation types is the manner in which radiation can enter the sensitive volume of the detector. Many gamma survey instruments will not appear to have a detector, but only an electronics box. This is because the gamma can easily penetrate the metal electronics enclosure and the detector is placed inside where it is protected from damage. The Ludlum Model 19 Micro R meter is an example of such a detector. Alpha and beta detectors must have thin entrance windows so that these particles can enter the sensitive volume. Some gas filled detectors are designed with a thick metal shield so they can discriminate between beta and gamma; with the shield open, the detector is sensitive to both beta and gamma; with it closed, it will detect only gamma, since the shield absorbs the beta before they can interact with the detector.

A good survey meter should be portable, rugged, sensitive, simple in construction, and reliable. Portability implies lightness and compactness with a suitable handle or strap for carrying. Ruggedness requires that an instrument be capable of withstanding mild shock without damage. Sensitivity demands an instrument which will respond to the type of energy level of the radiation being measured. Rarely does one find an instrument capable of measuring all types and energies of radiation that are encountered in practice. Simplicity in construction necessitates convenient arrangement of components and simple circuitry comprised of parts which may be replaced easily. Reliability is that attribute which implies ability to duplicate response under similar circumstances.

Ludlum Model 19 Micro R Meter

The Ludlum Model 19 Micro R Meter is designed to monitor low-level gamma radiation. The instrument utilizes an internally mounted Sodium iodide scintillator crystal. The meter face has two scales, one in black representing 0-50 μR/hr and one in red representing 0-25

μR/hr. The meter range is controlled with a six position switch: OFF, 5000, 500, 250, 50 and 25. The full scale reading of the meter is equal to the switch setting; the red scale corresponds to the 25 and 250 position and the black scale to the other three positions. As an example, if the switch is in the 500 position and the meter pointer is aligned with the "30" scale marking, the radiation field is 300 μR/hr.

The Ludlum Model 19 is equipped with five additional switches or buttons. One button, labeled L, lights the meter face while depressed. This allows accurate readings in poor lighting conditions. The BAT button tests the battery condition. If the batteries are good, the meter pointer will deflect to the "batt OK" portion of the scale. The audio switch controls the audible signal; in the ON position, a "beeping" signal accompanies each radiation event that is detected. The switch marked with the F and S controls the meter response; the S (slow) position is used for most applications, although in conditions where the radiation level is changing rapidly, the F (fast) position will provide a better representation of the radiation level. The remaining button resets the detector operating high voltage should a transient pulse cause it to be disabled.

Detector Probes

Detector probes will fall into two major categories: gas-filled detectors and scintillation detectors. These have been briefly discussed in the introduction section. This section will describe a few of the most commonly used probes.

The Geiger-Mueller (GM) pancake probe is very common and is most valuable for monitoring for surface activity on equipment, benchtops, soil surface and personnel. The probe may be used to monitor alpha, beta or gamma radiation. The sensitive volume of the detector is covered with a thin mica window of about 1.75 inch diameter. This window allows detection of alpha and low energy beta. The fragile window is protected by a metal screen, and care must be taken to avoid puncturing it.

End-window GM probes may also be used for alpha, beta, and gamma monitoring. These tubes are generally cylindrical, about 6-8 inches long and have mica entrance windows about 1 inch in diameter. The window often does not have a protective screen and is easily punctured. Because of its configuration, this tube is not as convenient as a pancake probe for surface monitoring. Also, because of the smaller entrance window, it is less efficient for detecting alpha and beta.

Thin-walled GM probes are used for beta and gamma detection. The tube is constructed within steel walls through which beta rays can pass. The tube is housed in a protective cage fitted with a movable steel shield. With the shield in place, beta are absorbed and only gamma can be detected. When the shield is moved away from the cage opening, the detector is sensitive to both beta and gamma.

Scintillation probes are available for alpha, beta, and gamma. They differ in the type of scintillator used and the detector housing. Alpha detectors are made of thin activated Zinc sulfide crystals. The beta detectors generally use thin scintillation plastic crystals. Gamma probes use thick crystals of activated Sodium iodide. Beta and alpha probes have entrance windows of thin aluminized mylar. This window protects the detector from light which would be sensed by the photomultiplier as if it were a high radiation field. Care must be taken not to puncture the window.

The alpha probes often have large surface areas (50-100 cm^2) to allow efficient detection of low levels of alpha contamination. The gamma detectors are usually housed in an Aluminum shell. This shell is not easy to puncture and is quite rugged, although dropping or banging it against a hard object may break the crystal or the photomultiplier.

Personnel Dosimeters

The amount of radiation dose received by an individual working in a radiation field is measured by the use of personnel dosimeters. Two types that are frequently used are the direct-reading dosimeter and the thermoluminescent dosimeter (TLD).

The direct-reading dosimeter provides an immediate indication of the gamma radiation dose the wearer has received. By checking his dosimeter periodically, the wearer can get an up-to-the-minute estimate of the total gamma dose he/she has received. Only gamma radiation is measured. There is no way that beta radiation can penetrate the walls of the dosimeter to cause ionization.

Inside the detection chamber of the dosimeter is a stationary metal electrode with a movable quartz fiber attached to it. The dosimeter is charged so that both the electrode and the fiber are positively charged. Because both are positively charged, they repel each other, and the movable fiber moves as far away from the electrode as it can. When gamma radiation causes ionization in the detection chamber, the negative ions move to the positively charged electrode or fiber. This action reduces the positive charge and allows the fiber to move a little closer to the stationary electrode. The movement of the fiber, then, is a measure of the amount of gamma radiation absorbed by the detector.

In direct-reading pocket dosimeters, a scale is placed so that the hairline on the scale is the movable fiber. As the fiber moves, the scale indicates the total amount of gamma radiation absorbed by the dosimeter. A magnifying glass inside the dosimeter enables the scale to be read. This provides an immediate estimate of an individual's total gamma exposure.

Anyone who is instructed to wear a direct-reading dosimeter should make sure that it is properly charged. When a dosimeter is properly charged, there is sufficient potential between the electrode and the fiber that the fiber is significantly displaced and the hairline on the scale reads near zero. In general, a dosimeter is considered adequately charged if it reads below 10 mR.

If a dosimeter is not properly charged, a charger must be used to charge it before it can be worn. The dosimeter is pushed into the charger, and the charger control is turned until the dosimeter is zeroed. The dosimeter must be checked again after it is taken out of the charger. Sometimes the hairline shifts when the dosimeter is removed from the charger, and the dosimeter will have to be readjusted so that the hairline will end up at or near zero.

Because the direct-reading dosimeter measures the whole-body gamma radiation dose, it should be worn on the trunk of the body. When using a dosimeter, care must be taken not to bang or drop it. Rough treatment may cause the electrode to discharge completely, sending the hairline all the way upscale.

Thermoluminescent dosimeters (TLDs) are often used for beta and gamma whole-body measurements. Inside the TLD is a very small quantity of crystalline material called a detector chip that is used to measure beta and gamma exposure. A typical detector chip is approximately 1/8 inch across and 1/32 inch thick.

To understand how a detector chip measures radiation, we first need to go through a short review of electron energy levels. As we know, electrons in a solid material prefer to be in their ground energy state. This is especially true for a crystalline material. If radiation imparts enough energy to one of these electrons, the electron will jump up to a higher, instable energy level. However, since the electron prefers to be in the ground state, it will drop to the ground state and emit the extra energy in the form of heat, x-rays, or light.

In TLD material, there is an in-between state called a metastable state, which acts as an electron trap. When radiation strikes the ground state electron, the electron jumps up and is trapped in the metastable state, It remains there until it gets enough energy to move it up to the unstable state. This energy is supplied when the TLD chip is heated to a high enough temperature. Then the electron will drop back down to the ground state and, because the TLD chip is a luminescent material, it will release its extra energy in the form of light. The total quantity of light emitted by electrons returning to the ground state is proportional to the number of electrons that were trapped in the metastable state. The number of electrons trapped in the metastable state is proportional to the amount of beta and gamma radiation that interacts with the material. This means the amount of light emitted when the TLD is heated is proportional to the total amount of beta and gamma radiation interacting with the material.

In the photomultiplier tube, electrons are produced in the photocathode, multiplied across the dynodes, and finally collected on the anode. This then produces a pulse in the circuit that is proportional to the total amount of beta and gamma radiation absorbed by the TLD material.

There are several reasons for using TLDs instead of film badges. One reason is size - TLD chips are so small that they can be taped to the fingers to measure exposure to the extremities without interfering with work. A second reason is sensitivity. The TLD is generally more sensitive than a film badge, more accurate in the low mR range, and able to provide a better overall indication of the total beta/gamma dose received. A third reason is that the TLD chip can be reused after it is read.

As with the direct-reading dosimeter, TLD is normally worn on the trunk of the body to give the best indication of whole-body dose. There are times, however, when these devices might be worn on other parts of the body. For example, a TLD might be moved to an arm or a leg if these portions of the body might receive more radiation than the trunk area. An additional device such as a finger ring might also be used to measure an extremity dose. A finger ring contains a TLD chip to measure absorbed dose from beta and gamma radiation.

APPENDIX I

DIRECT-READING INSTRUMENTS USED FOR EVALUATION				
Hazard Monitored	**Instrument**	**Application**	**Detection Method**	**Notes**
Combustible Gas/Vapor	Combustible Gas Indicator	Measures the concentration of a combustible gas or vapor.	A filament is heated by burning the combustible gas/vapor. The increase in heat is measured.	Calibrated before use.
Oxygen Deficiency	Oxygen Meter	Measures the percentage of oxygen in air.	Uses an electrochemical sensor to measure the partial pressure of oxygen in air.	Calibrated before each use in normal air.
Ionizing radiation	Geiger-Muller (G-M) counter Scintillator tube	Environmental radiation monitor. Some monitors can distinguish among the types of ionizing radiation.	G-M: ionizing radiation reacts with inert gas producing electric current radiation. Scintillator: ionizing radiation produces photons of light within a crystal. Crystals are specific to types of radiation e.g., Sodium iodide crystal for gamma radiation.	Must be calibrated annually at a specialized facility.
Organics	1) Colorimetric tubes	Measure concentration of specific gases and vapors.	The substance reacts with the indicator chemical producing a stain whose length in the tube is proportional to the concentration of the substance.	Leak test before use. Check flow rate and volume periodically. Check shelf life of tubes before use.
	2) Flame ionizing Detector (FID) with Gas Chromatograph (GC) Option.	Measure total concentration or organics in survey mode; identifies and measure specific compounds in GC mode.	Gases and vapors are ionized in a flame. A current is produced in proportion to the number of carbon atoms present.	Requires experience to operate. Fuel source is Hydrogen.

APPENDIX I

DIRECT-READING INSTRUMENTS USED FOR EVALUATION				
Hazard Monitored	**Instrument**	**Application**	**Detection Method**	**Notes**
Organics cont'd	3) Photoionizing Detectors	Measures total concentrations of substance(s). Some identification of compounds is possible if more than one probe is used.	Ultraviolet radiation ionizes molecules, produces ions proportional to concentration.	Does not detect methane. Compounds have different ionization potentials.
	4) Portable infrared Spectrophotometer	Designed to quantify component mixtures.	Infrared radiation (IR) is passed through a sample; each compound will absorb IR at a specific frequency. Amount of absorption is proportional to concentration.	Requires knowledge of IR frequencies for chemical. Short battery life. Needs to be operated at a stable location (table top).
	5) Catalytic Combustion Meters (Super Sensitive Combustible Gas Indicators)	Measures substances capable of being combusted.	Oxidation takes place on the surface of a heated catalytic bead element. Oxidation is proportional to concentration.	Similar to CGI, but used for ppm measurements.
Inorganics (Volatile)	1) Colorimetric tubes	Measure concentration of specific inorganic gases and vapors.	See previous description.	See previous note.
	2) Photoionizing Detectors	Measure total concentration of some inorganics.	See previous description.	See previous note.
	3) Portable Infrared Spectrophotometer	Designed to quantify one or two component mixtures. Will detect oxides of Nitrogen, Ammonia, Hydrogen cyanide, Hydrogen fluoride and Sulfur dioxide.	See previous description.	See previous note.

APPENDIX I

DIRECT-READING INSTRUMENTS USED FOR EVALUATION				
Hazard Monitored	**Instrument**	**Application**	**Detection Method**	**Notes**
Inorganics (Volatile) cont'd	4) Specific Chemical Monitors	Measure concentration of specific gases and vapors.	Electrochemical sensor or metal oxide semiconductor UV light absorption for Mercury vapor detection.	Limited number of chemical can be detected. Even through specific, there can be interferences.
Aerosols/*Particulates	Direct-Reading Instruments for Analyzing Airborne Particulates.	Measures and sizes the concentration of aerosols in air.	Operates on one of four basic techniques: 1) Optical 2) Electrical 3) Piezoelectric	Individual instruments have specific notes. Instruments are available to measure fibers.
*These direct-reading instruments will readout total or respirable aerosol matter not the composition of the aerosols. The content, e.g., Lead, pesticides, of a dust, fume, mist, fog, spray or smoke must be separately.				

RESPONSE ORGANIZATION

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, students will be able to:

1. Establish a command structure, communication levels, and lines of authority for response to a hazardous materials incident

2. Given parameters diagram an incident command structure

3. Establish lines of communication and authority within that structure

4. Identify the major areas of concern for given levels of the structure

5. As a member of a team, establish goals and objectives

6. Function in the assigned position for a given scenario

7. Recognize the need for a Scene Safety Plan and be able to implement one

8. As a member of a team, identify resources needed for a given scenario

9. As a member of a team, identify areas of concern related to safety.

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

RESPONSE ORGANIZATION

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RESPONSE ORGANIZATION

I Introduction

The number of personnel needed to respond to a hazardous materials incident can vary greatly. Regardless if a few or many responders are involved they must be organized. Without a coordinated, organized effort, the primary reason for responding, to protect the public's health, the environment and property, may be ineffective.

Every hazardous material incident is unique. The materials involved, their effects as well as the operations required to prevent or reduce the effects of their release, are incident specific. Common, however, to all incidents is the need for planning, organizing, locating resources, and implementing response operations.

II. Contingency Plans for Emergency Response

When an incident involving hazardous materials, or any other kind of man-caused or natural disaster occurs, people in the effected area may attempt to control and alleviate the situation. Some sort of organization, will naturally take place.

Without a community emergency contingency plan, the ability to effectively manage any incident is diminished. Time is wasted defining the problem, organizing personnel, locating resources and taking action. These obstacles effect response activities creating additional problems that might have been avoided if prompt actions were taken.

A more effective response to any kind of man made or natural disaster, including hazardous materials accidents, occurs when a contingency plan exists. Contingency plans anticipate the myriad of problems faced by responders and through the planning process develop, in advance, guidelines to follow and complete in an effective way. A functional response organization is developed and resources are identified. Notification systems are determined and arrangements made to obtain technical, as well as, other necessary resources.

When the plan is activated, the organization can begin to function, rapidly. Control activities are initiated with less confusion and fewer delays than are encountered in implementing operations in a "no-plan" response. A pre-existing plan also reduces the risk to both the responders and the public by establishing, in advance, procedures for protecting their health and safety.

A contingency plan can lessen many of the problems encountered in a response to hazardous materials. However, even a good, tested plan can not anticipate and address all the circumstances created by a release of chemicals. A well-written plan acknowledges that incident-specific adaptations are necessary and is written to provide flexibility.

Hazardous Materials Contingency Plans to be effective must be:

Well-written	Flexible
Continuously reviewed and modified	Frequently Tested
Agreed upon by all involved	Current

III. Organizing The Response Effort

The number of people responding to an incident may vary greatly, and represent a variety of personnel from government as well as private industry. Some incidents are readily managed by trained responders from local jurisdictions. Others may require additional responders from state and federal agencies and from private industries. These groups, each with diverse functions and responsibilities, must be organized into a cohesive response team unit capable of conducting the required tactical activities.

Hazardous Materials Emergency Response Plans exist at each level of government. Each local, state, and federal agency defines how that level of government will respond, establishes the response organization, and provides operational procedures. The federal response plan recognizes the role of local and state responders in a federal response effort. It contains provisions for mechanisms for coordinating response efforts at all levels of government. Likewise, state plans contain their role, responsibilities and relationship with local government response activities.

In general, federal, state and local response plans vary considerably in detail and scope. Local plans are usually more specific, state and national plans are not as definitive. Typically however, whichever plan is in effect, the organization plan involved is adapted and modified to meet the needs of the incident.

To function efficiently, the organization established must:

1. Provide a leader
2. Establish authority
3. Develop policy and procedures
4. Determine objectives
5. Assign responsibilities
6. Manage resources (money, equipment, and personnel)
7. Plan and direct operations
8. Establish internal communications
9. Establish communications with outside organizations

IV. Table of Organization

In any organization involving more than a few responders, it is necessary to define its structure. This structure of organization defines the relationship between the various components (division, branches, or sections). It delineates a chain of command and establishes internal communication channels.

Organization tables are complemented by functional statements which describe the authority, responsibilities and duties of the components. To a large degree, the form and complexity of the organizational chart and the functional statements, depend on the magnitude of the incident, the operations needed and the number of people or agencies involved. The key requirements of an organizational chart are:

1. Delineating a chain-of-command
2. Assigning responsibilities and functions
3. Specifying personnel requirements
4. Establishing internal communications

V. Incident Command System (ICS)

A major incident requires a large response force with individuals performing many specialized functions. The Incident Command System is designed to be flexible enough to permit the Incident Commander to adapt it to any situation and still maintain management control over responding personnel. The size and complexity of the organization needed is dictated by the magnitude of the particular incident.

The ICS establishes a chain-of command, and lists key personnel and their functions (see Section 4 of you student manual for the ICS we are using, also see the Incident Command Package, and Section V of this section).

VI. Key Personnel and Their Functions

Key personnel and their assignments are normally specified in the response plan. As operations commence adaptations may be needed in the preplanned structure of the organization. During the incident unanticipated operations may be required, requiring functional additions to the organization.

Major incidents require many people with a diversity of expertise and skills. Key personnel and the functions they execute should be tailored to meet the needs of a particular hazardous materials incident.

Key personnel and functions that may be needed are:

INCIDENT COMMANDER: Responsible for incident activities including the development and implementation of strategic decisions and for approving the ordering and releasing of resources.

RECORDER: Responsible for the collection and organization of incident situation and status information.

SAFETY OFFICER: Responsible for monitoring and assessing hazardous, unsafe conditions and developing measures for assuring personnel safety of the overall incident. Also may terminate, alter, and suspend activities.

OPERATIONS OFFICER: Responsible for the management of all operations directly applicable to the primary mission.

SCIENCE OFFICER: Responsible for management of the identification team and reporting on progress of identification of unknown or known substance.

RESOURCE OFFICER: Responsible for procuring personnel, equipment, and supplies. Also responsible for receiving and staging all supplies for the incident, maintaining an inventory of supplies and expendable and nonexpendable supplies and equipment.

ENTRY TEAM: Responsible for completing the goals and objective set forth by the Operations Officer.

BACKUP TEAM: Responsible for knowing the goals and objective of the Entry Team set forth by the Operation Officer and to stay in the ready position as long as the Entry Team is in the "HOT ZONE", for the immediate rescue of the Entry Team or any other assistance that may be needed.

DECONTAMINATION TEAM: Responsible for appropriate decontamination procedures and installation of decon equipment as assigned to by the Operations or Decon Officer within the Contamination Reduction Corridor (CRC) (Warm Zone).

* PUBLIC INFORMATION OFFICER: Responsible for the formulation and release of incident information to the news media and other appropriate agencies and organizations.

* SECURITY OFFICER: Responsible for evacuation procedures, (on and off site), and providing overall incident control, (traffic and incident).

* ASSISTANT SECURITY OFFICER: Responsible for assisting the Security Officer in evacuation, incident control and traffic control.

* ASSISTANT SAFETY: Responsible for assisting the Safety Officer in coordinating safety activities directly related to the hazardous materials operation.

* DECONTAMINATION OFFICER: Responsible for supervising and control of all phases of the contamination reduction zone (CRZ) (Warm Zone).

* THESE ICS POSITIONS ARE ONLY FOR THE TRANSPORTATION INCIDENT ON FRIDAY.

VII. Implementing Response Operations

The release or potential release of a hazardous material requires operations that will eventually restore the situation to as near as possible to pre-incident conditions. Although each incident establishes its own operational requirements, there is a general sequence of response operations common to all responses.

Planning and implementing a response, as a minimum, requires the responders to:

Organize: Establish an organization, select key personnel, assign responsibilities and make modifications as operations proceed.

Evaluate the Situation: Based on available information make preliminary hazard evaluation. Determine impact of incident with or without intervention.

Develop a Plan of Action: Develop preliminary operations plan for collecting information, implementing immediate countermeasures and rescue operations and instituting emergency actions. Continually reevaluate the situation as supplemental information becomes available.

Make Preliminary Off-Scene Surveys: Collect additional data to evaluate situation (use direct-reading instruments, collect sample(s), make visual observations). Institute emergency actions to protect public health and the environment. Identify requirements for on-scene reconnaissance. Determine levels of protection, if necessary, for off-scene personnel. Establish boundaries for contaminated area(s).

Make Initial On-Scene Reconnaissances: Collect data (use direct-reading instruments, collect samples, make visual observations) to determine or verify hazardous conditions and make an overall assessment of the incident. Modify initial entry safety procedures as more data is obtained. Determine levels of protection for initial entry team(s) and subsequent operations. Plan and implement scene control and decontamination procedures.

Modify Original Plan of Action: Modify or adapt original plan based on additional information obtained during initial entry(s). Revise immediate emergency measures. Plan long term actions including:

1. Additional monitoring and sampling
2. Containment / confinement options
3. Cleanup and restoration measures
4. Resource requirements
5. Site safety plan
6. Legal implications and litigation
7. Site activity documentation

Of paramount importance in any response is the safety and health of the responders. Their risk increases as they get closer to the hazardous materials. Operations on-scene, must be carefully planned and executed. Before entering the immediate area of a release or potential release, as much information as possible should be collected. For example, shipping papers, transportation placards, existing records, container labels and other visual observations (in the time available) concerning the types and degree of hazard and risks which may exist, are useful.

Available information is used to determine:

1. Whether off-site measurements are needed
2. The need to go on-site
3. The types of equipment available
4. What data is needed to evaluate hazards
   - Organic vapors/gases
   - Inorganic vapors/gases
   - Particulate
   - Oxygen concentration
   - Radiation
   - Samples needed for laboratory analysis
5. Levels of protection for entry team(s) needed
6. What equipment is needed
7. The number and size of entry team(s)
8. Frequency of briefings for the response team
9. The need for site control procedures including:
   - Designation of work zones
   - Access control
   - Physical barriers
10. What decontamination procedure are required
11. The need for having backup medical resources
12. Taking emergency actions/countermeasures
13. The priority for collecting data and samples

All the above information is layout in the Scene Safety Plan that has to be developed and implemented for each incident (the Scene Safety Plan is in the student workbook as well as, in the Safety Officer's book and forms). The Instructor will assist in filling out this form.

VIII. Summary

To effectively prevent or reduce the impact of a hazardous materials incident on people, environment or property the personnel responding must be organized into a structured response organization. For the response organization to be effective it must be developed in advance, be tested and be an integral part of a Hazardous Materials Contingency Plan. To a large degree, the success of the response is dependent upon how well the response personnel are organized. When an organization (specified in a contingency plan) is developed, it must be flexible enough to adapt to the ever changing conditions created as the incident progresses, whether large or small.

APPENDIX I: INCIDENT COMMANDER'S GUIDANCE DOCUMENT

I. Command Structure

A. Fill in command chart as personnel are assigned and hand out incident command clipboards.

B. Vest and equipment will not be available until the day of the incident.

II. Response Team Staffing

A. PERSONNEL

The following positions and functions represent possible operational requirements of a major response effort;

1. INCIDENT COMMANDER:

   Responsible for incident activities including the development and implementation of strategic decisions and for approving the ordering and releasing of resources.

2. RECORDER:

   Responsible for the collection and organization of incident status and situation information.

3. SAFETY OFFICER:

   Responsible for monitoring and assessing hazardous, unsafe conditions and developing measures for assuring personnel safety of the overall incident.

4. OPERATIONS OFFICER:

   Responsible for the management of all operations directly applicable to the primary mission.

5. SCIENCE OFFICER:

   Responsible for management of the identification team and reporting on progress of identification of unknown or known substance.

6. RESOURCE OFFICER:

Responsible for procuring personnel, equipment, and supplies, receiving and staging all supplies for the incident, maintain an inventory of supplies and servicing nonexpendable supplies and equipment.

7. ENTRY TEAM:

Responsible for completing the goals and objectives set forth by the Operations Officer.

8. BACK-UP TEAM:

Responsible for knowing the goals and objectives of the Entry Team set forth by the Operation Officer and to stay in the ready position as long as the Entry Team is in the "HOT ZONE", for the prepare of rescue or any other assistance that may be needed.

9. DECONTAMINATION TEAM:

Responsible for the appropriate decontamination procedures and installation of decon equipment as assigned to them by the Decon Officer within the Contamination Reduction Corridor (CRC).

*10. PUBLIC INFORMATION OFFICER:

Responsible for the formulation and release of incident information to the news media and other appropriate agencies and organizations.

*11. SECURITY OFFICER:

Responsible for evacuation procedures, (on and off site), and providing overall incident control, (traffic and incident).

*12. DEPUTY SECURITY OFFICER:

Responsible for assisting the Security Officer in evacuation, incident control and traffic control.

*13. ASSISTANT SAFETY:

Responsible for assisting the Safety Officer in coordinating safety related activities directly related to the hazardous materials operation.

*14. DECONTAMINATION OFFICER:

Responsible for supervising and control of all phases of the contamination reduction zone (CRZ).

* These ICS positions are only for the Transportation Incident on Friday.

B. ORGANIZATIONAL FUNCTION STATEMENT

An organizational function statement and chart should be developed at the earliest possible time to determine the necessary operations and communication channels that are to be established for incident activities. Consideration should be given to the following:

1. Chain of command.
2. Delegation of authority.
3. Clearly defined functions and communication.
4. Work relationships and activities coordination.
5. Internal channels of communication.
6. Limit on responsibility.
7. Sequence of activities and order of initiation.
8. Contingency planning.

C. RESPONSE TEAM ACTIVITIES WORK SHEETS

The following work sheets shall be given to the appropriate personnel and should be used to help assist in providing a safer operation.

1. INCIDENT COMMANDER:

a. Command Structures
b. Defining Hazardous Materials Problems
c. The Chemtox Hot Line
d. Hazardous Materials Information Sources
e. Hazardous Materials Tactical Command Sheet
f. Scene Overview

2. RECORDER:

a. Unit log, 4 pages
b. Hazardous Material Incident Report-Fixer Facility

3. SAFETY OFFICER:

a. Safety Officer worksheet
b. Scene Safety Plan, 12 pages
c. HazMat Incident Medical Evaluation Chart
d. Personnel Protection and Exposure Chart

4. OPERATIONS:

a. Operation Officer worksheet
b. Pre-entry checklist
c. Briefing and Debriefing forms, 3 pages

5. SCIENCE OFFICER:

a. Hazardous Substance Data Sheet, 3 pages
b. Hazardous Materials Response form, 2 pages

6. RESOURCE OFFICER:

a. Hazardous Materials Incident Cost Recovery Form, 3 pages
b. Resource list for warehouse exercise
c. Local recourse list

7. DECONTAMINATION TEAM:

a. Decontamination checklist
b. Team needs to write out and develop there own decontamination plan and chart.

III. Personal Protection Equipment

A. SELECTION CRITERIA

Equipment to protect the body against contact with known or anticipated chemical hazard severity, manner of exposure, and route(s) of entry. Select from the four categories of protective equipment which were developed according to the degree of protection afforded. Those categories and their respective use are as follows:

LEVEL A:

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

LEVEL B:

Should be worn when the highest level of respiratory protection is needed, but a lesser level of skin protection. Level B is the minimum level recommended on initial incident entries until the hazards have been further defined by on-scene surveys and appropriate personnel protection is used.

LEVEL C:

Should be worn when the type(s) of airborne substances is known, the concentration(s) is measured, and the criteria for using air purifying respirators are met.

LEVEL D:

Should not be worn on any incident with respiratory or skin hazard. It is primarily a work uniform providing minimum protection.

B. REPRESENTATIVE EQUIPMENT

The following represents personal protection equipment identified for each level of protection and should be worn by designated individuals. Science Officer needs to do the research to determine the appropriate level of protection and selection of suit material.

1. LEVEL A

Use equipment as worn in Level A exercise with 2-way radio inside suit attached to SCBA.
"PLEASE DO NOT USE ANY TAPE ON LEVEL A SUITS"

2. LEVEL B

Use equipment as worn in Level B exercises with 2-way radios attached to the SCBA. Tape can be used on level suits.

3. LEVEL C

There are no air purifying respirators available, if the criteria of APR's are met, then these can be simulated.

4. LEVEL D

Whatever clothing personnel are wearing, will comply with this level.

IV. Response Team Equipment and Materials

A. Use the resource list provided. If additional equipment is required, submit a request to an instructor. You cannot simulate any item without instructor approval.

B. Use local resources list for supplies and agencies to support the incident. You may write-in any local resource available in your area.

C. The Hazardous Materials Incident Cost Recovery Form must be completed at the end of the incident.

V. Field Reference Sources

A. All references shown in the information resource section is available to use. If you require other references, ask an instructor.

B. Fill out the Hazardous Substance Data Sheet and Hazardous Response Form.

C. Science Officer needs to research to determine:

1. Physical/chemical properties
2. Level of protection
3. Compatible suit material
4. Decontamination solution needed for decon.

VI. Decontamination Equipment and Layout

A. Your decon equipment is listed on the resource list and will be together in one area for your use at the incident location. If you need more equipment, mark the location in the decon line with a piece of tape and write on it the type of equipment needed.

B. The layout of the decontamination line must to be completed using the information received in the decon section. You must have a written diagram.

C. The Science Officer needs to do the research to determine the proper solution to use.

VII. Atmospheric Hazard Guidelines

A. Determine the type of data needed.

B. Using the proper instrument and good operating technique, the instructor may give you readings. Indications of emissions from the incident such a continuous CGI reading of 25% or greater, less than 19.5% oxygen, or 1mR/hr of Ionizing radiation are present, EPA action levels, if any or all of these condition exists, reevaluate the situation.

C. See Scene Safety Plan for more define details.

D. Use the Atmospheric Hazard Guidelines as a reference.

VIII. Personal Exposure and Medical Evaluation

A. <u>PERSONAL EXPOSURE</u>

The Personnel Protection and Exposure Chart must be filled out every time a worker goes into any work zone after the work zones have be established.

B. PERSONAL MEDICAL EVALUATION

The HazMat Incident Medical Evaluation Chart must be filled out before and after any worker gets into any level of protection.

IX. Health and Safety Practices

A. Health and safety requirements for incident operations must be designed not only to protect personnel against the hazards associated with chemical substance, but also to minimize injury or harm due to other types of hazards such as electrical, heavy equipment operations, falling objects, tripping, etc..

B. Personal precautions, such as controls that have been established in the Scene Safety Plans, must be followed.

C. A Scene Safety Plan must be developed encompassing all phases of the incident operations and made available to all personnel. This plan is the responsibility of the Safety Officer and is 12 pages long. Assistance in preparing the Scene Safety Plan can be obtained from the instructors.

X. Initial Scene Survey

A. An incident generally involves the escape of normally controlled substances into the environment via air, water, or land surfaces. Response activities involve control actions to minimize and prevent or reduce the transfer of contaminants from going from one zone to another or off-scene via the workers and/or equipment that may be contaminated. Initial Scene Survey must be done to help control the incident, as well as help establish incident goals and objectives.

B. To reduce the possibility of transfer of contaminants from zone to zone or transferred off-scene, controlling of contaminants is essential. This can be accomplished by establishing work zones. Issues which need to be addressed when establishing zones:

1. Physical barriers to exclude unnecessary personnel
2. Check points with limited access to the zones, or areas within the zones
3. Minimizing personnel and equipment in a zone
4. Establishment of containment zones
5. Decontamination procedures
6. Conducting operations in a manner to reduce the possibility of contamination

C. One method of reducing the potential for transfer of contamination off-scene is to delineate zones or work areas based upon expected contamination. Within the zones prescribed operations would occur utilizing appropriate personnel protection equipment. Movement between areas would be controlled at checkpoints. Three contiguous zones are recommended.

1. Exclusion or Hot Zone (contaminated area)
2. Contamination Reduction or Warm Zone (Contamination Reduction Corridor CRC)
3. Support or Cold Zone (Non-Contaminated area)

D. The use of a three-zone system of area designation, access control points and exacting decontamination procedures provides a reasonable assurance against the translocation of contaminating substance. This control system is based on a "worst case" situation and requires a larger number of personnel and an abundance of equipment and material to operate. Less stringent scene control and decontamination procedures or adaption of the procedures described may be utilized based upon more accurate information on the types of contaminants involved and the contaminating hazards they present. This information can be obtained through air monitoring, instrument survey, wipe tests for possible personnel or equipment contamination and technical data concerning the characteristics and behavior of material present. Predicated upon having more reliable data about encountered conditions, scene control requirement should be modified for the specific situation.

E. When locating a field command post, and other support necessities in the support or Cold Zone are dependent on a number of factors including:

1. Wind direction - Preferably the Command Post should be located upwind of the incident exclusion zone. However, wind directions shift and other conditions may be such that the ideal location based on wind direction does not exist.
2. Accessibility - The terrain, woods, topography and space, may limit availability of Command Post location.
3. Roads - Adequate roads or unavailability thereof.
4. Proximity to incident - Relatively easy access to the incident is needed.
5. The instructors will establish the following:
   a. Command post location
   b. Exclusion or Hot Zone and line
   c. Wind direction will always be in your favor
6. Establishment of zone dimensions takes considerable planning to assure safe working distances for each zone which are balanced against practical work considerations. Physical and topographical barriers may constrain ideal locations.

XI. Reconnaissance

A. After establishing Hot Zone, than the initial on-scene reconnaissance must be considered. This can be accomplished by some or/all of the following;

1. Determine the reason for going on-scene
2. Determine data needs
   a. Rescue
   b. Combustible gases

c. Oxygen deficiency
d. Organic or inorganic vapors
e. Radiation

3. Instruments available
4. Level of protection needed - entry team
5. Number of personal in entry team
6. Number of personal in backup team
7. Medical evaluation completed on entry and backup teams
8. Establish the Warm and Cold zones.
9. Decontamination procedures must be setup before entry team can go in.
10. Emergency actions/countermeasures been established
11. Any additional equipment needed
12. Emergency actions to protect public and the environment
13. Brief entry and backup team before entry and debrief after entry

XII. Demobilization

A. Talk with responsible party to establish a cleanup contractor to take care of cleanup an disposal of all contaminated items.

B. Ensure incident has been mitigated and you have communicated with the cleanup contractor and they can handle the incident from mitigation to restoring property as close to normal as possible per EPA requirements.

C. Ensure that an orderly, safe, and cost effective removal of personnel and equipment is accomplished at the completion of the incident.

DECONTAMINATION

STUDENT PERFORMANCE OBJECTIVES

At the conclusion of this unit, participants will be able to:

1. Describe the components that make up a decontamination plan

2. List four of the eight basic ways to prevent contamination on personnel and equipment

3. Describe four of the eight ways a decon member can stop cross contamination

4. Name five areas on protective clothing that get contaminated the easiest

5. State the basic decon solution

6. Describe two testing methods to show effective decon

7. State the basic differences between level A and level B decon

8. Recommend the minimum level of protection for:
   a. Setting up the decon line
   b. Working on the decon line

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

STUDENT PERFORMANCE OBJECTIVES (cont.)

9. Explain the disposal methods for decon

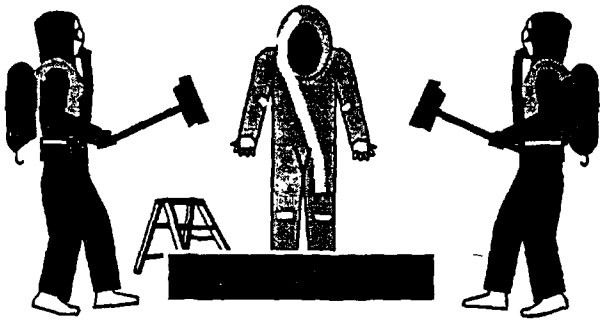
10. Identify who decontaminates the decon members

11. Demonstrate how to do medical decon.

NOTE: Unless otherwise stated, the conditions for performance are using all references and materials provided in the course, and the standards of performance are without error.

NOTES

DECONTAMINATION



S-1

OBJECTIVES

- Regulations requiring decon
- Decontamination plan
- Preventing or reducing contamination
- Various types of decon

S-2

OBJECTIVES (cont.)

- Factors that influence decon
- PPE used for decon
- Disposal methods
- Medical emergencies

S-3

NOTES

REGULATION
OSHA 1910.120(q)

Employer shall develop plans

- Operations level = basic implementation
- Technician = understand and implement
- Specialist = determine and implement
- IC = understand importance

S-4

DEFINITION

The process of removing or neutralizing contaminants that have accumulated on personnel, property, and equipment

S-5

PLAN

- Development
- Part of scene safety plan
- Person responsible

S-6

NOTES

PLAN
Reasons

- Number and layout of decon stations
- Equipment needs
- Appropriate decon methods
- Contamination of clean areas
- Contaminant contact minimized
- Disposal of clothing and equipment

S-7

PLAN
Revision

REVISE THE PLAN WHENEVER:

- Level of PPE changes
- Ambient or other conditions change
- Hazards are reassessed

TRAIN ALL PERSONNEL ON THE PLAN

S-8

CONTAMINATION
Prevention

SAFE WORK PRACTICES

DO NOT:

Walk, sit, or stand, get splashed by, or come in contact with airborne or liquid materials unless it cannot be helped

KEEP:

Equipment and instruments out of contaminants whenever possible

S-9

NOTES

CONTAMINATION Prevention (cont.)

- Wear disposable garments
- Use disposable equipment when possible
- Cover equipment and tools when possible
- Use proper donning and doffing procedures
- Use remote sampling and handling equipment

S-10

CONTAMINATION Prevention (cont.)

PPE INSPECTION

- Ensure there are no cuts or punctures
- Close all flaps, zippers, buttons, and ties
- Tape openings of gloves, boots, and jackets
- Do not use tape on level A

S-11

CONTAMINATION Location

- Surface only or permeated into PPE
- Sometimes easy to detect and remove on the surface
- Permeated material may be difficult or impossible to detect and remove
- Without removal, permeation continues until breakthrough occurs

S-12

NOTES

FIVE MAJOR FACTORS OF PERMEATION

- Contact time
- Chemical concentration
- Temperature
  - Ambient
  - Chemical
- Size of chemical molecules
- Physical state (solid, liquid, or gas)

S-13

THREE DECON REMOVAL METHODS

1. Physical removal
   - Dislodging/displacement
   - Washing/rinsing
   - Wiping/brushing
   - Evaporation
   - High pressure (air or water)
   - Disposal
   - Vacuum (dry decon)

S-14

THREE DECON REMOVAL METHODS (cont.)

2. Chemical removal
   - Done only if recommended by a chemist, industrial hygienist, or qualified professional
3. Inactivate/inert
   - Chemical detoxification
   - Disinfection
   - Sterilization

S-15

NOTES

CLEANING SOLUTIONS

EPA RECOMMENDS ONLY SOAP AND WATER FOR ALL WET DECON

Before using any other solution, contact the chemical manufacturer and check chemical compatibility and suit material compatibility

S-16

TESTING DECON EFFECTIVENESS

- Visual observation
  - Discoloration or stains
  - Visible contaminant
  - Material degradation and breakdown
- Ultraviolet light
  - Hydrocarbons become visible

S-17

TESTING DECON EFFECTIVENESS (cont.)

- Wipe sampling
  - Dry or wet cloth swab; send to lab
  - Sample inner and outer surfaces
- Cleaning solution analysis
  - Sample final rinse
- Permeation testing
  - Send sample pieces from suit to lab

S-18

HEALTH AND SAFETY HAZARDS

- Compatibility of decon solution with PPE and hazardous substances
- Effective decon methods
- Personnel in control zones before decon is established (i.e., hot zone)

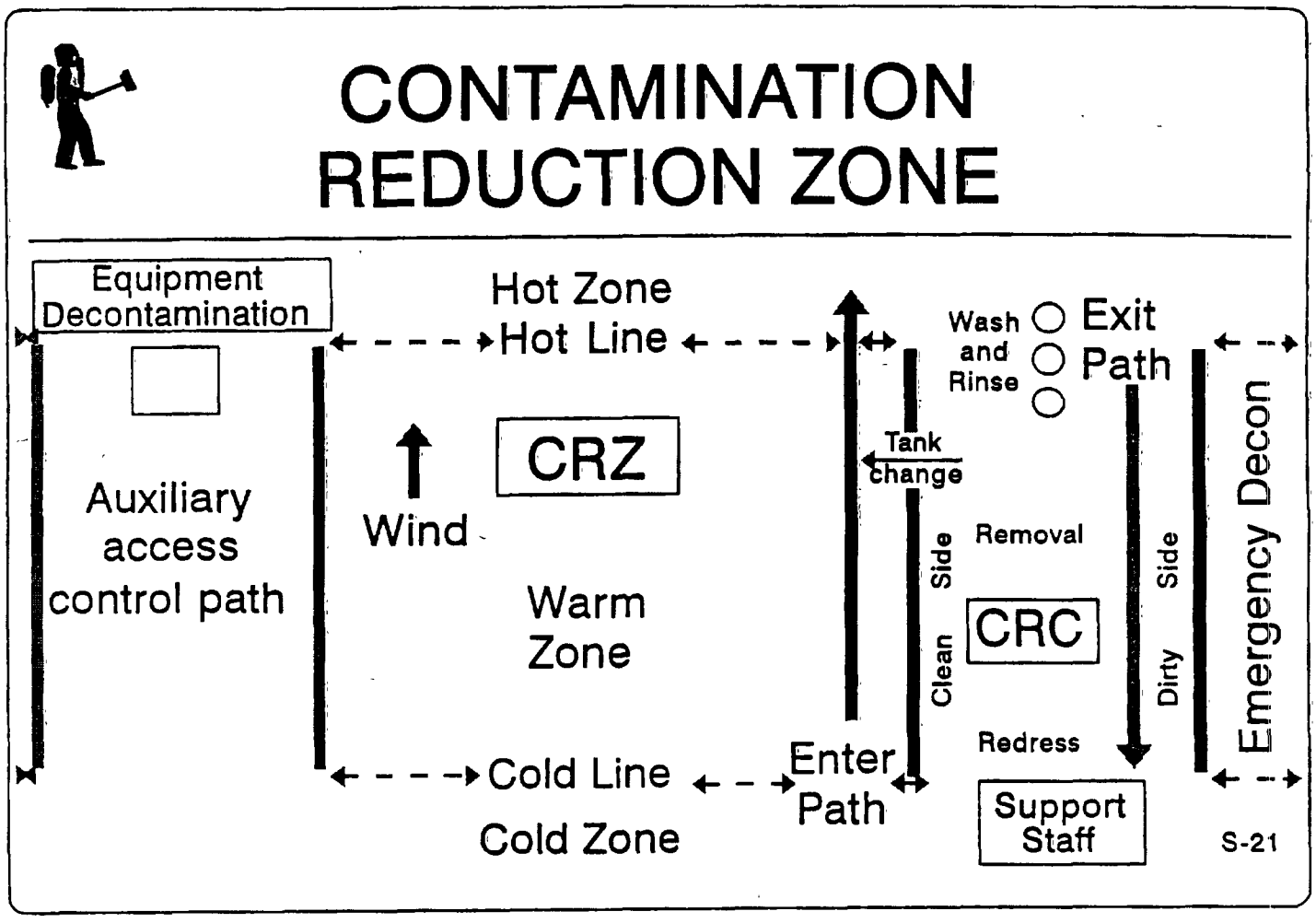
S-19

DECON DESIGN

- Located in the CRZ between the Hot and Cold Zones
- The level and type of decon are dependent on the material(s) found
- Should include emergency contingencies

S-20

NOTES


CONTAMINATION REDUCTION ZONE
Equipment Decontamination
Hot Zone
Hot Line
Wash and Rinse
Exit Path
CRZ
Tank change
Auxiliary access control path
Wind
Removal
Side
Side
Emergency Decon
Warm Zone
CRC
Clean
Dirty
Redress
Cold Line
Enter Path
Support Staff
Cold Zone
S-21

NOTES

DECON PROCEDURES

- Place chemically impervious ground cover in decon area
- Follow a series of specific tasks
- Perform work at several stations
- Separate work stations to prevent cross contamination
- Perform work in order of decreasing contamination (dirty to clean)

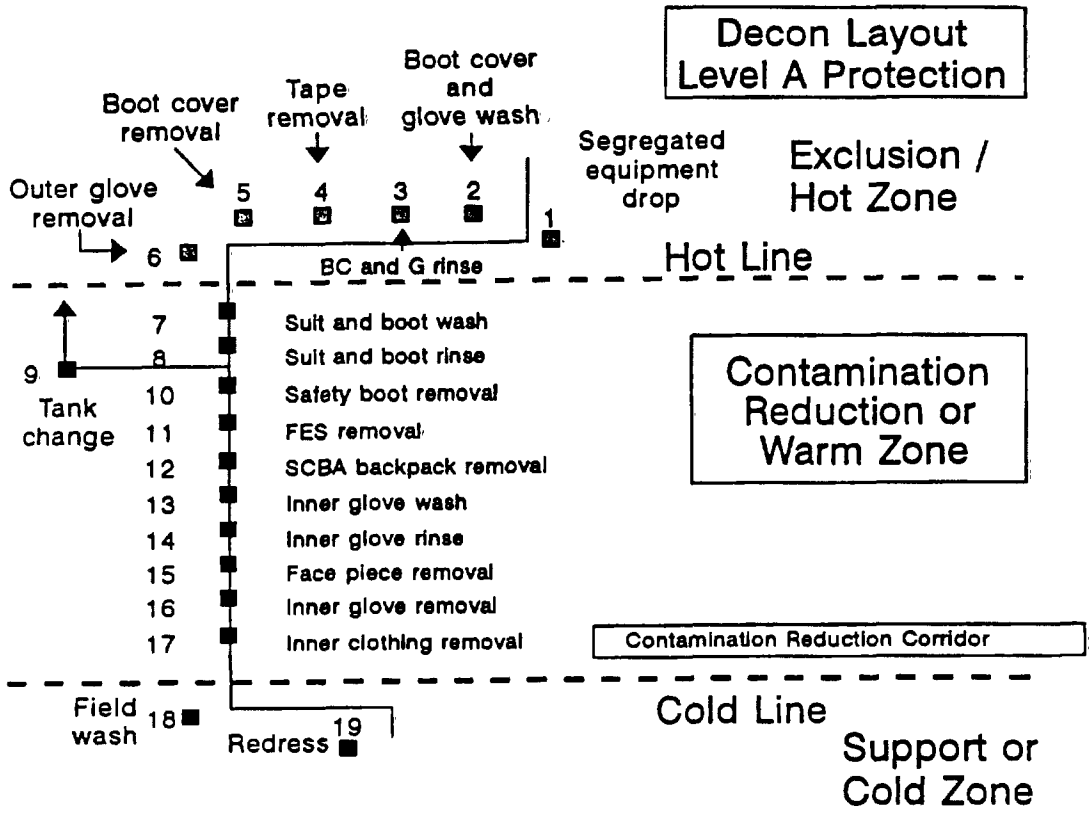
S-22

DECON PROCEDURES (cont.)

- Set up in a straight line when possible
- Size depends on:
  - Number of work stations
  - Scene layout and topography
  - Usually 75' × 15' is adequate

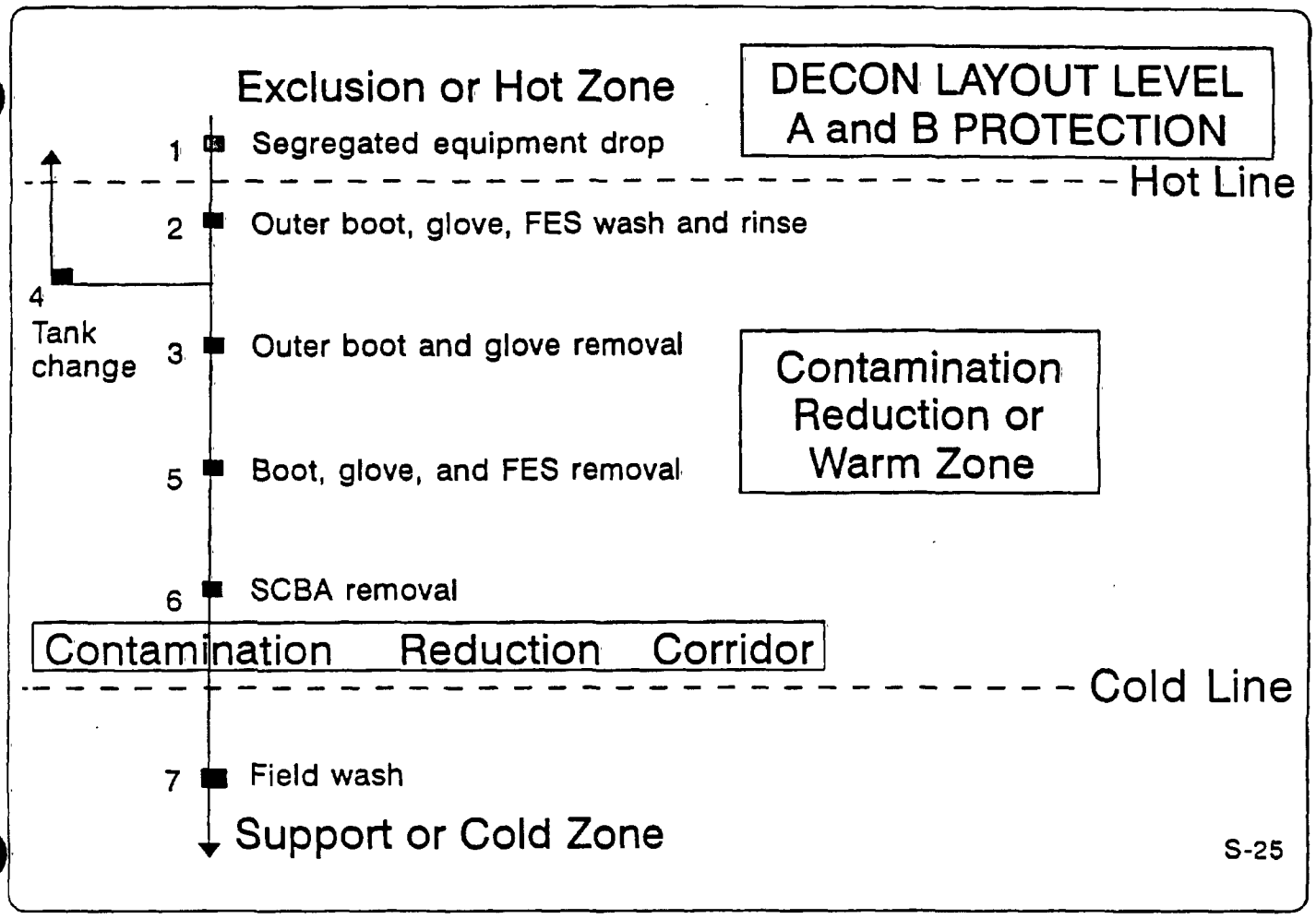
S-23

NOTES

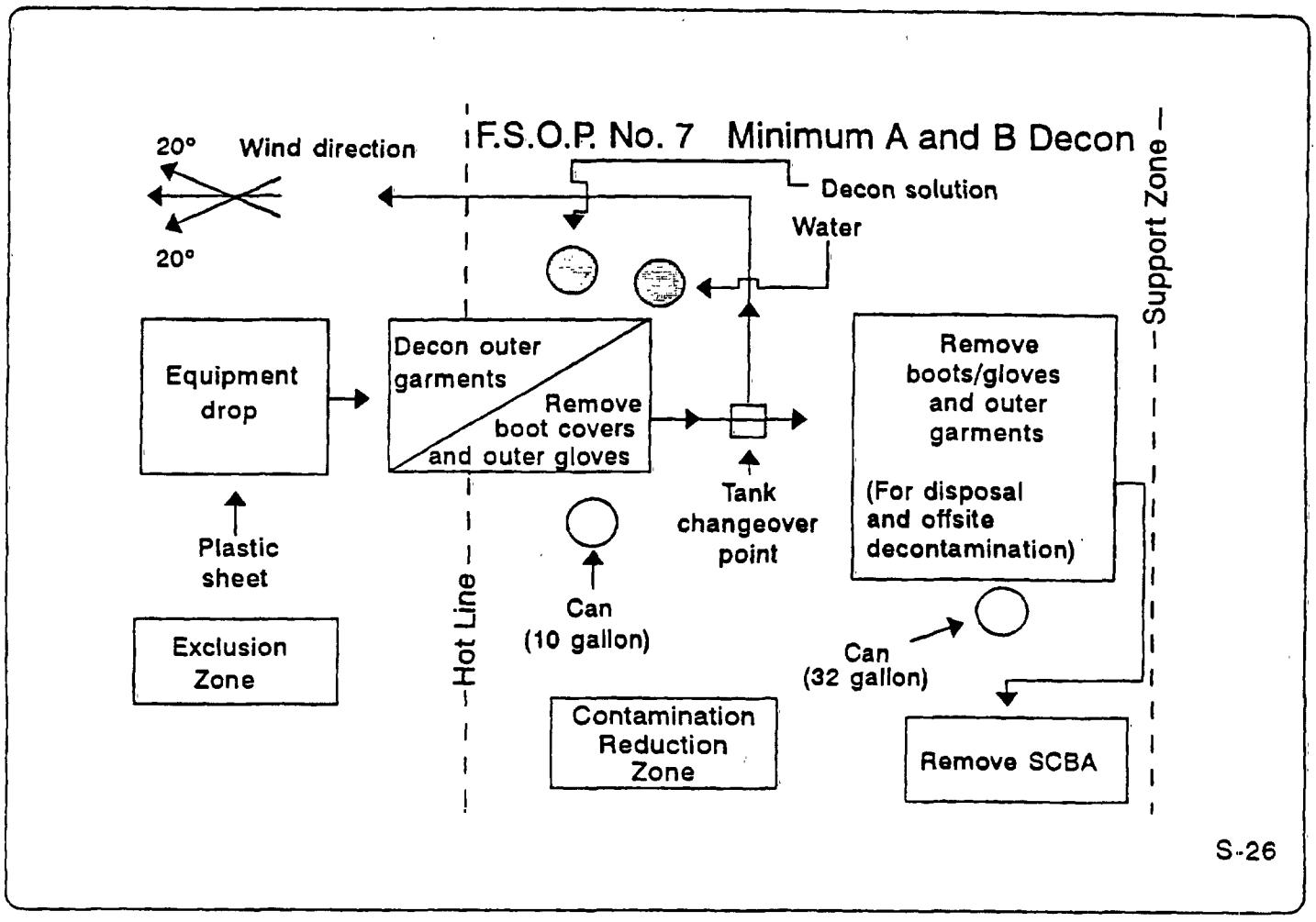

Decon Layout
Level A Protection
Boot cover removal
Tape removal
Boot cover and glove wash
Segregated equipment drop
Exclusion / Hot Zone
Outer glove removal
5
4
3
2
1
6
BC and G rinse
Hot Line
7
8
9
Tank change
10
11
12
13
14
15
16
17
Suit and boot wash
Suit and boot rinse
Safety boot removal
FES removal
SCBA backpack removal
Inner glove wash
Inner glove rinse
Face piece removal
Inner glove removal
Inner clothing removal
Contamination Reduction or Warm Zone
Contamination Reduction Corridor
Field wash
18
Redress
19
Cold Line
Support or Cold Zone

S-24

NOTES


Exclusion or Hot Zone
DECON LAYOUT LEVEL
A and B PROTECTION
1 Segregated equipment drop
Hot Line
2 Outer boot, glove, FES wash and rinse
4
Tank
change
3 Outer boot and glove removal
Contamination
Reduction or
Warm Zone
5 Boot, glove, and FES removal
6 SCBA removal
Contamination Reduction Corridor
Cold Line
7 Field wash
Support or Cold Zone
S-25

NOTES


F.S.O.P. No. 7 Minimum A and B Decon
20°
Wind direction
20°
Decon solution
Water
Support Zone
Equipment drop
Decon outer garments
Remove boot covers and outer gloves
Remove boots/gloves and outer garments
(For disposal and offsite decontamination)
Tank changeover point
Plastic sheet
Hot Line
Can (10 gallon)
Can (32 gallon)
Exclusion Zone
Contamination Reduction Zone
Remove SCBA
S-26

NOTES

NOTES

PERSONAL PROTECTION

- Decon workers can set up the decontamination reduction corridor in level D protection
- Once the warm zone has been activated, the minimum level of protection is one level less or the same as the entry team
- The first position in decon may require a greater level than the rest
- Decon workers must clean up their area, restock, and decon themselves

S-27

DISPOSAL METHODS

- All equipment used must be disposed of or decontaminated properly
- All spent solutions must be collected and disposed of properly
- Clothing and solid materials must be placed in plastic bags pending further testing, decon, and/or disposal according to local, state, or federal standards

S-28

EMERGENCY DECONTAMINATION

- The primary concern is for response personnel, then the public
  - Prevent loss of life
  - Prevent severe injury
- Plan for medical emergencies
  - Decon victim(s)
  - Protect medical personnel
  - Dispose of contaminated PPE

S-29

NOTES

EMERGENCY DECONTAMINATION (cont.)

Decision to decon victim is based on

- Type and severity of contamination or injury
- Immediate life-saving and first aid needs
- Aggravation of the injury or delay of life-saving treatment

S-30

EMERGENCY DECONTAMINATION (cont.)

- Wash, rinse, and/or cut off PPE or clothing
- Alert medical personnel of potential contamination; protect medic unit
- Send chemical information with the victim
- Send response personnel familiar with the incident with victim if possible

S-31

SELF-CONTAINED BREATHING APPARATUS

TOPIC		PAGE NO.
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	B. HOSE MASK	1
	C. AIRLINE RESPIRATOR	1
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	B. HIGH-PRESSURE HOSE	5
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SELF-CONTAINED BREATHING APPARATUS

VII. NFPA 1981 "OPEN CIRCUIT SELF-CONTAINED BREATHING APPARATUS FOR FIREFIGHTERS" 1987 EDITION 7

A. BASIC DESIGN REQUIREMENTS 8

B. GENERAL REQUIREMENTS 8

C. PERFORMANCE TESTS 8

1. AIRFLOW 8

2. THERMAL RESISTANCE TEST 8

3. VIBRATION AND SHOCK 9

4. FABRIC COMPONENTS TEST 9

5. ACCELERATED CORROSION RESISTANCE TEST 9

6. PARTICULATE RESISTANCE TEST 9

7. FACEPIECE LENS ABRASION RESISTANCE TEST 9

8. COMMUNICATIONS TEST 9

APP. I SCBA CHECKOUT-MSA MODEL 401 ULTRALITE II 10

SELF-CONTAINED BREATHING APPARATUS

I. INTRODUCTION

Respiratory apparatus must frequently be used during response to hazardous materials incidents. If the contaminant is unknown or the requirements for using air-purifying respirators cannot be met, then an atmosphere supplying respirator is required. Several types of atmosphere supplying devices are available:

A. Oxygen-generating

One of the oldest respirators is the oxygen-generating respirator, which utilizes a canister of potassium superoxide. The chemical reacts with water vapor to produce oxygen which replenishes the wearer's exhaled breath. Exhaled CO_2 is removed by a scrubber device containing lithium hydroxide. This reoxygenated air is then returned to the wearer. Oxygen-generating respirators have been used by the military and for escape purposes in mines. It generally is not used for hazardous material applications because of the chemical reaction taking place within the respirator itself.

B. Hose mask

This type of respirator consists of a facepiece attached to a large diameter hose which transports clean air from a remote area. In units where the wearer breathes the air in, the hose lines can go up to 75 feet. With powered units the hose length can vary from 50 to 250 feet.

C. Air line respirator

The air line respirator is similar to the hose mask, except that breathing grade air is delivered to the wearer under pressure; either from a compressor or a bank of compressed air cylinders. The air may flow continuously, or it may be delivered as the wearer breathes (demands it). The air source must not be depletable, and no more than 300 feet of air line is allowed. An escape device is required for entry into an IDLH atmosphere.

D. Self-contained breathing apparatus

The self-contained breathing apparatus (SCBA) consists of a facepiece and regulator mechanism connected to a cylinder of compressed air or oxygen carried by the wearer.

The self-contained breathing apparatus (SCBA) is generally used because it allows the wearer to work without being confined by a hose or air line. The wearer of the SCBA depends on it to supply clean breathing air.

If the wearer is not properly trained to wear the SCBA or it is not properly cared for, then it may fail to provide the protection expected.

The user should be completely familiar with the SCBA being worn. Checkout procedures have been developed for inspecting an SCBA prior to use, allowing the user to recognize potential problems. An individual who checks out the unit is more comfortable and confident wearing it.

There are two types of apparatus: closed-circuit, which use compressed oxygen, and open-circuit, which use compressed air. SCBA's may operate in one of two modes, demand or pressure-demand (positive-pressure). The length of time an SCBA operates is based on the air supply. The units available operate from 5 minutes to over 4 hours.

Pressure demand or positive pressure is the only approved type of open circuit SCBA for use in Hazardous Environments by the U.S. EPA and NFPA.

Both open- and closed-circuit SCBA's will be discussed and the modes of operation explained. The bulk of the discussion deals with open circuit pressure-demand SCBA's which are most widely used because they offer more protection.

II. MODES OF OPERATION

A. Negative Pressure

In the demand mode, a negative pressure is created inside the facepiece and breathing tubes when the wearer inhales (**Table 1**). This negative pressure draws down a diaphragm in the regulator in an SCBA. The diaphragm depresses and opens the admission valve, allowing air to be inhaled. As long as the negative pressure remains, air flows to the facepiece.

The problem with demand operation is that the wearer can inhale contaminated air through any gaps in the facepiece-to-face sealing surface. Hence, a demand apparatus with a full facepiece is assigned a Protection Factor of only 100, the same as for a full face air-purifying respirator.

B. Pressure-Demand

An SCBA operating in the pressure-demand mode maintains a positive pressure inside the facepiece at all times. The system is designed so that the admission valve remains open until enough pressure is built up to close it. The pressure builds up because air is prevented from leaving the system until the wearer exhales. Less pressure is required to close the admission valve than is required to open the spring-loaded exhalation valve.

At all times, the pressure in the facepiece is greater than the ambient pressure outside the facepiece. If any leakage occurs, it is outward from the facepiece. Because of this, the pressure-demand or positive pressure SCBA has been assigned a Protection Factor of 10,000.

TABLE 1 RELATIVE PRESSURE INSIDE AND OUTSIDE SCBA FACEPIECE		
	Demand	Pressure demand (positive pressure)
Inhalation	-	+
Exhalation	+	+
Static (between breaths)	same	+

III. TYPES OF APPARATUS

A. Closed-Circuit

The closed-circuit SCBA (**Figure 1**), commonly called the rebreather, was developed especially for oxygen-deficient situations. Because it recycles exhaled breath and carries only a small oxygen supply, the service time can be considerably greater than an open-circuit device, which must carry all of the user's breathing air.

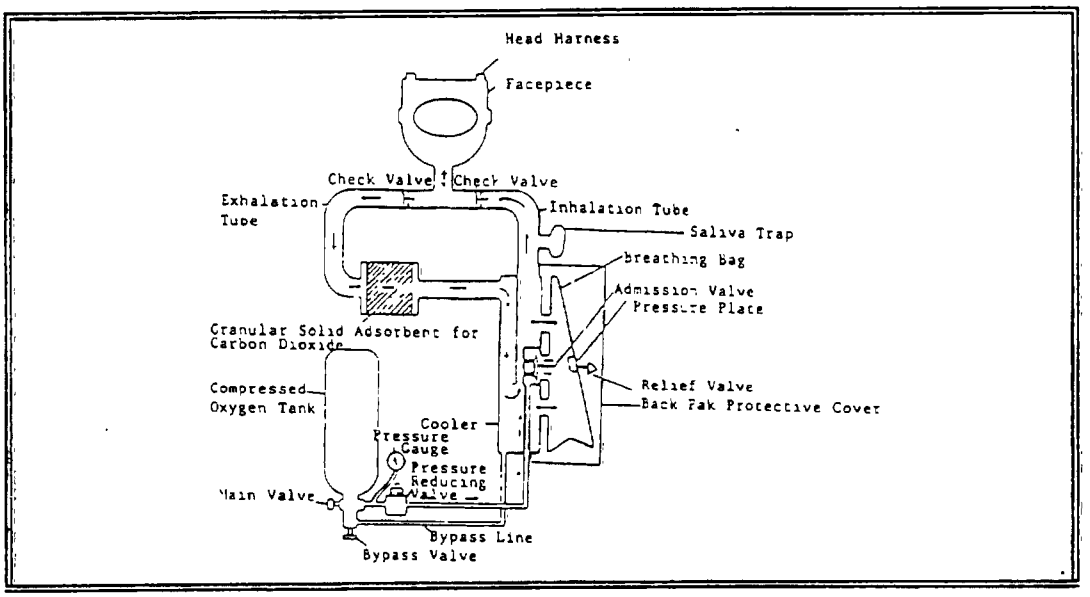

FIGURE 1
CLOSED-CIRCUIT SCBA

The air for breathing is mixed in a flexible breathing bag. This air is inhaled, deflating the breathing bag. The deflation depresses the admission valve, allowing the oxygen to enter the bag. There it mixes with exhaled breath, from which carbon dioxide has just been removed by passage through a CO_2 scrubber.

Most rebreathers operate in the demand mode. Several rebreathers are designed to provide a positive pressure in the facepiece. The approval schedule 13F under 30 CFR Part II for closed-circuit SCBA makes no provisions for testing "demand" or "pressure-demand" rebreathers. The approval schedule was set up to certify only rebreathers that happen to operate in the demand mode. Thus, rebreathers designed to operate in the positive pressure mode can be approved strictly as closed-circuit apparatus. Since regulations make no distinction, and selection is based on approval criteria, rebreathers designed to maintain a positive pressure can only be considered as a demand-type apparatus. Rebreathers use either compressed oxygen or liquid oxygen. To assure the quality of the air to be breathed, the oxygen must be at least medical grade breathing oxygen which meets the requirements set by the "U.S. Pharmacopeia".

B. Open-Circuit

The open-circuit SCBA requires a supply of compressed breathing air. The user simply inhales and exhales. The exhaled air is exhausted from the system. Because the air is not recycled, the wearer must carry the full air supply, which limits a unit to the amount of air that the wearer can easily carry. Available SCBA's can last from 5 to 60 minutes. Units which have 5-to-15 minute air supplies are only applicable to escape situations.

The air used in open-circuit apparatus must meet the requirements in the Compressed Gas Association's Pamphlet G-7.1, which calls for at least "Grade D". Grade D air must contain 19.5 to 23.5% Oxygen with the balance being predominantly nitrogen. condensed hydrocarbons are limited to 5 mg/m^3, carbon monoxide to 20 parts per million (ppm) and carbon dioxide to 1,000 ppm. An undesirable odor is also prohibited. Air quality can be checked using an Oxygen meter, Carbon monoxide meter and detector tubes.

IV. COMPONENTS OF A TYPICAL OPEN-CIRCUIT PRESSURE DEMAND SCBA

A. Cylinder

Compressed air is considered a hazardous material. For this reason, any cylinder used with a SCBA must meet the Department of Transportation's (DOT) "General Requirements for Shipments and Packaging" (49 CFR Part 173) and "Shipping Container Specifications" (49 CFR Part 178).

A hydrostatic test must be performed on a cylinder at regular intervals: Steel and aluminum cylinders, every five years; composite cylinders such as glass fiber or aluminum, every three years. Composite cylinders designed with fiberglass are relatively new, and have a DOT exemption because there are no set construction requirements at this time. Overall, difference is in weight. The construction technology reduces the weight of the cylinder, and thereby, the overall weight of the SCBA.

Air volume of 45 cubic feet of Grade D air at a pressure of 2,216 pounds per square inch (psi) is needed for a 30-minute supply. Cylinders are filled using a compressor or a cascade system of several large cylinders of breathing air. If the cylinder is overfilled, a rupture disc releases the pressure. The rupture disc is located at the cylinder valve, along with a cylinder pressure gauge to be accurate within + 5%. Because the gauge is exposed and subject to abuse, it should be used only for judging if the cylinder is full, and not for monitoring air supply to the wearer.

B. High-Pressure Hose

The high-pressure hose connects the cylinder and the regulator. The hose should be connected to the cylinder only by hand and never with a wrench. An O-ring inside the connector assures a good seal.

C. Alarm

A low-pressure warning alarm is located near the connection to the cylinder. This alarm sounds to alert the wearer that only 20-25% of the full cylinder air supply is available for retreat, usually 5 to 8 minutes.

D. Regulator Assembly

Air travels from the cylinder through the high-pressure hose to the regulator (**Figure 2**). From there, it can travel one of two paths. If the by-pass valve is opened, air travels directly through the breathing hose into the facepiece. If the mainline valve is opened, air passes through the regulator and is controlled by that mechanism. At the regulator, before air enters one of the valves, is another pressure gauge which also must be accurate to + 5%. Because it is visible and well protected, this gauge should be used to monitor the air supply.

Under normal conditions, the bypass valve is closed and the mainline valve opened so air can center the regular. Once in the regulator, the air pressure is reduced from the actual cylinder pressure to approximately 50-100 psi by reducing mechanism. A pressure relief valve is located after the pressure reducer for safety should the pressure reducer malfunction. The airflow rate to meet NIOSH standards must meet or exceed 40 liters/minute. NFPA 1981 states the airflow rate must meet or exceed 100 liters/minute.

E. Breathing Hose and Facepiece

The breathing hose connects the regulator to the facepiece. Rubber gaskets at both ends provide tight seals. The hose is usually constructed of neoprene and is corrugated to allow stretching.

Above the point in the mask where the hose is connected, is a one way check valve. This valve allows air to be drawn from the hose when the wearer inhales but prevents

exhaled air from entering the breathing hose. If the check valve is not in place, the exhaled air may not be completely exhausted from the facepieces.

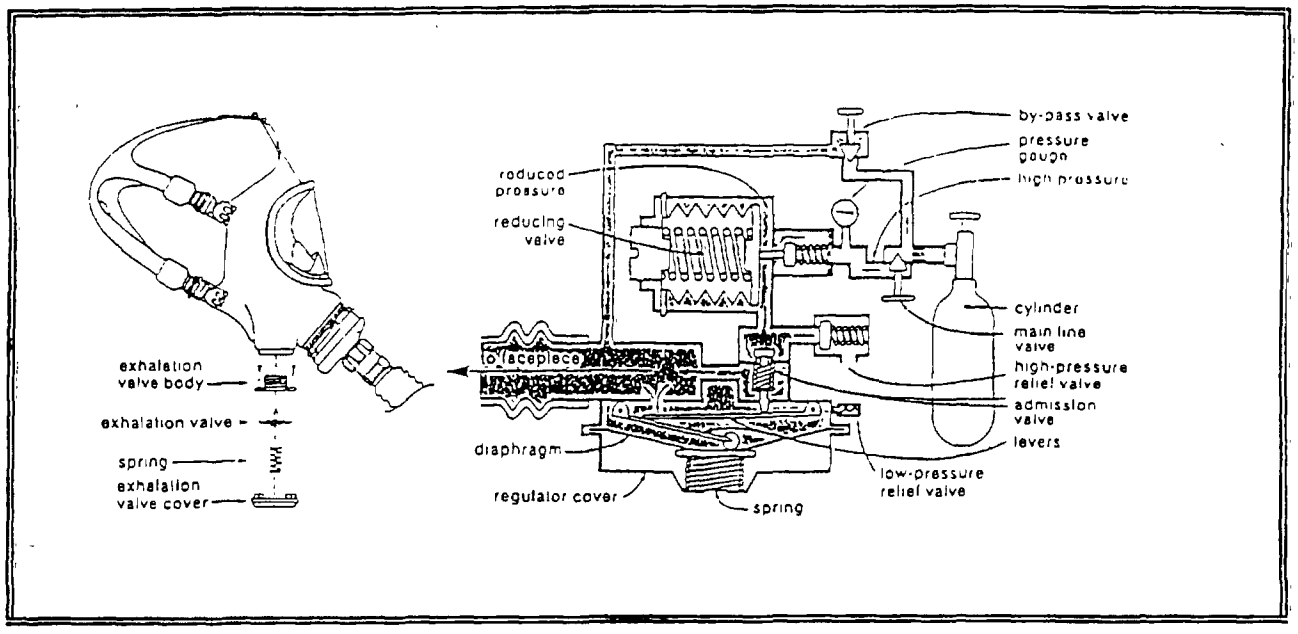

FIGURE 2
REGULATOR ASSEMBLY

"Reprinted from MSA Data Sheet 01-00-11: *Pressure Demand Air Mask and Air Club*™ by Mine Safety Appliances Co.

The facepiece is normally constructed of Neoprene, but sometimes of silicone rubber. Five- or six-point suspension is used to hold the mask to the face. The visor lens is made of polycarbonate or other clear, shatter proof, and chemically resistant material. At the bottom of the facepiece is an exhalation value.

Some masks include an air-tight speaking diaphragm, which facilitates communications while preventing contaminated air from entering.

F. Backpack and Harness

A back pack and harness support the cylinder and regulator, allowing the user to move freely. Weight should be supported on the hips not the shoulders.

V. INSPECTION AND CHECKOUT

The SCBA must be inspected according to manufacturers as well as 29 CFR recommendations. In addition, the SCBA should be checked out immediately prior to use. Checkout and inspection procedures should be followed closely to assure safe operation of the unit.

A. A cylinder on a SCBA typically carries the following information (**Figure 3, page 7**).

1. DOT exemption for composite cylinder
2. DOT rated pressure and air volume
3. Cylinder number
4. Manufacturer's name, symbol and part number
5. Original hydrostatic test date, month/year

VI. INFORMATION ON CYLINDER LABEL

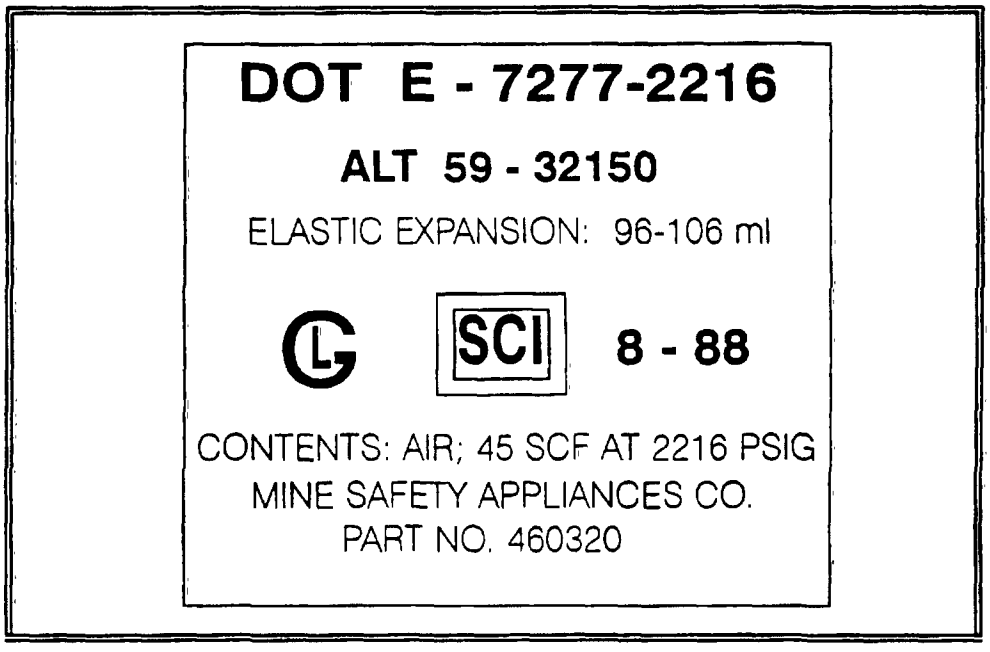

FIGURE 3
INFORMATION ON TYPICAL SCBA CYLINDER LABEL

*Reprinted from MSA Data Sheet 01-00-11: *Pressure Demand Air Mask and Air Club*™ by Mine Safety Appliances Co.

VII. NFPA 1981 "OPEN CIRCUIT SELF-CONTAINED BREATHING APPARATUS FOR FIREFIGHTERS" 1987 Edition

The National Fire Protection (NFPA) has developed a standard for performance requirements and appropriate testing procedures designed to simulate various environmental conditions that

fire fighter's SCBA can be exposed to during use and storage. These requirements are in addition to the basic NIOSH/MSHA certification requirements. This Standard, NFPA 1981, now applies only to open circuit SCBA.

A. Basic Design Requirements

The basic design requirements for SCBA units under 1981 are that:

1. The units be NIOSH/MSMA certified positive-pressure.

2. The maximum weight shall not exceed 35 pounds, in accordance with NIOSH/MSMA certification.

3. The rated service time shall be 30 minutes or more.

4. No positive-pressure unit that can be switched to demand mode.

5. The unit shall not be approved under the Bureau of Mines Schedule

6. The manufacturer shall provide with each SCBA instructions on maintenance, storage, disinfecting, inspection, use, operations, limitations and training materials.

B. General Requirements

Additionally, SCBA units must meet certain general requirements which include:

1. Labeling showing that the unit meets the requirements.

2. Initial, annual and fifth year testing of the SCBA.

3. Retesting of unit after any modifications.

4. Test series to include three categories, with one SCBA used per category.

C. Performance Tests

1. Airflow

This test increases the current NIOSH breathing machine requirements of 40 liters per minute to 100 liters per minute. The 100 liters per minute volume was derived from a review of several studies indicating that a ventilation rate of 100 standard liters per minute encompasses the 98th percentile of all fire fighters studies.

NOTE: An airflow test is then performed after each of the following tests, with the exception of the fabric component test, to ensure breathing apparatus performance.

2. Thermal Resistance Test

This series of tests expose the breathing apparatus to various temperature extremes and temperature cycles that breathing apparatus might be exposed to during actual firefighting operations.

3. Vibration and Shock

This test is designed to provide a reasonable level of assurance that when the breathing apparatus is exposed to vibration, such as being carried on a rig that often travels over rough road surfaces, the apparatus will perform and function properly.

4. Fabric Components Test

Flame, heat and thread tests are added to provide a reasonable level of assurance that the fabric components of a harness assembly used to hold the backplate to the wearer's body will remain intact during firefighting operations.

5. Accelerated Corrosion Resistance Test

This test is to provide a reasonable level of assurance that the breathing apparatus is designed to resist corrosion that may form and interfere with the apparatus performance and function.

6. Particulate Resistance Test

This test exposes the breathing apparatus to a specified concentration of particulates to provide a reasonable level of assurance that the apparatus is designed to properly function when exposed to dust conditions commonly present during firefighting operations.

7. Facepiece Lens Abrasion Resistance Test

This test is designed to provide a reasonable level of assurance that the facepiece lens of the breathing apparatus is not easily scratched during firefighting operations that could result in reduced visibility for the fire fighter.

8. Communications Test

This test is designed to assure that the facepiece of the breathing apparatus does not significantly reduce a fire fighter's normal voice communications.

APPENDIX I

SCBA CHECKOUT - MSA MODEL 401 ULTRALITE II

1. MONTHLY INSPECTION

   a. Check cylinder label for current hydrostatic test date.

   b. Inspect cylinder for large dents or gouges in metal or fiberglass.

   c. Inspect cylinder gauge for damage.

   d. Complete full checkout procedure (Steps 3 thru 8).

   e. Fill out appropriate records with results and recommendations.

2. REGULAR INSPECTION

   a. Immediate prior to donning.

   b. Prior to storing after cleaning and sanitization.

3. BEFORE PROCEEDING, CHECK THAT:

   a. High-pressure-hose connector is tight on cylinder fitting.

   b. By-pass valve is closed.

   c. Mainline valve is closed.

   d. Regulator outlet is not covered or obstructed.

4. BACKPACK AND HARNESS ASSEMBLY

   a. Visually inspect straps for wear, damage, completeness, etc.

   b. Check wear function of buckle.

   c. Check backplate for damage and attachment to cylinder.

5. CYLINDER AND HIGH-PRESSURE-HOSE ASSEMBLY

a. Check cylinder to assure that it is firmly fastened to backplate.

b. Open cylinder valve; listen or feel for leakage around packing and hose connection.

c. Check high-pressure-hose for damage or leaks.

6. REGULATOR

a. Cover regulator outlet with palm of hand or rubber dust cover.

b. Open mainline valve.

c. Note stoppage of air flow after positive pressure builds.

d. Close mainline valve.

e. REMOVE HAND OR DUST COVER FROM REGULATOR OUTLET.

f. Open by-pass valve slowly to assure proper function.

g. Close by-pass valve.

h. Cover regulator outlet again with palm of hand or dust cover.

i. Open mainline valve.

j. Note pressure reading on regulator gauge.

k. Close cylinder valve while keeping hand or dust cover over regulator outlet.

l. Slowly remove hand or dust cover from outlet and allow air to flow.

m. Note pressure when low-pressure warning alarm sounds; it should be between 550-650 psi.

n. Remove hand from regulator.

o. Close mainline valve.

7. FACEPIECE AND CORRUGATED BREATHING TUBE

a. Inspect head harness and facepiece for damage, serrations, and deteriorated rubber.

b. Inspect lens for damage and proper seal in facepiece.

c. Inspect facepiece for presence of diaphragm and wagon wheel.

d. Stretch breathing tube and carefully inspect for holes and deterioration.

e. Inspect connector for damage and presence of washer.

f. Perform negative pressure test with facepiece donned.

8. STORAGE

a. Close cylinder valve.

b. Bleed pressure from high-pressure-hose by opening mainline valve.

c. Refill cylinder to 2216 psi.

d. Tightly connect high-pressure-hose to cylinder.

e. Close by-pass valve.

f. Fully extend all straps.

g. Store facepiece in a clean plastic bag for protection.

GLOSSARY

Accident - An unexpected event generally resulting in injury, loss of property, or disruption of service.

Action Level - A quantitative limit of a chemical, biological, or radiological agent at which actions are taken to prevent or reduce exposure or contact.

Acute Exposure - A dose that is delivered to a receptor in a single event or in a short period of time.

Air Surveillance - Use of air monitoring and air sampling during a response to identify and quantify airborne contaminants on and off-site, and monitor changes in air contaminants that occur over the lifetime of the incidents.

Aquifer - A water bearing formation of permeable rock, sand, or gravel capable of yielding water to a well or spring.

Boiling Point - The temperature at which a liquid changes to a vapor.

Chronic Exposure - Low doses repeatedly delivered to a receptor over a long period of time.

Combustibility - The ability of a material to act as a fuel.

Condensation Point - The temperature at which a vapor changes to a liquid.

Confinement - Control methods used to limit the physical area or size of a released material. Examples:dams, dikes, and absorption processes.

Containment - Control methods used keep the material in its container.Examples:plugging and patching.

Contaminant/Contamination - An unwanted and non-beneficial substance.

Control - Chemical or physical methods used to prevent or reduce the hazards associated with a material. Example: Neutralizing an acid spill.

Decontamination - The process of physically removing contaminants from individuals and equipment or changing their chemical nature to innocuous substances

Degree of Hazard - A relative measure of how much harm a substance can do.

Density - The density of a substance is its mass per unit volume, commonly expressed in grams per cubic centimeter (g/cc). The density of water is 1 g/cc since 1 cc has a mass of 1 gram.

Direct-Reading Instruments - A portable device that rapidly measures and displays the concentration of a contaminant in the environment.

Emergency - A sudden and unexpected event calling for immediate action.

Emergency Removal - Action or actions undertaken, in a time-critical situation, to prevent, minimize, or mitigate a release that poses an immediate and/or significant threat(s) to human health or welfare or to the environment.(See also Removal Action)

Environmental Assessment - The measurement or prediction of the concentration, transport, dispersion, and final fate of a released hazardous substance in the environment.

Environmental Emergencies - Incidents involving the release (or potential release) of hazardous materials into the environment which require immediate action.

Environmental Hazard - A condition capable of posing an unreasonable risk to air, water, or soil quality, and to plants or wildlife.

Environmental Sample - Samples that are considered to contain no contaminants or low concentrations of contaminants as compared to hazardous samples.

Episode - Incident.

First Responder - The first personnel to arrive on the scene of a hazardous materials incident. Usually officials from local emergency services, fire fighters, and police.

Flammability - The ability of a liquid or gas to generate a sufficient concentration of combustible vapors under normal conditions to be ignited and produce a flame.

Flashpoint - The minimum temperature at which a substance produces sufficient flammable vapors to ignite.

Freezing Point - The temperature at which a liquid changes to a solid.

Groundwater - Water found in the saturated portions of geologic formations beneath the surface of land or water.

Hazard - A circumstance or condition that can do harm. Hazards are categorized into four groups: biological, chemical, radiation, and physical.

Hazard Classes - A series of nine descriptive terms that have been established by the UN Committee of Experts to categorize the hazardous nature of chemical, physical, and biological materials. These categories are:

1. Explosives,
2. Non-flammable and flammable gases,
3. Flammable liquids,
4. Flammable solids,

5. Oxidizing materials,
6. Poisons, irritants, and disease causing materials,
7. Radioactive materials,
8. Corrosive materials, and
9. Dangerous materials.

Hazard Evaluation - The impact or risk the hazardous substance poses to public health and the environment.

HAZARDLINE - A data information/retrieval system containing regulatory and precautionary data on about 5,000 hazardous chemicals, as well as OSHA, EPA, NIOSH, and ANSI standards and criteria documents relative to court decisions, standards, and guidelines.

Hazardous - Capable of posing an unreasonable risk to health and safety (Department of Transportation). Capable of doing harm.

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. (Department of Transportation)

Hazardous Sample - Samples that are considered to contain high concentrations of contaminants.

Hazardous Substance - 1) A material and its mixtures or solutions that are listed in the Appendix to the Hazardous Materials Table, 49 CFR 172.101, when offered for transportation in one package, or in one transport vehicle if not packaged, and when the quantity of the material therein equals or exceeds the reportable quantity. 2) Any substance designated pursuant to Section 311(b)(2) (A) of the Federal Water Pollution Control Act, (B) any element, compound, mixture solution, or substance designated pursuant to Section 102 of this Act, (C) any hazardous waste having the characteristics identified under or listed pursuant to Section 3001 of the Solid Waste Disposal Act (but not including any waste of the regulation of which under the Solid Waste Disposal Act has been suspended by Act of Congress), (D) any toxic pollutant listed under Section 307(a) of the Federal Water Pollution Control Act, (E) any hazardous air pollutant listed under Section 112 of the Clean Air Act, and (F) any imminently hazardous chemical substance or mixture with respect to which the Administrator has taken action pursuant to Section 7 of the Toxic Substances Control Act. The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under subparagraphs (A) through (F) of this paragraph, and the term does not include natural gas, natural gas liquids, liquified natural gas, or synthetic gas usable for fuel (of mixtures of natural gas and such synthetic gas).

Hazardous Waste - Any material that is subject to the hazardous waste manifest requirements of the Environmental Protection Agency specified in 40 CFR, Part 262 or would be subject to these requirements in the absence of an interim authorization to a State under 40 CFR Part 123, Subpart F.

Incident - The release or potential release of a hazardous substance or material into the environment.

Incident Characterization - The process of identifying the substance(s) involved in an incident, determining exposure pathways and projecting the effect it will have on people, property, wildlife and plants, and the disruption of services.

Incident Evaluation - The process of assessing the impact released or potentially released substances pose to public health and the environment.

Information - Knowledge acquired concerning the conditions or circumstances particular to an incident.

Inspection - Same as investigation.

Intelligence - Information obtained from existing records or documentation, placards, labels, signs, special configuration of containers, visual observations, technical records, eye witnesses, and others.

Investigation - On-scene and off-scene survey(s) conducted to provide a qualitative and quantitative assessment of hazards associated with a scene site.

Limited Quantity - With the exception of Poison B materials, the maximum amount of a hazardous material for which there is a specific labeling and packaging exception.

Melting Point - The temperature at which a solid changes to a liquid.

Mitigation - Actions taken to prevent or reduce the severity of threats to human health and the environment.

Monitoring - The process of sampling and measuring certain environmental parameters on a real-time basis for spatial and time variations. For example, air monitoring may be conducted with direct-reading instruments to indicate relative changes in air contaminant concentrations at various times.

National Contingency Plan - Policies and procedures that the Federal Government follows in implementing responses to hazardous substances.

Off-Scene - Presence outside of the work site .

On-Scene - Presence within the boundaries of the work site.

Pathways of Dispersion - The environmental medium (water, groundwater, soil, and air) through which a chemical is transported.

Persistent Chemicals - A substance which resists biodegradation and/or chemical transformation when released into the environment and tends to accumulate on land, in air, in water, or in organic matter.

Planned Removal (Non-Time-Critical Removal) - The removal of released hazardous substances that pose a threat or potential threat to human health or welfare or to the environment from a site within a non-immediate time period. Under CERCLA: Actions intended to minimize increases in exposure such that time and cost commitments are limited to 12 months and/or two million dollars. (See also Emergency Removal)

Pollutant - A substance or mixture which after release into the environment and upon exposure to any organism will or may reasonably be anticipated to cause adverse effects in such organisms or their offspring.

Pollutant Transport - An array of mechanisms by which a substance may migrate outside the immediate location of the release or discharge of the substance. For example, pollution of groundwater by hazardous waste leachate migrating from a landfill.

Published Exposure Level - The exposure limits published by *NIOSH Recommendations for Occupational Health Standards (1986).*

Qualified Individual - A person who through education, experience, or professional accreditation is competent to make judgements concerning a particular subject matter. A Certified Industrial Hygienist may be a qualified individual for preparing a site safety plan.

Regulated Material - A substance or material that is subject to regulations set forth by the Environmental Protection Agency, the Department of Transportation, or any other federal agency.

Release - Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of hazardous substances into the environment.

Remedial Actions - As in the National Contingency Plan, responses to releases on a National Priority List that are consistent with treatment-oriented remedy that is protective of human health and the environment and that permanently and significantly reduces toxicity, mobility, or volume of hazardous substances.

Removal Actions - Any appropriate actions(s) taken to abate, minimize, stabilize, mitigate, or eliminate the release or threat of release that poses a threat to human health or welfare or to the environment. As set forth in the National Contingency Plan, these actions shall be terminated after $2 million has been obligated or 12 months have elapsed from the date of initial response.

Reportable Quantity - As set forth in the Clean Water Act, the minimum amount (pounds or kilograms) of a hazardous substance that may be discharged in a 24 hour period that requires notification of the appropriate government agency.

Response Actions - Actions taken to recognize, evaluate, and control an incident.

Response Operations - Same as Response Actions.

Risk - The probability that harm will occur.

Risk Assessment - The use of factual base to define the health effects of exposure of individuals or populations to hazardous materials and situations.

Risk Management - The process of weighing policy alternatives and selecting the most appropriate regulatory action integrating the results of risk assessment with engineering data and with social and economic concerns to reach a decision.

Routes of Exposure - The manner in which a contaminant enters the body through inhalation, ingestion, skin absorption, and injection.

Safety - Freedom from man, equipment, material, and environmental interactions that result in injury or illness.

Sampling - The collection of representative portion of the universe. Example: the collection of a water sample from a contaminated stream.

Severe - A relative term used to describe the degree to which hazardous material releases can cause adverse effects to human health and the environment.

Site - Location.

Site Safety Plan - Written, site-specific safety criteria that establishes requirements for protecting the health and safety of responders during all activities conducted at an incident.

Solubility - The tendency to dissolve in water.

Specific Gravity (SpG) - The ratio of the density of a substance, at a given temperature, to the density of water at the temperature of its maximum density of 4°C.

Toxicity - The ability of a substance to produce injury once it reaches a susceptible site in or on the body.

Toxicology - The study of the interactions between chemical agents and biological systems.

Vapor Pressure - The pressure exerted by a vapor against the sides of a closed container.

Work Plan - Written directives that specifically describe all work activities that are to take place at a work site.

WORKBOOK

EMERGENCY RESPONSE TO HAZARDOUS MATERIAL INCIDENTS

(165.15)

EXERCISES TABLE OF CONTENTS

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INFORMATION RESOURCES EXERCISE

I. STUDENT PERFORMANCE OBJECTIVES (SPOs)

A. Given a chemical name, list at least five references available for use a hazardous materials incident.
B. Given a hazardous materials data sheet complete the information needed for a safe entry into a given effected area.
C. Describe the limited use computer databases have in emergency response.
D. List five reference books that could be included in a basic reference library.

II. PROCEDURE

A. Read the scenario to determine the chemical involved, and other information provided in this incident.
B. Given reference materials listed below, each student select a reference book and complete the data table and supplementary questions with that reference, then as a group assist each other and complete the questions.
C. Complete the data table and supplementary questions.
D. The references that are to be used are:
   1. Department of Transportation Emergency Response Guidebook (DOT).
   2. National Fire Protection Association Guide to Hazardous Material (NFPA).
   3. Emergency Handling of Hazardous Materials in Surface Transportation (AAR).
   4. National Institute for Occupational Safety and Health, Pocket Guide (NIOSH {P}).
   5. Emergency Care for Hazardous Materials Exposure (ECHME).
   6. Hawley's Condensed Chemical Dictionary (CCD).
   7. Material Safety Data Sheet (MSDS) Dictionary.
   8. International Society of Fire Service Instructors (ISFSI) HazMat Incident Guide.

III. SCENARIO

A train wreck has occurred and a trailer on flat car (TOFC) has derailed. The place of the derailment is a light industrial area with some private dwellings, approximately twenty, 55 gallon drums have spilled from the trailer and are releasing a clear liquid.

A fire has started about 300 yards from the spill. The placard with a UN/NA number of 1093 is on the trailer.

IV. TIME LIMIT

The students have 20 minutes to work on the exercise and then the instructor will go over the results.

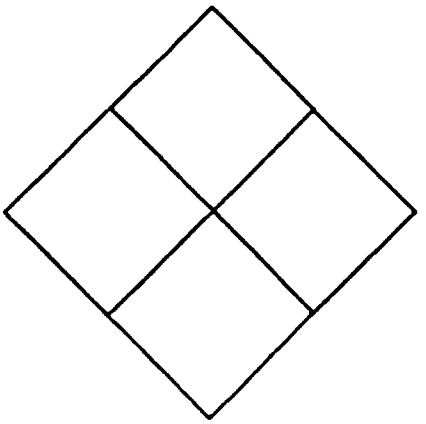
Using the sources provided, fill out the data table and fact sheet.

Product I.D: NAME _____

UN# _____ CAS# _____-_____-_____

Red
FLAMMABILITY

Blue
HEALTH



Yellow
REACTIVITY

White
SPECIAL INFORMATION

Chemical and Physical Properties

SOURCE G#26 DATA	NFPA	AAR	NIOSH (P)	ECHME	CCD
Phys. State					
Boiling Pt.					
Melting Pt.					
Spev. Grav.					
Solubility					
Vapor Density					
Vapor Press (@ temp)					
LEL/UEL					
Flash Pt.					
Auto Ignit.					
Page					

QUESTIONS

1. The commercial uses for this chemical are:

_____

2. This chemical is labeled as *"inhibited"*. What does this mean?

_____

3. T or F. This chemical, in liquid form, is always easily identified by it's odor.

_____

4. What level of protection is recommended for responding to this chemical?

_____

5. What liquid or liquid mixtures are recommended for decontamination of personnel and equipment exposed to this chemical?

_____

6. What evacuation distances should be used in incidents involving this chemical?

_____

7. The CHEMTREC telephone number is 1-800/_____
   The National Response Center telephone number is 1-800/_____

8. In the International Classification System there are __ major classes. This chemical would fall under what class or classes?

_____

9. What are the synonyms for this chemical?

_____

10. If we had a land spill of this liquid, what should we do to absorb it?

_____

CHEMICAL PROTECTIVE CLOTHING EXERCISE

I. OBJECTIVE

A. List three references used to select levels of protection.
B. Relate how A.D. Little qualitative ratings are referenced in this Field Guide for the Selection of Chemical Protective Clothing.
C. Given a scenario and the above reference material, select the proper level of protection and the composition for that ensemble.
D. Emphasize the need to determine the basic chemical problem and in relation to the protective equipment.
E. Describe the problems when a fire is involved in relation to chemical protective clothing.

II. PROCEDURE

A. Evaluate the seven situations and consider the following:
   1. Chemical(s) hazards
   2. Physical Hazards
   3. Work functions
B. Using the information provided on pages 9-35, select the minimum level of protection.
C. Using the information provided on pages 36-59, recommend the type of material to be used for the level of protection chosen.

III. SCENARIO

Read the seven scenarios on pages 6-8 using just the information that is given in the scenario; do not read anything into the scenario. Use common sense in determining strategy and tactics.

IV. AVAILABLE PERSONAL PROTECTIVE CLOTHING

4 Fully encapsulating suits of each fabric rated as per A.D. Little, pages 38-45.
4 Butyl/Viton Suits - fully encapsulating suits
4 PVC Suits - fully encapsulating suits
4 Aluminized Flash Suits
8 Tyvek Suits - disposable
12 PVC Splash or Chemical Suits
6 Each Pair Bunker Pants and Coats (Nomex)
6 Pair Fire Boots (Neoprene)
6 Fire Fighters Helmets
6 Hard Hats
12 SCBA Paks
Assorted gloves - Leather, Butyl-Rubber, Latex, PVC, and Viton
Assorted boots - Butyl-Rubber, PVC, and Neoprene

V. TIME LIMIT

Approximately one hour of homework

1. Truck Incident: Liquid nitrogen is escaping from an insulated refrigerator truck. Your Haz Mat team is called to investigate, locate and stop the leak. What minimum level of protection is required and what material should be used for the personnel protective clothing?

_____

_____

_____

_____

_____

_____

_____

2. After a garbage company dumped a truck load of garbage in one of the parking areas, smoke started coming from the load. The truck driver sprayed the load with water from a fire extinguisher. Vapors formed around several small containers marked "Aluminum Phosphide". The truck driver complained of nose and throat irritation. Enroute to the hospital he developed respiratory distress and lapsed into an unconscious state. Your team has been requested to identify the vapor he was exposed to and to overpack the reacting containers. What minimum level of protection is required and what material should be used for the personnel protective clothing?_____

_____

_____

_____

_____

_____

3. A truck carrying several 55 gallon drums of Benzene is involved in an accident. The drums have ruptured, and their contents has spilled on the ground. It is in danger of making its way into nearby sewers. Your Haz Mat team has been called to contain the spill, prevent the substance from entering the sewer, and mitigate the incident until the cleanup contractor arrives. What minimum level of protection is required and what material should be used for the personnel protective clothing?_____

_____

_____

_____

_____

_____

_____

4. An anhydrous ammonia vapor cloud forms after a tank truck accident. Response personnel must enter the cloud and plug the leak. The ammonia concentration outside the cloud is 400 ppm. What minimum level of protective clothing is required? The only available protective clothing consists of turnout gear and leather gloves. Is the Nomex turnout gear compatible with ammonia and can it be worn in this response?_____

_____

_____

_____

_____

_____

5. At an industrial facility the night watchman discovers a leak in the 1,000 gallon tank labeled PHENOL. A pool of liquid about 8 ft. by 10 ft. covers the ground. Because there is a possibility of phenol migrating offsite and coming into contact with other substances at a nearby facility, response personnel must stop the leak. What minimum level of protection is required and what material should be used for the personnel protective clothing?_____

_____

_____

_____

_____

_____

_____

6. Doctors and nurses in the surgical operating room have been forced to leave due to the presence of a very strong odor, which has left many of the staff with symptoms of nausea and dizziness. The hospital has been evacuated and venting of the operating room has occurred. The Haz Mat team has been requested to enter to determine the problem. What minimum level of protection is required and what material should be used for the personnel protective clothing?_____

_____

_____

_____

_____

_____

_____

7. A tractor trailer carrying 10 drums of toluene - 2,4,-diisocyanate (TDI) waste, 10 drums of parathion, 8 drums of phosphorous trichloride, 5 drums of benzene, and 2 lab pack drums containing glass containers of hydrocyanic acid is parked at a truck stop. An explosion occurs in the trailer causing one drum to be blown through the roof. Upon opening the rear doors of the trailer, a large quantity of liquid was noted on the tops of some of the drums and on the trailer floor. The trailer must be entered to evaluate the situation. What is the minimum level of protection required and what material should be used for the personnel protective clothing?_____

CHEMICAL INFORMATION SOURCES

1) Merck Index, 10th Edition

2) Hawley's Condensed Chemical Dictionary, 11th Edition

3) Dangerous Properties of Hazardous Materials, 6th Edition
By: N. Irving Sax

363. Aluminum Phosphide. Celphos; Detia; Phostoxin. AlP; mol wt 57.96. Al 46.55%, P 53.44%. Prepd from red phosphorus and aluminum powder: White, Bushey, *J. Am. Chem. Soc.* 66, 1666 (1944); *Inorg. Syn.* 4, 23 (1953); Montignie, *Bull. Soc. Chim. France* 1946, 276; from Al and Zn_2P_3: Wang *et al.*, *J. Inorg. Nucl. Chem.* 25, 326 (1963). Use as insecticidal fumigant: W. Freyberg, W. Haupt, U.S. pat. 2,117,158 (1938 to Freyberg).

Dark gray or dark yellow crystals. Cubic zinc blende structure. Must be protected from moist air since it reacts readily to produce phosphine which is highly toxic. d_4^{15} 2.85 (Montignie); d 2.40 (Wang *et al.*). Does not melt or decompose thermally at temps up to 1000°. Treatment with water and acid produces phosphine in quantitative yields.

USE: Source of phosphine; in semiconductor research; as fumigant.

The Merck Index

"Reprinted from Merck Index, 11th edition, 1989 by Susan Budavari, ed. with permission of Merck & Company, Inc."

aluminum phosphide AlP.

Properties: Dark gray or dark yellow crystals; sp. gr. 2.85. Evolves phosphine.

Hazard: Toxic; flammable, dangerous fire risk.

Uses: Insecticide; fumigant.

Shipping regulations: (Rail, Air) Flammable Solid label and Dangerous When Wet label. Not acceptable passenger.

Condensed Chemical Dictionary

"Reprinted from Condensed Chemical Dictionary, 10th edition, 1981 by Gessner G. Hawley with permission of Van Nostrand Reinhold."

AHE750 CAS:20859-73-8 *HR: 3*
ALUMINUM PHOSPHIDE
DOT: UN 1397
mf: AlP mw: 57.95

PROP: Dark gray or dark yellow crystals. D: 2.85 @ 25°/4°. Mp: >1000°.

SYNS: AIP ◇ AL-PHOS ◇ ALUMINUM FOSFIDE (DUTCH) ◇ ALUMINUM MONOPHOSPHIDE ◇ CELPHIDE ◇ CELPHOS ◇ DELICIA ◇ DETIA GAS EX-B ◇ FOSFURI di ALLUMINIO (ITALIAN) ◇ FUMITOXIN ◇ PHOSPHURES d'ALUMIUM (FRENCH) ◇ RCRA WASTE NUMBER P006

TOXICITY DATA with REFERENCE
orl-hmn LD50:20 mg/kg 85ARAE 3,38,76
ihl-mam LCLo:1 ppm PCOC** -,25,66

CONSENSUS REPORTS: EPA Extremely Hazardous Substances List. Reported in EPA TSCA Inventory.

ACGIH TLV: TWA 2 mg(Al)/m^3
DOT Classification: Label: Flammable Solid and Dangerous When Wet; IMO: Flammable Solid; Label: Dangerous When Wet and Poison.

SAFETY PROFILE: A human poison by inhalation and ingestion. Dangerous; in contact with water, steam, or alkali it slowly yields PH_3, which is spontaneously flammable in air. Explosive reaction on contact with mineral acids produces phosphine. When heated to decomposition it yields toxic PO_x. See also ALUMINUM COMPOUNDS, PHOSPHIDES, and PHOSPHINE.

Dangerous Properties of Hazardous Materials
by: N. Irving Sax

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510. Ammonia. H_3N; mol wt 17.03. N 82.25%. H 17.75%. NH_3. Manufactured from water gas (obtained by blowing steam through incandescent coke) as source of hydrogen, and from producer gas (obtained from steam and air through incandescent coke), as source of nitrogen by the Haber-Bosch process. Manuf from natural gas: Faith, Keyes & Clark's *Industrial Chemicals*, F. A. Lowenheim, M. K. Moran, Eds. (Wiley-Interscience, New York, 4th ed., 1975) pp 83-92. Historical monograph: A. Mittasch, *Geschichte der Ammoniaksynthese* (Verlag Chemie, 1951). Reviews of prepn, properties and chemistry: Several authors in *Mellor's* Vol. VIII, supplement I, *Nitrogen* part 1 (1964) pp 240-369; Jones in *Comprehensive Inorganic Chemistry* Vol. 2, J. C. Bailar, Jr. *et al.*, Eds. (Pergamon Press, Oxford, 1973) pp 199-227; J. R. LeBlanc *et al.*, in Kirk-Othmer *Encyclopedia of Chemical Technology* vol. 2 (Wiley-Interscience, New York, 3rd ed., 1978) pp 470-516.

Colorless gas; very pungent odor (characteristic of drying urine). Lower limit of human perception: 0.04 g/cubic meter or 53 ppm. One liter of the gas weighs 0.7714 g. d 0.5967 (air = 1). mp −77.7°. bp_{760} −33.35°. Densities of liq NH_3 (temp; press.): 0.6818 (−33.35°; 1 atm); 0.6585 (−15°; 2.332 atm); 0.6386 (0°; 4.238 atm); 0.6175 (15°; 7.188 atm); 0.5875 (35°; 13.321 atm). Critical temp 132.4°; critical press. 111.5 atm. Heat capacity (25°) 8.38 cal/mole/deg. Mixtures of ammonia and air will explode when ignited under favorable conditions: *Angew. Chem.* 43, 302 (1930), but ammonia is generally regarded as nonflammable. Corrosive, alkaline gas. pH of 1.0*N* aq soln 11.6; of 0.1*N* aq soln 11.1; of 0.01*N* aq soln 10.6. Water at 0° holds 47%, at 15° 38%, at 20° 34%, at 25° 31%, at 30° 28%, at 50° 18%. d_4^{20} (aq solns): 0.9939 (1%); 0.9811 (4%); 0.9651 (8%); 0.9362 (16%); 0.9229 (20%); 0.9101 (24%); 0.8980 (28%). fp (aq solns): −2.9° (4%); −8.1° (8%); −23.1° (16%); −34.9° (20%); −44.5° (24%); −69.2° (28%). Solution of NH_3 in water is exothermic. 95% alcohol at 20° holds 15%, at 30° 11%. Abs ethanol at 0° 20%, at 25° 10%. Methanol at 25° 16%. It is also sol in chloroform and ether. Liquid ammonia produces low temps by its own evaporation. Heat of vaporization: 5.581 kcal/mole. It is a good solvent for many elements and compds. Usually marketed in liquefied form in steel cylinders or as ammonia water (aqua ammonia, ammonium hydroxide) in drums and bottles.

Caution: Inhalation of concd vapor causes edema of respiratory tract, spasm of the glottis, asphyxia. Treatment must be prompt to prevent death, *cf.* Patty's *Industrial Hygiene and Toxicology* vol. 2B, G. D. Clayton, F. E. Clayton, Eds. (Wiley-Interscience, New York, 3rd ed., 1981) pp 3045-3052.

USE: Manuf nitric acid, explosives, synthetic fibers, fertilizers. In refrigeration. In the chemical industry.

The Merck Index

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ammonia, anhydrous. NH_3. CAS: 7664-41-7
Third highest-volume chemical produced in US (1985).

Properties: Colorless gas (or liquid); sharp, intensely irritating odor; lighter than air; easily liquefied by pressure; bp −33.5C; fp −77C; vap press of liquid 8.5 atm (20C); sp vol 22.7 cu ft/lb (70C); d (liquid) 0.77 at 0C and 0.6819 at bp; very soluble in water, alcohol, ether; volume 22.7 cu ft/lb (70C); d of liquid 0.77 at 0C; 0.6819 at bp; very soluble in water, alcohol, and ether. Autoign temperature 1204F (650C). Combustible. *Note*: Ammonia is the first complex molecule to be identified in interstellar space, it has been observed in galactic dust clouds in the Milky Way and is believed to constitute the rings of the planet Saturn.

Derivation: From synthesis gas, a mixture of carbon monoxide, hydrogen, carbon dioxide, and nitrogen (from air) obtained by steam reforming or by partial combustion of natural gas (US), or from the action of steam on hot coke (Haber-Bosch process). The latter method is used in South Africa. After removal of the carbon oxides, the gas composition is adjusted to a ratio of 3 parts H_2 to 1 part N_2 and passed to the synthesis unit over a catalyst at pressures of about 300 atm and temperature of approximately 500C. The catalyst most widely used is produced by fusion of iron oxide (Fe_3O_4) containing aluminum oxide and potassium oxide as promoters, followed by reduction of the oxide. Chemisorption of the nitrogen on the catalyst surface is the rate-controlling step.

Other methods include use of refinery off-gases, coke-oven gas, electrolytic hydrogen, and calcium cyanimide. Ammonia has been made experimentally using solar energy to activate the reaction

$$N_2 + 3H_2O \xrightarrow[TiO_2]{h\nu} 2NH_3 + 1.5O_2.$$

Ammonia is formed as an end product of animal metabolism by decomposition of uric acid.

Grade: Commercial 99.5%, refrigerant 99.97%.

Hazard: Inhalation of concentrated fumes may be fatal. TLV: 25 ppm in air. Moderate fire risk, explosive limits in air 16 to 25%. Forms explosive compounds in contact with silver or mercury.

Use: Fertilizers, either as such or in form of compounds, e.g., ammonium nitrate, manufacture of nitric acid, hydrazine hydrate, hydrogen cyanide, urethane, acrylonitrile, and sodium carbonate (by Solvay process); refrigerant, nitriding of steel, condensation catalyst, synthetic fibers, dyeing, neutralizing agent in petroleum industry, latex preservative, explosives, nitrocellulose, urea-formaldehyde, nitroparaffins, melamine, ethylenediamine, sulfite cooking liquors, fuel cells, rocket fuel, yeast nutrient, developing diazo films.

See also ammonium hydroxide; Haber, Fritz; synthesis gas.

Condensed Chemical Dictionary

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AMY500 CAS:7664-41-7 *HR: 3*
AMMONIA
DOT: UN 1005/UN 2073/UN 2672
mf: H_3N mw: 17.04

PROP: Colorless gas, extremely pungent odor, liquefied by compression. Mp: −77.7°, bp: −33.35°, lel: 16%, uel: 25%, d: 0.771 g/liter @ 0°, 0.817 g/liter @ −79°, autoign temp: 1204°F, vap press: 10 atm @ 25.7°, vap d: 0.6. Very sol in water; moderately sol in alc.

SYNS: AMMONIAC (FRENCH) ◇ AMMONIACA (ITALIAN) ◇ AMMONIA GAS ◇ AMMONIAK (GERMAN) ◇ AMONIAK (POLISH) ◇ ANHYDROUS AMMONIA ◇ SPIRIT of HARTSHORN

TOXICITY DATA with REFERENCE
mmo-esc 1500 ppm/3H AMNTA4 85,119,51
cyt-rat-ihl 19800 μg/m³/16W BZARAZ 27,102,74
ihl-hmn LCLo:30000 ppm/5M TJSGA8 45,458,67
ihl-hmn TCLo:20 ppm:IRR AGGHAR 13,528,55
unk-man LDLo:132 mg/kg 85DCAI 2,73,70
orl-rat LD50:350 mg/kg PHIT**
ihl-rat LCLo:2000 ppm/4H JIHTAB 31,343,49
ihl-mus LD50:4837 ppm/1H NTIS** PB214-270
ihl-cat LCLo:7000 ppm/1H JIHTAB 26,29,44
ihl-cat TCLo:1000 ppm/10M AEHLAU 35,6,80
ihl-rbt LCLo:7000 ppm/1H JIHTAB 26,29,44
ihl-mam LCLo:5000 ppm/5M AEPPAE 138,65,28

CONSENSUS REPORTS: EPA Extremely Hazardous Substances List. Community Right-To-Know List. Reported in EPA TSCA Inventory.

OSHA PEL: TWA 35 ppm
ACGIH TLV: TWA 25 ppm; STEL 35 ppm
DFG MAK: 50 ppm (35 mg/m³)
NIOSH REL: CL 50 ppm
DOT Classification: Nonflammable Gas; Label: NONFLAM. Gas (UN1005, UN2073); Poison A; Label: Poison Gas (UN1005).

SAFETY PROFILE: A human poison by an unspecified route. Poison experimentally by inhalation, ingestion, and possibly other routes. An eye, mucous membrane, and systemic irritant by inhalation. Mutation data reported. A common air contaminant. Difficult to ignite. Explosion hazard when exposed to flame or in a fire. NH_3 + air in a fire can detonate. Potentially violent or explosive reactions on contact with interhalogens (e.g., bromine pentafluoride, chlorine trifluoride), 1,2-dichloroethane (with liquid NH_3), boron halides, chloroformamidnium nitrate, ethylene oxide (polymerization reaction), magnesium perchlorate, nitrogen trichloride, oxygen + platinum, or strong oxidants (e.g., potassium chlorate, nitryl chloride, chromyl chloride, dichlorine oxide, chromium trioxide, trioxygen difluoride, nitric acid, hydrogen peroxide, tetramethylammonium amide, thiocarbonyl azide thiocyanate, sulfinyl chloride, thiotriazyl chloride, ammonium peroxodisulfate, fluorine, nitrogen oxide, dinitrogen tetraoxide, and liquid oxygen). Forms sensitive explosive mixtures with air + hydrocarbons, 1-chloro-2,4-dinitrobenzene, 2-,or 4-chloronitrobenzene (above 160°C/30 bar), ethanol + silver nitrate, germanium derivatives, stibine, and chlorine. Reaction with silver chloride, silver nitrate, silver azide, and silver oxide form the explosive silver nitride. Reactions with chlorine azide, bromine, iodine, iodine + potassium, heavy metals and their compounds (e.g. gold(III) chloride, mercury, and potassium thallium amide ammoniate), tellurium halides (e.g., tellurium tetrabromide, and tellurium tetrachloride)and pentaborane(9) give explosive products. Incompatible in contact with Ag, acetaldehyde, acrolein, B, BI_3, halogens, $HClO_3$, ClO, chlorites, chlorosilane, (ethylene dichloride + liquid ammonia), Au, hexachloromelamine, (hydrazine + alkali metals), HBr, HOCl, $Mg(ClO_4)_2$, N_2O_4, NCl_3, NF_3, OF_2, P_2O_5, P_2O_3, picric acid, (K + AsH_3), (K + PH_3), (K + $NaNO_2$), potassium ferricyanide, potassium mercuric cyanide, (Na + CO), Sb, S, SCl_2, tellurium hydropentachloride, trichloromelamine, NO_2Cl, SbH_3, tetramethylammonium amide, $SOCl_2$, and thiotrithiazylchloride. Incandescent reaction when heated with calcium. Emits toxic fumes of NH_3 and NO_x when exposed to heat. To fight fire stop flow of gas.

Dangerous Properties of Hazardous Materials
by: N. Irving Sax

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1074. **Benzene.** Benzol; cyclohexatriene. C_6H_6, mol wt 78 11. C 92.25%, H 7.75%. Discovered by Faraday in compressed oil gas in 1825. Obtained in the coking of coal and in the production of illuminating gas from coal. Purification by washing with water· Brit. pat 863,711 (1961 to Schloven-Chemie and H. Koppers GmbH), *C.A.* 55, 16971f (1961) Lab prepn from aniline: Gattermann-Wieland, *Praxis des organischen Chemikers* (de Gruyter, Berlin, 40th ed., 1961) p 247. Production of pure benzene: French, *Ind. Chemist* 39, 9-12 (1963) Manuf. Faith, Keyes & Clark's *Industrial Chemicals*, F. A. Lowenheim, M. K. Moran, Eds. (Wiley-Interscience, New York, 4th ed., 1975) pp 126-137. Physical properties: Thorne *et al.*, *Ind. Eng. Chem. Anal. Ed.* 17, 481 (1945). Solubility studies: F. P. Schwarz, *Anal. Chem.* 52, 10 (1980). Toxicity data Kimura *et al.*, *Toxicol. Appl. Pharmacol* 19, 699 (1971) Review of toxicology· E Browning, *Toxicity and Metabolism of Industrial Solvents* (Elsevier, New York, 1965) pp 3-65; R Snyder *et al.*, *Rev Biochem. Toxicol.* 3, 123-154 (1981). *Review:* W. P Purcell in Kirk-Othmer *Encyclopedia of Chemical Technology* vol. 3 (Wiley-Interscience, New York, 3rd ed , 1978) pp 744-771.

Clear, colorless, highly flammable liquid; characteristic odor. d_4^{15} 0 8787. bp 80 1° mp +5 5°. n_D^{20} 1.50108. Flash pt, closed cup: 12°F (−11°C) Soly in water at 23.5°C (w/w): 0.188%. Miscible with alcohol, chloroform, ether, carbon disulfide, carbon tetrachloride, glacial acetic acid, acetone, oils. *Keep in well-closed containers in a cool place and away from fire.* LD_{50} orally in young adult rats: 3.8 ml/kg (Kimura)

Sodium deriv, C_6H_5Na, *phenyl sodium.* Prepn: Schlosser, *Angew. Chem.* 76, 267 (1964). Solid mass, dec by water, acids, alkalies. Sol in liquid ammonia, tetrahydrofuran.

Human Toxicity: Acute (from ingestion or inhalation): Irritation of mucous membranes, restlessness, convulsions, excitement, depression Death may follow from respiratory failure. *Chronic.* Bone marrow depression and aplasia; rarely, leukemia. Harmful amts may be absorbed through skin Benzene has been listed as a known carcinogen. *Fourth Annual Report on Carcinogens* (NTP 85-002, 1985) p 34

USE. Manuf of medicinal chemicals, dyes and many other organic compounds, artificial leather, linoleum, oil cloth, airplane dopes, varnishes, lacquers, as solvent for waxes, resins, oils, etc

THERAP CAT (VET): Destroys screwworm larvae in wounds

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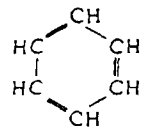
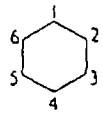
benzene. CAS: 71-43-2. C_6H_6. 16th highest-volume chemical produced in US (1985).



I

II



III

IV

Structure: I. Complete ring showing all elements. II. Standard ring showing double bonds only. III Simple ring without double bonds, with numerals indicating position of carbon atoms to which substituent atoms or groups may be attached (2 = ortho, 3 = meta, 4 = para). IV. Generalized structure with enclosed circle suggesting the resonance of this compound. This structure is now in general use. These structures are also referred to as the benzene nucleus.

Properties: Colorless to light-yellow, mobile, nonpolar liquid of highly refractive nature; aromatic odor; vapors burn with smoky flame; bp 80.1C; fp 5.5C, d 0.8790 (20/4C); wt/gal 7.32 lb; refr index 1.50110 at 20C, flash p 12F (−11C) (CC), surface tension 29 dynes/cm: Autoign temperature 1044F (562C). Miscible with alcohol, ether, acetone, carbon tetrachloride, carbon disulfide, acetic acid; slightly soluble in water.

Derivation: (a) Hydrodealkylation of toluene or pyrolysis of gasoline; (b) transalkylation of toluene by disproportionation reaction; (c) catalytic reforming of petroleum; (d) fractional distillation of coal tar.

Grade: Crude, straw color; motor; industrial pure (2C); nitration (1C); thiophene-free; 99 mole %; 99.94 mole %; nanograde.

Hazard: A carcinogen. Highly toxic. Flammable; dangerous fire risk. Explosive limits in air 1.5 to 8% by volume. TLV: 10 ppm in air.

Use: Manufacturing of ethylbenzene (for styrene monomer); dodecylbenzene (for detergents); cyclohexane (for nylon); phenol; nitrobenzene (for aniline); maleic anhydride; chlorobenzene; diphenyl; benzene hexachloride; benzene sulfonic acid; as a solvent.

See also aromatic.

Condensed Chemical Dictionary

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BBL250 CAS:71-43-2 *HR: 3*
BENZENE
DOT: UN 1114
mf: C_6H_6 mw: 78.12

PROP: Clear, colorless liquid. Mp: 5.51°, bp: 80.093-80.094°, flash p: 12°F (CC), d: 0.8794 @ 20°, autoign temp: 1044°F, lel: 1.4%, uel: 8.0%, vap press: 100 mm @ 26.1°, vap d: 2.77, ULC: 95-100.

SYNS: (6)ANNULENE ◇ BENZEEN (DUTCH) ◇ BENZEN (POLISH) ◇ BENZIN (OBS.) ◇ BENZINE (OBS.) ◇ BENZOL (DOT) ◇ BENZOLE ◇ BENZOLENE ◇ BENZOLO (ITALIAN) ◇ BICARBURET of HYDROGEN ◇ CARBON OIL ◇ COAL NAPHTHA ◇ CYCLOHEXATRIENE ◇ FENZEN (CZECH) ◇ MINERAL NAPHTHA ◇ MOTOR BENZOL ◇ NCI-C55276 ◇ NITRATION BENZENE ◇ PHENE ◇ PHENYL HYDRIDE ◇ PYROBENZOL ◇ PYROBENZOLE ◇ RCRA WASTE NUMBER U019

TOXICITY DATA with REFERENCE
skn-rbt 15 mg/24H open MLD AIHAAP 23,95,62
skn-rbt 20 mg/24H MOD 85JCAE-,25,86
eye-rbt 88 mg MOD AMIHAB 14,387,56
eye-rbt 2 mg/24H SEV 28ZPAK -,23,72
oms-hmn:lym 5 μmol/L CNREA8 45,2471,85
mma-mus:emb 2500 mg/L PMRSDJ 5,639,85
orl-mus TDLo:6500 mg/kg (female 8-12D post):REP TCMUD8 6,361,86
ihl-mus TCLo:5 ppm (female 6-15D post):TER TXCYAC 42,135,86
ihl-man TCLo:200 mg/m³/78W-I:CAR,BLD EJCAAH 7,83,71
ihl-hmn TCLo:10 ppm/8H/10Y-I:CAR,BLD TRBMAV 37,155,78
orl-rat TDLo:52 g/kg/52W-I:CAR MELAAD 70,352,79
ihl-rat TCLo:1200 ppm/6H/10W-I:ETA PAACAJ 25,75,84
orl-mus TDLo:18250 mg/kg/2Y-C:CAR NTPTR* NTP-TR-289,86
skn-mus TDLo:1200 g/kg/49W-I:NEO BJCAAI 16,275,62
ihl-hmn TC:150 ppm/15M/8Y-I:CAR,BLD BLOOAW 52,285,78
ihl-man TC:600 mg/m³/4Y-I:CAR,BLD NEJMAG 271,872,64
ihl-man TC:150 ppm/11Y-I:CAR,BLD BLUTA9 28,293,74
ihl-hmn TC:8 ppb/4W-I:CAR,BLD NEJMAG 316,1044,87
ihl-hmn TC:10 mg/m³/11Y-I:CAR,BLD BJIMAG 44,124,87
ihl-hmn LCLo:2 pph/5M TABIA2 3,231,33
orl-man LDLo:50 mg/kg YAKUD5 22,883,80
ihl-hmn LCLo:20000 ppm/5M 29ZUA8 -,-,53
ihl-man TCLo:150 ppm/1Y-I:BLD BLUTA9 28,293,74
ihl-hmn TCLo:100 ppm INMEAF 17,199,48
ihl-hmn LCLo:65 mg/m³/5Y:BLD ARGEAR 44,145,74
orl-rat LD50:3306 mg/kg TXAPA9 19,699,71
ihl-rat LC50:10000 ppm/7H 28ZRAQ -,113,60
ipr-rat LD50:2890 μg/kg 36YFAG -,302,77
orl-mus LD50:4700 mg/kg HYSAAV 32,349,67
ihl-mus LC50:9980 ppm JIHTAB 25,366,43
ipr-mus LD50:340 mg/kg ANYAA9 243,104,75
orl-dog LDLo:2000 mg/kg HBAMAK 4,1313,35
ihl-dog LCLo:146000 mg/m³ HBTXAC 1,324,56
ihl-cat LCLo:170000 mg/m³ HBTXAC 1,324,56
ivn-rbt LDLo:88 mg/kg JTEHD6 -(Suppl 2),45,77

CONSENSUS REPORTS: NTP Fifth Annual Report on Carcinogens. IARC Cancer Review: Group 1 IMEMDT 7,120,87, Human Limited Evidence IMEMDT 7,203,74; Animal Inadequate Evidence IMEMDT 7,203,74; IARC Cancer Review: Animal Limited Evidence IMEMDT 29,93,82; Human Sufficient Evidence IMEMDT 29,93,82. NTP Carcinogenesis Studies (gavage); Clear Evidence: mouse, rat NTPTR* NTP-TR-289,86 EPA Genetic Toxicology Program. Reported in EPA TSCA Inventory. On Community Right-To-Know List.

OSHA PEL: (Transitional: TWA 10 ppm; CL 25 ppm; Pk 50 ppm/10M) TWA 1 ppm; STEL 5 ppm; Pk 5 ppm/15M/8H; Cancer Hazard
ACGIH TLV: TWA 10 ppm; Suspected Human Carcinogen (Proposed: TWA 0.1 ppm; Confirmed Human Carcinogen); BEI: 50 mg(total phenol)/L in urine at end of shift recommended as a mean value.
DFG TRK: 5 ppm (16 mg/m³) Human Carcinogen.
NIOSH REL: TWA 0.32 mg/m³; CL 3.2 mg/m³/15M
DOT Classification: Flammable Liquid; Label: Flammable Liquid.

SAFETY PROFILE: Confirmed human carcinogen producing myeloid leukemia, Hodgkin's disease, and lymphomas by inhalation. Experimental carcinogenic, neoplastigenic, and tumorigenic data. A human poison by inhalation. An experimental poison by skin contact, intraperitoneal, intravenous, and possibly other routes. Moderately toxic by ingestion and subcutaneous routes. A severe eye and moderate skin irritant. Human systemic effects by inhalation and ingestion: blood changes, increased body temperature. Experimental teratogenic and reproductive effects. Human mutation data reported. A narcotic. In industry, inhalation is the primary route of chronic benzene poisoning. Poisoning by skin contact has been reported. Recent (1987) research indicates that effects are seen at less than 1 ppm. Exposures needed to be reduced to 0.1 ppm before no toxic effects were observed. Elimination is chiefly through the lungs. A common air contaminant.

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A dangerous fire hazard when exposed to heat or flame. Explodes on contact with diborane, bromine pentafluoride, permanganic acid, peroxomonosulfuric acid, and peroxodisulfuric acid. Forms sensitive, explosive mixtures with iodine pentafluoride, silver perchlorate, nitryl perchlorate, nitric acid, liquid oxygen, ozone, arsenic pentafluoride + potassium methoxide (explodes above 30°C). Ignites on contact with sodium peroxide + water, dioxygenyl tetrafluoroborate, iodine heptafluoride, and dioxygen difluoride. Vigorous or incandescent reaction with hydrogen + Raney nickel (above 210°C), uranium hexafluoride, and bromine trifluoride. Can react vigorously with oxidizing materials, such as Cl_2, CrO_3, O_2, $NClO_4$, O_3, perchlorates, ($AlCl_3$ + $FClO_4$), (H_2SO_4 + permanganates), K_2O_2, ($AgClO_4$ + acetic acid), Na_2O_2. Moderate explosion hazard when exposed to heat or flame. Use with adequate ventilation. To fight fire, use foam, CO_2, dry chemical.

Poisoning occurs most commonly via inhalation of the vapor, although benzene can penetrate the skin and cause poisoning. Locally, benzene has a comparatively strong irritating effect, producing erythema and burning, and, in more severe cases, edema and even blistering. Exposure to high concentrations of the vapor (3000 ppm or higher) may result from failure of equipment or spillage. Such exposure, while rare in industry, may cause acute poisoning, characterized by the narcotic action of benzene on the central nervous system. The anesthetic action of benzene is similar to that of other anesthetic gases, consisting of a preliminary stage of excitation followed by depression and, if exposure is continued, death through respiratory failure. The chronic, rather than the acute form, of benzene poisoning is important in industry. It is a recognized leukemogen. There is no specific blood picture occurring in cases of chronic benzol poisoning. The bone marrow may be hypoplastic, normal, or hyperplastic, the changes reflected in the peripheral blood. Anemia, leucopenia, macrocytosis, reticulocytosis, thrombocytopenia, high color index, and prolonged bleeding time may be present. Cases of myeloid leukemia have been reported. For the worker, repeated blood examinations are necessary, including hemoglobin determinations, white and red cell counts, and differential smears. Where a worker shows a progressive drop in either red or white cells, or where the white count remains low, 5,000/mm_3 or the red count <4.0 million/mm_3, on two successive monthly examinations, the worker should be immediately removed from benzene exposure. Elimination is chiefly through the lungs, when fresh air is breathed. The portion that is absorbed is oxidized, and the oxidation products are combined with sulfuric and glycuronic acids and eliminated in the urine. This may be used as a diagnostic sign. Benzene has a definite cumulative action, and exposure to a relatively high concentration is not serious from the point of view of causing damage to the blood-forming system, provided the exposure is not repeated. In acute poisoning, the worker becomes confused and dizzy, complains of tightening of the leg muscles and of pressure over the forehead, then passes into a stage of excitement. If allowed to remain exposed, he quickly becomes stupefied and lapses into coma. In non-fatal cases, recovery is usually complete with no permanent disability. In chronic poisoning the onset is slow, with the symptoms vague, fatigue, headache, dizziness, nausea and loss of appetite, loss of weight and weakness are common complaints in early cases. Later, pallor, nosebleeds, bleeding gums, menorrhagia, petechiae and purpura may develop. There is great individual variation in the signs and symptoms of chronic benzene poisoning.

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4722. Hydrogen Cyanide. *Hydrocyanic acid;* Blausäure (German); prussic acid. CHN; mol wt 27.03. C 44.44%, H 3.73%, N 51.83%. HCN. Prepd on a large scale by the catalytic oxidation of ammonia-methane mixtures (Andrussow Process): *see* Andrussow, *Angew. Chem.* 48, 593 (1935); Maffezzoni, *Chim. Ind. (Milan)* 34, 460 (1952); Faith, Keyes & Clark's *Industrial Chemicals*, F. A. Lowenheim, M. K. Moran, Ed. (Wiley-Interscience, New York, 4th ed., 1975) pp 482-486 May also be prepd by the catalytic decompn of formamide. Conveniently prepd in the laboratory by acidifying NaCN or $K_4[Fe(CN)_6]$: Glemser in *Handbook of Preparative Inorganic Chemistry* vol. 1, G. Brauer, Ed. (Academic Press, New York, 2nd ed., 1963) pp 658-660.

Colorless gas or liquid; characteristic odor; very weakly acid (does not redden litmus); burns in air with a blue flame; *intensely poisonous* even when mixed with air. d(gas) 0.941 (air = 1); d(liq) 0.687. mp −13.4°. bp 25.6°. Miscible with water, alc; slightly sol in ether. LC_{50} in rats, mice, dogs: 544 ppm (5 min), 169 ppm (30 min), 300 ppm (3 min), K. C. Back *et al.*, *Reclassification of Materials Listed as Transportation Health Hazards* (TSA-20-72-3; PB214-270).

Human Toxicity: High concn produces tachypnea (causing increased intake of cyanide); then dyspnea, paralysis, unconsciousness, convulsions and respiratory arrest. Headache, vertigo, nausea and vomiting may occur with lesser concns. Chronic exposure over long periods may cause fatigue, weakness. Exposure to 150 ppm for ½ to 1 hr may endanger life. Death may result from a few min exposure to 300 ppm. Average fatal dose: 50 to 60 mg. *Antidote:* Sodium nitrite and sodium thiosulfate, *cf.* Patty's *Industrial Hygiene and Toxicology* vol. 2C, G. D. Clayton, F. E. Clayton, Eds. (Wiley-Interscience, NewYork, 3rd ed., 1982) pp 4850-4853.

USE: The compressed gas is used for exterminating rodents and insects in ships and for killing insects on trees, etc. *Must be handled by specially trained experts.*

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hydrocyanic acid (prussic acid; hydrogen cyanide; formonitrile) HCN.

Properties: Water-white liquid at temperatures below 26.5° C; faint odor of bitter almonds; usual commercial material is 96–99.5% pure; sp. gr. (liquid) 0.688 (20/4° C); density (gas) 0.938 g/l; b.p. 25.6° C; freezing point −13.3° C; flash point 0° F (−17.7° C); soluble in water. The solution is weakly acidic; sensitive to light. When not absolutely pure or stabilized, hydrogen cyanide polymerizes spontaneously with explosive violence. Miscible in all proportions with water, alcohol; soluble in ether. Autoignition temp. 1000° F (537° C).

Derivation: (a) By catalytically reacting ammonia and air with methane or natural gas. (b) By recovery from coke oven gases. (c) From bituminous coal and ammonia at 1250° C. HCN occurs naturally in some plants (almond, oleander).

Grades: Technical (96–98%); 2, 5 and 10% solutions. All grades usually contain a stabilizer, usually 0.05% phosphoric acid.

Containers: Bottles; steel cylinders; tank cars.

Hazard: Highly toxic by ingestion, inhalation, and skin absorption. Flammable, dangerous fire risk. Explosive limits in air, 6 to 41%. Tolerance, 10 ppm in air; absorbed by skin.

Uses: Manufacture of acrylonitrile, acrylates, adiponitrile, cyanide salts, dyes; chelates; rodenticide; pesticide.

Shipping regulations: (Liquefied) (Rail) Flammable Gas and Poison Gas labels; Not acceptable passenger. (Air) Not acceptable. (Solution over 5%) (Rail) Flammable Gas and Poison Gas labels. Not acceptable passenger. (Air) Not acceptable. (Unstabilized) (Rail, Air) Not acceptable. (Less than 5% solution) (Rail, Air) Poison label. Not acceptable passenger.

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HHS000 CAS:74-90-8 *HR: 3*
HYDROCYANIC ACID
DOT: NA 1051/UN 1613/UN 1614
mf: CHN mw: 27.03

PROP: Odor of bitter almonds. Mp: −13.2°, bp: 25.7°, lel: 5.6%, uel: 40%, flash p: 0°F (CC), d: 0.6876 @ 20°/4°, autoign temp: 1000°F, vap press: 400 mm @ 9.8°, vap d: 0.932. Misc in water, alc, and ether.

SYNS: ACIDE CYANHYDRIQUE (FRENCH) ◇ ACIDO CIANIDRICO (ITALIAN) ◇ AERO liquid HCN ◇ BLAUSAEURE (GERMAN) ◇ BLAUWZUUR (DUTCH) ◇ CYAANWATERSTOF (DUTCH) ◇ CYANWASSERSTOFF (GERMAN) ◇ CYCLON ◇ CYCLONE B ◇ CYJANOWODOR (POLISH) ◇ HCN ◇ HYDROCYANIC ACID, liquefied (DOT) ◇ HYDROCYANIC ACID (PRUSSIC), unstabilized (DOT) ◇ HYDROGEN CYANIDE (OSHA, ACGIH) ◇ HYDROGEN CYANIDE, anhydrous, stabilized (DOT) ◇ PRUSSIC ACID (DOT) ◇ PRUSSIC ACID, unstabilized ◇ RCRA WASTE NUMBER P063 ◇ ZACLON DISCOIDS

TOXICITY DATA with REFERENCE
orl-hmn LDLo:570 μg/kg PCOC** -,596,66
ihl-hmn LCLo:200 ppm/5M TABIA2 3,231,33
ihl-hmn LCLo:120 mg/m³/1H JIHTAB 24,255,42
ihl-hmn LCLo:200 mg/m³/10M WHOTAC -,30,70
ihl-man LCLo:400 mg/m³/2M 85GMAT -,75,82
scu-hmn LDLo:1 mg/kg SCJUAD 4,33,67
ivn-hmn LD50:1 mg/kg SCJUAD 4,33,67
ivn-man TDLo:55 μg/kg:PUL NTIS** PB158-508
unr-man LDLo:1471 μg/kg 85DCAI 2,73,70
ihl-rat LC50:484 ppm/5M TXAPA9 42,417,77
ivn-rat LD50:810 μg/kg NTIS** AD-A028-501
orl-mus LD50:3700 μg/kg APFRAD 19,740,61
ihl-mus LC50:323 ppm/5M TXAPA9 42,417,77
ipr-mus LD50:2990 μg/kg BJPCAL 23,455,64
scu-mus LDLo:3 mg/kg HBAMAK 4,1340,35
ivn-mus LD50:990 μg/kg NTIS** AD-A028-501
ims-mus LD50:2700 μg/kg BJPCAL 23,455,64
orl-dog LDLo:4 mg/kg HBAMAK 4,1340,35
ihl-dog LC50:616 mg/m³/1M NTIS** AD-A028-501
scu-dog LDLo:1700 μg/kg HBAMAK 4,1340,35
ivn-dog LD50:1340 μg/kg NTIS** AD-A028-501
ihl-mky LC50:1616 mg/m³/1M NTIS** AD-A028-501

CONSENSUS REPORTS: EPA Extremely Hazardous Substances List. Community Right-To-Know List. Reported in EPA TSCA Inventory.

OSHA PEL: (Transitional: TWA 10 ppm (skin)); STEL 4.7 ppm (skin)
ACGIH TLV: CL 10 ppm (skin)
DFG MAK: 10 ppm (11 mg/m³)
NIOSH REL: (Cyanide) CL 5 mg(CN)/m³/10M
DOT Classification: Poison A; Label: Poison Gas and Flammable Gas; IMO: Poison B; Label: Poison (UN 1614); IMO: Poison B; Label: Flammable Liquid and Poison; Forbidden, Unstabilized.

SAFETY PROFILE: A deadly human and experimental poison by all routes. Hydrocyanic acid and the cyanides are true protoplasmic poisons, combining in the tissues with the enzymes associated with cellular oxidation. They thereby render the oxygen unavailable to the tissues and cause death through asphyxia. The suspension of tissue oxidation lasts only while the cyanide is present; upon its removal, normal function is restored provided death has not already occurred. HCN does not combine easily with hemoglobin, but it does combine readily with methemoglobin to form cyanmethemoglobin. This property is utilized in the treatment of cyanide poisoning when an attempt is made to induce methemoglobin formation. The presence of cherry-red venous blood in cases of cyanide poisoning is due to the inability of the tissues to remove the oxygen from the blood. Exposure to concentrations of 100-200 ppm for periods of 30-60 minutes can cause death. In cases of acute cyanide poisoning death is extremely rapid, although sometimes breathing may continue for a few minutes. In less acute cases, there is cyanosis, headache, dizziness, unsteadiness of gait, a feeling of suffocation, and nausea. Where the patient recovers, there is rarely any disability.

Very dangerous fire hazard when exposed to heat, flame or oxidizers. Can polymerize explosively at 50-60C° or in the presence of traces of alkali. Severe explosion hazard when exposed to heat or flame or by chemical reaction with oxidizers. The anhydrous liquid is stabilized at or below room temperature by the addition of acid. The gas forms explosive mixtures with air. Reacts violently with acetaldehyde. To fight fire, use CO_2, non-alkaline dry chemical, foam. When heated to decomposition or in reaction with water, steam, acid or acid fumes it produces highly toxic fumes of CN^-. An insecticide. See also CYANIDE.

Dangerous Properties of Hazardous Materials
by: N. Irving Sax

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6522. Nitrogen. N; at. wt 14.0067; at. no. 7; valences 3, 5; elemental state: N_2. Two naturally occurring isotopes: 14 (99.635%); 15 (0.365%); five short-lived, artificial, radioactive isotopes: 12; 13; 16-18. Discovered in 1772 by Daniel Rutherford and independently by Scheele and Cavendish. Constitutes about 75.5% by weight or 78.06% by volume of the atmosphere; found frequently in volcanic or mine gases, gases from springs and gases occluded in minerals and rocks; an essential constituent of all living organisms; fixed or combined nitrogen is present in many mineral deposits. Prepn from sodium (and alkaline earth) azides by heating the azide: Tiede, *Ber.* 46, 4100 (1913); 49, 1745 (1916); Justi, *Ann. Physik* [5] 10, 985 (1931). Prepd industrially by fractional distln of liquid air; by removal of oxygen by combustion; by reduction of ammonia. Purification of nitrogen furnished in steel cylinders: Kautsky, Thiele, Z. *Anorg. Allgem. Chem.* 152, 342 (1926); Kendall, *Science* 73, 395 (1931); Schenk in *Handbook of Preparative Inorganic Chemistry* vol. 1, G. Brauer, Ed. (Academic Press, New York, 2nd ed., 1963) pp 458-460. Review of nitrogen and nitrogen compounds: Jones in *Comprehensive Inorganic Chemistry* vol. 2, J. C. Bailar, Jr. *et al.*, Eds. (Pergamon Press, Oxford, 1973) pp 147-388; R. W. Schroeder in Kirk-Othmer *Encyclopedia of Chemical Technology* vol. 15 (Wiley-Interscience, New York, 3rd ed., 1981) pp 932-941. Books: W. L. Jolly, *The Inorganic Chemistry of Nitrogen* (Benjamin, New York, 1964) 124 pp; *Mellor's* Vol. VIII, Supplements I, II, *Nitrogen*, part 1 (1964) 619 pp; part 2 (1967) 676 pp; M. Sittig, *Nitrogen in Industry* (Van Nostrand, Princeton, 1965) 278 pp.

Odorless gas; condenses to a liq, bp −195.79° (77.36°K); solidifies to a snow-white mass, mp −210.01° (63.14°K). $d^{0,1}$ (0°, 1 atm) 1.25046 g/l. Critical temp: −147.1°; critical press: 33.5 atm; critical density: 0.311 g/cm³. Sparingly sol in water: 100 volumes of water absorbs 2.4 volumes of gas at 0°, 1.6 volumes at 20° Soly in water at 50, 75 and 100° from 25 to 1000 atmospheres: Wiebe *et al.*, *J. Am. Chem. Soc.* 55, 947 (1933). Soly in liq ammonia: Wiebe *et al.*, *ibid.* 975. Soly in alc: one volume of alcohol dissolves 0.1124 volume of nitrogen at 20°. Liquid oxygen at −195.5° absorbs 50.7% of its weight of gaseous nitrogen. Heat of dissociation of the nitrogen molecule (N_2): 225.1 kcal/mole. Combines with oxygen and hydrogen on sparking, forming nitric oxide and ammonia, respectively. Combines directly with lithium, and at a red heat with calcium, strontium, and barium to form nitrides. Forms cyanides when heated with carbon in presence of alkalies or barium oxide.

USE: In manuf of ammonia, nitric acid, nitrates, cyanides, etc.; in manuf explosives; in filling high-temp thermometers, incandescent bulbs; to form an inert atm for preservation of materials, for use in dry boxes or glove bags Liquid nitrogen in food-freezing processes; in the laboratory as a coolant. Pharmaceutic aid (air displacement). *Caution:* In high concns it is a simple asphyxiant.

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nitrogen. CAS: 7727-37-0. N. Gaseous element of atomic number 7 of group VA of the Periodic system, aw 14.0067, valences = 1, 2, 3, 4, 5. There are 2 stable and 4 radioactive isotopes, the molecular formula is N_2. Second highest-volume chemical produced in US (1985).

Properties: Colorless, odorless, tasteless, diatomic gas constituting approximately four-fifths of the air; colorless liquid, chemically unreactive, d 1.251 g/L (0C, 1 atm), d (gas) 0.96737 (air = 1.00), (liquid) 0.804, (solid) 1.0265, fp −210C, bp −195.5C, slightly soluble in water, slightly soluble in alcohol, an asphyxiant gas. Combustible.

Derivation: From liquid air by fractional distillation, by reducing ammonia.

Grade: USP, prepurified 99.966% min, extra dry 99.7% min, water pumped 99.6% min.

Use: Production of ammonia, acrylonitrile, nitrates, cyanamide, cyanides, nitrides; manufacture of explosives; inert gas for purging, blanketing, and exerting pressure; electric and electronic industries; in-transit food refrigeration and freeze drying; pressurizing liquid propellants; quick-freezing foods; chilling in aluminum foundries; bright annealing of steel; cryogenic preservation, food antioxidant; source of pressure in oil wells; inflating tires; component of fertilizer mixtures.

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Condensed Chemical Dictionary

NGP500 CAS:7727-37-9 *HR: 1*
NITROGEN
DOT: UN 1066/UN 1977
mf: N_2 mw: 28.02

PROP: Colorless gas, colorless liquid or cubic crystals at low temp. Mp: −210.0°, d: 1.2506 g/L @ 0°, d (liquid). 0.808 @ −195.8°. Condenses to a liquid. Sltly sol in water; sol in liquid ammonia, alc.

SYNS: NITROGEN, compressed (DOT) ◇ NITROGEN, refrigerated liquid (DOT) ◇ NITROGEN GAS

CONSENSUS REPORTS: Reported in EPA TSCA Inventory.

DOT Classification: Nonflammable Gas; Label: Nonflammable Gas.

SAFETY PROFILE: Low toxicity. In high concentrations it is a simple asphyxiant. The release of nitrogen from solution in the blood, with formation of small bubbles, is the cause of most of the symptoms and changes found in compressed air illness (caisson disease). It is a narcotic at high concentration and high pressure. Both the narcotic effects and the bends are hazards of compressed air atmospheres such as found in underwater diving. Nonflammable Gas. Can react violently with lithium, neodymium, titanium under the proper conditions. See also ARGON.

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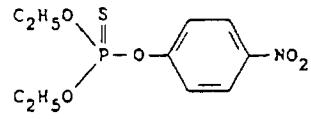
Dangerous Properties of Hazardous Materials by: N. Irving Sax

6983. Parathion. *Phosphorothioic acid O,O-diethyl O-(4-nitrophenyl) ester; O,O*-diethyl *O-p*-nitrophenyl phosphorothioate; diethyl-*p*-nitrophenyl monothiophosphate; DNTP, S.N.P.; E 605; AC 3422; ENT 15108; Alkron; Alleron; Aphamite; Etilon; Folidol; Fosferno; Niran; Paraphos; Rhodiatox; Thiophos. $C_{10}H_{14}NO_5PS$; mol wt 291.27. C 41.23%, H 4.84%, N 4 81%, O 27.47%, P 10.64%, S 11.01%. Non-systemic contact and stomach insecticide and acaricide. Original prepn: Thurston, *FIAT Report 949* (1946); Coates, Topley, *BIOS Final Report 1808* (1947). See also Fletcher *et al., J. Am. Chem. Soc.* 70, 3943 (1948). Conversion to toxic oxygen analogs: *See* Paraoxon. *Review:* Hall, *Advances in Chemistry Series* 1, 150 (1950). Review of industrial syntheses: Chadwick, Watt, "Thiophosphates" in *Phosphorus and its Compounds* vol. 2, J. R. Van Wazer, Ed. (Interscience, New York, 1961) pp 1257-1262. Review of distribution, transport and fate in the environment: M. S. Mulla *et al., Residue Rev.* 81, 1-159 (1981).



Pale yellow liquid. bp_{760} 375°; $bp_{0.6}$ 157-162°. mp 6°. n_D^{25} 1.5370. d_4^{25} 1.26. Vapor press at 20°: 3.78 × 10^{-5} mm Hg. Surface tension at 25°: 39.2 dynes/cm. Viscosity at 25°: 15.30 cp. Absorption spectra: Williams, *Ind. Eng. Chem.* 43, 950 (1951). Freely sol in alcohols, esters, ethers, ketones, aromatic hydrocarbons. Practically insol in water (20 ppm), petr ether, kerosene, and the usual spray oils. Incompatible with substances having a pH higher than 7.5. LD_{50} in female, male rats: 3.6, 13 mg/kg orally; 6.8, 21 mg/kg dermally, T. B. Gaines, *Toxicol. Appl. Pharmacol.* 14, 515 (1969).

Human Toxicity: Highly toxic. Acute effects include anorexia, nausea, vomiting, diarrhea, excessive salivation, pupillary constriction, bronchoconstriction, muscle twitching, convulsions, coma, respiratory failure. Cholinesterase inhibitor effects are cumulative, *cf. Clinical Toxicology of Commercial Products*, R. E. Gosselin *et al.*, Eds. (Williams & Wilkins, Baltimore, 4th ed., 1976) Section III, pp 263-271. Special precautions necessary to prevent inhalation and skin contamination.

USE: Insecticide; acaricide.

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parathion. (generic name for O,O-diethyl-O,p-nitrophenyl phosphorothioate; ethyl parathion; O,O-diethyl-p-nitrophenyl thiophosphate; AATP). CAS: 56-38-2.
$(C_2H_5O)_2P(S)OC_6H_4NO_2$.

Properties: Deep brown to yellow liquid, usually has faint odor, refr index 1.5367 (25C), d 1.26 (25/4C), bp 375C, fp 6C, vap press 0.003 mm (24C). very slightly soluble in water (20 ppm); completely soluble in esters, alcohols, ketones, ethers, aromatic hydrocarbons, animal and vegetable oils; insoluble in petroleum ether, kerosene, spray oils; stable in distilled water and in acid solution; hydrolyzed in the presence of alkaline materials; slow decomposition in air. Purity: Technical grade is 95% pure. Also supplied diluted with inert carriers of various types, and in various proportions.

Derivation: From sodium ethylate, thiophosphoryl chloride, and sodium p-nitrophenate.

Hazard: Highly toxic by skin contact, inhalation, or ingestion; cholinesterase inhibitor. Repeated exposure may, without symptoms, be increasingly hazardous. Fatalities have resulted from its accidental use; use may be restricted. TLV: 0.1 mg/m^3 of air.

Use: Insecticide and acaricide.

See also methyl parathion.

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PARATHION

CAS RN: 56382 NIOSH #: TF 4550000
mf: $C_{10}H_{14}NO_5PS$; mw: 291.28

Pale-yellow liquid. bp: 375°; mp: 6°. Very sol in alcos, esters, ethers, ketones, aromatic hydrocarbons; insol in water, petr ether, kerosene.

SYNS:

O,O-DIAETHYL-O-(4-NITRO-PHENYL)-MONOTHIOPHOSPHAT (GERMAN)
O,O-DIETHYL-O-(4-NITRO-FENIL)-MONOTHIOFOSFAAT (DUTCH)
O,O-DIETHYL-O-P-NITRO-FENYLESTER KYSELINY THIOFOSFORECNE (CZECH)
O,O-DIETHYL-O-4-NITROPHENYL-PHOSPHOROTHIOATE
DIETHYL-P-NITROPHENYL THIOPHOSPHATE
O,O-DIETHYL O-(P-NITRO-PHENYL) PHOSPHOROTHIOATE
O,O-DIETHYL-O-(4-NITRO-PHENYL) PHOSPHOROTHIOATE
DIETHYL 4-NITROPHENYL PHOS-PHOROTHIONATE
O,O-DIETHYL O-P-NITROPHENYL THIOPHOSPHATE
DIETHYL P-NITROPHENYL THIONOPHOSPHATE
O,O-DIETHYL-O-(P-NITRO-PHENYL)THIONOPHOSPHATE
O,O-DIETHYL O-4-NITROPHENYL THIOPHOSPHATE
DIETHYLPARATHION
O,O-DIETIL-O-(4-NITRO-FENIL)-MONOTIOFOSFATO (ITALIAN)
O,O-DIETHYL-O-P-NITROFENYL-TIOFOSFAT (CZECH)
ENT 15,108
NCI-C00226
NITROSTIGMINE
PARATHENE
PARATHION, LIQUID (DOT)
PHOSPHOSTIGMINE
STABILIZED ETHYL PARATHION
THIOPHOSPHATE DE O,O-DIETHYLE ET DE O-(4-NITRO-PHENYLE) (FRENCH)

TOXICITY DATA: 3	CODEN:
dnd-rat-orl 6 ppm	MUREAV 53,175,78
dnd-rat-ipr 3 ug/kg	MUREAV 53,175,78
dnd-mus-orl 6 ppm	MUREAV 53,175,78
dnd-mus-ipr 3 ug/kg	MUREAV 53,175,78
dnd-rat-orl 10 mg/kg/28D-I	MUREAV 53,175,78
dnd-rat-orl 20 mg/kg/28D-I	MUREAV 53,175,78
orl-rat TDLo:360 ug/kg (2-22D preg/15D post)	TOLEDS 3,11,79
scu-rat TDLo:6 mg/kg (13-16D preg)	PWPSA8 16,141,73
ihl-rat LC50:84 mg/m3/4H	NTIS** AD-A041-973
ipr-rat TDLo:3 mg/kg (11D preg)	AEHLAU 16,805,68
ipr-rat TDLo:3500 µg/kg (11D preg)	AEHLAU 16,805,68
orl-rat TDLo:1260 mg/kg/80W-C:ETA	NCITR* NCI-CG-TR-70,79
orl-hmn LDLo:240 ug/kg	CMEP** -,1,56
orl-wmn TDLo:5670 ug/kg:CNS	ANYAA9 160,383,69
unk-man LDLo:1471 ug/kg	85DCAI 2,73,70
orl-rat LD50:2 mg/kg	TXAPA9 11,546,67
ihl-rat LCLo:10 mg/m3/2H	AMIHBC 5,44,52
skn-rat LD50:6800 ug/kg	TXAPA9 2,88,60
ipr-rat LD50:1500 ug/kg	PSEBAA 114,509,63
ivn-rat LDLo:3 mg/kg	GUCHAZ 6,391,73
ims-rat LD50:6 mg/kg	JCINAO 37,350,58
orl-mus LD50:6 mg/kg	AMIHAB 11,487,55
skn-mus LD50:32400 ug/kg	ABCHA6 25,605,61
ipr-mus LD50:5600 ug/kg	IJBBBQ 15,336,78
ipr-rat LD50:3550 ug/kg	BLLIAX 38,151,58
scu-mus LD50:11500 ug/kg	ABCHA6 25,605,61

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ivn-mus LD50:7400 ug/kg	JPPMAB 19,612,67
ims-mus LD50:7200 ug/kg	AEPPAE 237,211,59
orl-dog LD50:3 mg/kg	SPEADM 78-1,33,78
ivn-dog LD50 12 mg/kg	JAMAAP 144,104,50
orl-cat LD50:930 ug/kg	ABCHA6 25,605,61
ivn-cat LD50:3 mg/kg	JAMAAP 144,104,50
orl-rbt LD50:10 mg/kg	SPEADM 78-1,33,78
ihl-rbt LCLo:50 mg/m3/2H	AMIHBC 5,44,52
skn-rbt LD50:40 mg/kg	AFDOAQ 16,3,52
orl-gpg LD50:8 mg/kg	ARZNAD 5,626,55
ihl-gpg LCLo:14 mg/m3/2H	AMIHBC 5,44,52
skn-gpg LD50:600 mg/kg	TXAPA9 7,559,65
ipr-gpg LD50:12 mg/kg	ARZNAD 5,626,55
orl-pgn LD50:3 mg/kg	TXAPA9 20,57,71
orl-qal LD50:6 mg/kg	TXAPA9 20,57,71
orl-dck LD50:2340 ug/kg	TXAPA9 22,556,72
skn-dck LD50:28 mg/kg	TXAPA9 47,451,79
orl-dom LD50:5 mg/kg	85DPAN -,-,71/76
unk-mam LD50:6 mg/kg	30ZDA9 -,323,71
orl-bwd LD50:2 mg/kg	TXAPA9 21,318,72
skn-bwd LD50:1800 ug/kg	TXAPA9 21,154,73

Aquatic Toxicity Rating: TLm96:under 1 ppm WQCHM* 4,-,74.

TLV: Air: 0.1 mg/m3 (skin) DTLVS* 4,320,80. *Toxicology Review:* ANAEA3 35,165,75; AQMOAC #73-19,1973; RREVAH 46,1,73; MZUZA8 (8),90,73; CNDQA8 10(3),43,75; ECMAAI 14(3),141,73; DTTIAF 80(20),485,73; RREVAH 63,1,76. EPA: Farm Worker Field Reentry FEREAC 39,16888,74. OSHA Standard: Air: TWA 110 ug/m3 (skin) (SCP-T) FEREAC 39,23540,74. DOT: Poison B, Label: Poison FEREAC 41,57018,76. Occupational Exposure to Parathion recm std: Air: TWA 0.05 mg/m3 NTIS** NCI Carcinogenesis Bioassay Completed; Results Indefinite: Rat (NCITR* NCI-CG-TR-70,79); Results Negative: Mouse (NCITR* NCI-CG-TR-70,79). "NIOSH Manual of Analytical Methods" VOL 1 158, VOL 3 S295.

THR: MUT data. An exper ETA. A ± CARC; A hmn CNS. HIGH ipr, orl, unk, ihl, skn, ivn, ims. A deadly poison. A cholinesterase inhibitor.

Parathion, like the other organic phosphorus poisons, acts as an irreversible inhibitor of the molecules of the enzyme cholinesterase and thus allows the accumulation of large amounts of acetylcholine. When a critical level of cholinesterase depletion is reached, grave symptoms appear. Whether death is actually caused entirely by cholinesterase depletion or by the disturbance of a number of enzymes is not yet known. Recovery is apparently complete if a poisoned animal or man has time to reform his critical quota of cholinesterase. However, if a second small dose is administered before recovery from the first is complete, the effect is partially additive.

Acute effects: Anorexia, nausea, vomiting, diarrhea, excessive salivation, pupillary constriction, bronchoconstriction, muscle twitching, convulsions, coma, respiratory failure. Effects are cumulative. Special precautions necessary to prevent inhal and skin contamination.

Dangerous chronic dose in man: Exposure to parathion reduces the cholinesterase level and the organism exposed remains susceptible to relatively low dosages of parathion until the cholinesterase level has regenerated. Small doses at frequent intervals are, therefore, more or less additive. There is not, however, at the present time, any indication that, when recovery from a given exposure is entirely complete, the exposed organism is prejudiced in any way. Laboratory findings are essentially normal except that by special techniques the cholinesterase level of the blood or serum may be shown to be greatly reduced. At autopsy, the same may be demonstrated for the cholinesterase level of the brain or other tissues provided fresh, unfixed tissue is employed.

The mean cholinesterase values of normal persons living without exposure to organic phosphorus insecticides have been found by various workers, using the Michel method, to range as follows:

Red blood cell	0.67-0.86	pH units/hr
Plasma	0.70-0.97	pH units/hr

It is believed that cholinesterase values of 0.5 or less for either cells or plasma represent abnormal depressions for most individuals. Nevertheless, people may experience far greater depressions (to 0.2 or less) without the onset of clinical signs or symptoms; this is especially true of workers who are exposed daily over a period of weeks but whose exposure at any one time is kept at a minimum.

Treatment for Poisoning: Keep the patient fully atropinized. Give 2-4 mg and repeat until signs of atropinization appear. The intravenous route is most rapid. The dosage of atropine is greater than that conventionally employed for other purposes but is within safe limits. Atropine relieves many of the distressing symptoms, reduces heart block, and dries secretions of the respiratory tract. Never give morphine, theophylline, or theophylline-ethylene-diamine (*AMINOPHYLLINE*). 2-PAM, alone or with atropine, is also an effective antidote.

If the patient has not yet shown symptoms or they have been allayed by the first dose of atropine, he must be completely and quickly decontaminated. Wearing rubber gloves, remove the patient's clothing and, with due regard for his condition at the moment, bathe him thoroughly with soap and water. If washing soda is available use it, for parathion is hydrolyzed more rapidly in the presence of alkali. Any relatively mild alkali may be used

If there is any suspicion that parathion has been ingested, induce vomiting, give some neutral material such as milk or water and induce vomiting again. Nausea may, of course, be anticipated on the basis of the systemic action of parathion but if vomiting is not profuse, gastric lavage may be used.If the pulmonary secretions have accumulated before atropine has become effective, the patient must be turned upside down or in some other positions of postural drainage in order to drain out mucus. Use suction and a catheter if necessary. If the stomach is distended, empty it with a Levine tube. Atropine does not protect against muscular weakness. The mechanism of death appears to be respiratory failure. The use of an oxygen tent or even the use of oxygen under slight positive pressure is advisable and

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should be started early. Watch the patient *constantly, for the need of artificial respiration may appear suddenly.* Equipment for artificial respiration should be placed by the patient's bed in readiness as soon as he is hospitalized. Cyanosis (anoxia) should be prevented by the most suitable means, since it aggravates the other signs of poisoning. Complete recovery may occur even after many hours of artificial respiration have been necessary. The acute emergency lasts 24-48 hrs, and the patient must be *watched continuously* during that time. Favorable response to one or more doses of atropine does not guarantee against sudden and fatal relapse. Medication mus be continued during the entire emergency. Following exposure heavy enough to produce symptoms, further organic phosphorus insecticide exposure of any sort should be avoided. The patient remains susceptible to relatively small exposures of parathion until regeneration of cholinesterase is complete or nearly so. Persons exposed to other organic phosphorus insecticides before complete recovery from a previous exposure are made more susceptible and vice-versa.

Decomp by heat. Violent reaction with endrin.

Disaster Hazard: Highly dangerous; shock can shatter the container, releasing the contents. When heated to decomp, emits highly tox fumes of NO_x, PO_x, SO_x.

For further information see Vol. 3, No. 3 of *DPIM Report.*

Dangerous Properties of Hazardous Materials
by: N. Irving Sax

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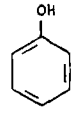
7206. Phenol. Carbolic acid; phenic acid; phenylic acid; phenyl hydroxide; hydroxybenzene; oxybenzene C_6H_6O; mol wt 94.11. C 76.57%, H 6.43%, O 17.00%. Obtained from coal tar, or made by fusing sodium benzenesulfonate with NaOH, or by heating monochlorobenzene with aq NaOH under high pressure. The crystalline article of commerce contains at least 98% phenol. Review of mfg processes: A. Dierichs, R. Kubicka, *Phenole und Basen, Vorkommen und Gewinnung* (Akademie-Verlag, Berlin, 1958) 472 pp, Faith, Keyes & Clark's *Industrial Chemicals*, F. A. Lowenheim, M. K. Moran, Eds. (Wiley-Interscience, New York, 4th ed., 1975) pp 612-623. Use in treatment of spasticity: D. E. Garland *et al.*, *Clin Orthop.* 165, 217 (1982); *eidem*, *Arch. Phys. Med. Rehab.* 65, 243 (1984). Review of use in pain relief. K. M. Wood, *Pain* 5, 205-229 (1978). Review of toxicology: H. Babich, D. L. Davis, *Regul. Toxicol. Pharmacol.* 1, 90-109 (1981). Toxicity: W. B. Deichmann, S. Witherup, *J. Pharmacol Exp. Ther.* 80, 233 (1944). *Review:* C Thurman in Kirk-Othmer *Encyclopedia of Chemical Technology* vol. 17 (Wiley-Interscience, New York, 3rd ed., 1982) pp 373-384.



Colorless, acicular crystals or white, crystalline mass; characteristic odor. *Poisonous and caustic!* Prone to redden on exposure to air and light, hastened by presence of alkalinity. d 1.071. When free from water and cresols it congeals at 41° and melts at 43°. Ultrapure material mp 40.85°. The commercial product contains an impurity which raises the mp. bp 182°. Flash pt, closed cup: 175°F (79°C). n_D^{41} 1.5425. pKa at 25° = 10.0. pH of aq solns about 6.0. It is liquefied by mixing with about 8% water. One gram dissolves in about 15 ml water, 12 ml benzene; very sol in alcohol, chloroform, ether, glycerol, carbon disulfide, petrolatum, volatile and fixed oils, aq alkali hydroxides. Almost insol in petr ether. LD_{50} orally in rats: 530 mg/kg (Deichmann, Witherup). *Keep well closed and protected from light. Do not handle with bare hands.*

Incompat. Phenol coagulates collodion; liquefies or becomes semiliquid when triturated with acetanilide, butylchloral hydrate, camphor, monobromated camphor, chloral hydrate, diuretin, lead acetate, menthol, naphthalene, naphthol, acetophenetidin, pyrogallol, resorcinol, salol, sodium phosphate, thymol, urethane, chloralamide, terpin hydrate.

Ammonium salt, C_6H_9NO, *ammonium phenate, ammonium carbolate.* White to pink cryst masses. Sol in water.

Sodium salt, C_6H_5NaO, *phenolate sodium.*

Aqueous solution with phenolate sodium, *Chloraseptic.*

Human Toxicity Ingestion of even small amounts may cause nausea, vomiting, circulatory collapse, tachypnea, paralysis, convulsions coma, greenish or smoky-colored urine, necrosis of mouth and G.I. tract, icterus, death from respiratory failure, sometimes from cardiac arrest. Average fatal dose is 15 g but death from as little as one gram has been reported. Fatal poisoning may also occur by skin absorption following application to large areas Chronic poisoning with renal and hepatic damage may occur from industrial contact. *See* C. J. Polson, R. N. Tattersall, *Clinical Toxicology* (Lippincott, Philadelphia, 1969) pp 51-62; Deichmann, Keplinger in Patty's *Industrial Hygiene and Toxicology* vol. 2A, G D. Clayton, F. E. Clayton, Eds. (Wiley-Interscience, New York, 3rd ed., 1981) pp 2567-2584

USE: As a general disinfectant, either in soln or mixed with slaked lime, etc., for toilets, stables, cesspools, floors, drains, etc; for the manuf of colorless or light-colored artificial resins, many medical and industrial organic compds and dyes; as a reagent in chemical analysis. Pharmaceutic aid (preservative).

THERAP CAT: Aqueous soln as topical anesthetic, topical antiseptic; topical antipruritic.

THERAP CAT (VET): Antiseptic caustic. Topical anesthetic in pruritic skin conditions. Has been used internally and externally as an antiseptic.

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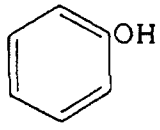
phenol. (1) A class of aromatic organic compounds in which one or more hydroxy groups are attached directly to the benzene ring. Examples are phenol itself (benzophenol), the cresols, xylenols, resorcinol, naphthols. Though technically alcohols, their properties are quite different.

(2) phenol. (carbolic acid; phenylic acid; benzophenol; hydroxybenzene). CAS: 108-95-2. C_6H_5OH.



34th highest-volume chemical produced in US (1985).

Properties: White, crystalline mass which turns pink or red if not perfectly pure or if under influence of light; absorbs water from the air and liquefies; distinctive odor; sharp burning taste. When in very weak solution it has a sweetish taste. D 1.07, mp 42.5–43C, bp 182C, flash p (CC) 172.4F (78C). Soluble in alcohol, water, ether, chloroform, glycerol, carbon disulfide, petrolatum, fixed or volatile oils, and alkalies. Autoign temperature 1319F (715C). Combustible.

Derivation: Most of the phenol in the US is made by the oxidation of cumene, yielding acetone as a byproduct. The first step in the reaction yields cumene hydroperoxide, which decomposes with dilute sulfuric acid to the primary products, plus acetophenone and phenyl dimethyl carbinol. Several other benzene-based processes have been used in the past; derivation from benzoic acid is also possible.

Method of purification: Rectification.

Grade: Fused, crystals, or liquid, all as technical (82%, 90%, 95%, other components mostly cresols), CP, and USP.

Hazard: Toxic by ingestion, inhalation, and skin absorption; strong irritant to tissue. TLV: 5 ppm in air.

Use: Phenolic resins, epoxy resins (bisphenol-A) nylon-6 (caprolactam), 2,4-D, selective solvent for refining lubricating oils, adipic acid, salicylic acid, phenolphthalein, pentachlorophenol, acetophenetidine, picric acid, germicidal paints, pharmaceuticals, laboratory reagent, dyes and indicators, slimicide, biocide, general disinfectant.

Note: High-boiling phenols are mixtures containing predominantly m-substituted alkyl phenols. Their boiling points range from 238 to 288C, they set to a glass at −30C.

Use: In phenolic resins, as fuel-oil sludge inhibitors, as solvents and as rubber chemicals.

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PHENOL

CAS RN: 108952 NIOSH #: SJ 3325000
mf: C_6H_6O; mw: 94.12

White, crystalline mass which turns pink or red if not perfectly pure, burning taste, distinctive odor. mp: 40.6°, bp: 181.9°, flash p: 175°F (CC), d: 1.072, autoign temp.: 1319°F, vap. press: 1 mm @ 40.1°, vap. d: 3 24. Sol in water; misc in alc, ether.

SYNS:

ACIDE CARBOLIQUE (FRENCH)
BAKER'S P AND S LIQUID AND OINTMENT
CARBOLIC ACID
CARBOLSAURE (GERMAN)
FENOL (DUTCH, POLISH)
FENOLO (ITALIAN)
HYDROXYBENZENE
MONOHYDROXYBENZENE
NCI-C50124
OXYBENZENE
PHENIC ACID
PHENOLE (GERMAN)
PHENYL HYDRATE
PHENYL HYDROXIDE
PHENYLIC ACID
PHENYLIC ALCOHOL

TOXICITY DATA 3	CODEN
skn-rbt 500 mg/24H SEV	BIOFX* 27-4/73
skn-rbt 535 mg open SEV	UCDS** 1/6/66
eye-rbt 5 mg SEV	UCDS** 1/6/66
mmo-sat 400 uL/plate	BECTA6 24,590,80
scc-hmn:lym 200 umol/L	CNREA8 40,1189,80
dnd-mam:lym 250 mmol/L	PNASA6 48,686,62
orl-rat TDLo:14 kg/kg/2Y-C:ETA	NCITR* NCI-CG-TR-203,80
orl-mus TDLo:27 kg/kg/2Y-C ETA	NCITR* NCI-CG-TR-203,80
skn-mus TDLo:16 gm/kg/40W-I:CARC	CNREA8 19,413,59
skn-mus TD:4000 mg/kg/24W-I:NEO	CNREA8 19,413,59
orl-hmn LDLo:140 mg/kg	29ZWAE -,329,68
orl-rat LD50:414 mg/kg	BIOFX* 27-4/73
skn-rat LD50:669 mg/kg	BJIMAG 27,155,70
ipr-rat LD50:250 mg/kg	BJPCAL 13,20,58
scu-rat LDLo:650 mg/kg	HBAMAK 4,1319,35
orl-mus LD50:300 mg/kg	JPETAB 88,400,46
ipr-mus LD50:360 mg/kg	AFREAW 3,197,51
scu-mus LD50:344 mg/kg	INHEAO 5,143,67
ivn-mus LD50:112 mg/kg	QJPPAL 12,212,39
orl-dog LDLo:500 mg/kg	HBAMAK 4,1319,35
par-dog LDLo:2000 mg/kg	RMSRA6 15,561,1895
orl-cat LDLo:80 mg/kg	HBAMAK 4,1319,35
scu-cat LDLo:80 mg/kg	JPETAB 80,233,44
par-cat LDLo:500 mg/kg	RMSRA6 15,561,1895
orl-rbt LDLo:420 mg/kg	JPETAB 80,233,44
skn-rbt LD50:850 mg/kg	AIHAAP 37(10),596,76
ipr-rbt LDLo:620 mg/kg	JPETAB 80,233,44
scu-rbt LDLo:620 mg/kg	JPETAB 80,233,44
ivn-rbt LDLo:180 mg/kg	JPETAB 80,233,44
par-rbt LDLo:300 mg/kg	RMSRA6 15,561,1895
ipr-gpg LDLo:300 mg/kg	HBTXAC 1,228,56
scu-gpg LDLo:450 mg/kg	HBTXAC 1,228,56
scu-frg LDLo:75 mg/kg	HBAMAK 4,1319,35
par-frg LDLo:290 mg/kg	AEPPAE 166,437,32
scu-frg LDLo:290 mg/kg	HBTXAC 1,228,56

Aquatic Toxicity Rating: TLm96:100-10 ppm WQCHM* 4,-,74.

TLV: Air: 5 ppm (skin) DTLVS* 4,328,80. *Toxicology Review:* CMTVAS 10(3),49,73; JIHTAB 31,146,49; MUREAV 47(2),75,78; FNSCA6 2,67,73; ZKKOBW 78,99,72. OSHA Standard: Air: TWA 5 ppm (skin) (SCP-L) FEREAC 39,23540,74 DOT: Poison B, Label: Poison FEREAC 41,57018,76. Occupational Exposure to Phenol recm std: Air: TWA 20 mg/m3; CL 60 mg/m3/15M NTIS**. Carcinogenesis Bioassay Completed; Results Negative (NCITR* NCI-CG-TR-203,80). "NIOSH Manual of Analytical Methods" VOL 3 S330. Reported in EPA TSCA Inventory, 1980.

THR. MUT data. A skn, eye irr. An exper CARC, NEO, ETA. HIGH orl, ipr, scu, par. MOD skn, scu, orl, par. In acute phenol poisoning, the main effect is on the CNS. Absorption from spilling phenolic solutions on the skin may be very rapid, and death results from collapse within 30 min to several hrs. Death has resulted from absorption of phenol through a skin area of 64 in. Where death is delayed, damage to the kidneys, liver, pancreas and spleen and edema of the lungs may result. Absorbed phenol is partly excreted by the kidneys, partly oxidized. Part of the excreted portion is combined with sulfuric and glycuronic acids; the remainder is excreted unchanged. The symptoms develop rapidly, frequently within 15-20 min following spilling of phenol on the skin. Headache, dizziness, muscular weakness, dimness of vision, ringing in the ears, irregular and rapid breathing, weak pulse, and dyspnea may all develop, and may be followed by loss of consciousness, collapse and death. When taken internally, there is also nausea, with or without vomiting, severe abdominal pain, and corrosion of the lips, mouth, throat, esophagus and stomach. There may be perforation. On the skin, the affected area is white, wrinkled and softened, and there is usually no immediate complaint of pain; later, intense burning is felt, followed by local anesthesia and still later, by gangrene. Chronic poisoning, following prolonged exposures to low concs of the vapor or mist, results in digestive disturbances (vomiting, difficulty in swallowing, excessive salivation, diarrhea, loss of appetite), nervous disorders (headache, fainting, dizziness, mental disturbances) and skin eruptions. Chronic poisoning may terminate fatally in cases where there has been extensive damage to the kidneys or liver. Dermatitis resulting from contact with phenol or phenol-containing products is fairly common in industry. A common air contaminant. As little as 1.5 g (oral) has killed.

Fire Hazard: Mod, when exposed to heat, flame or oxidizers and reacts violently with ($AlCl_3$ + nitrobenzene), butadiene, peroxydisulfuric acid, peroxymonosulfuric acid.

Spontaneous Heating. No.

Disaster Hazard: Dangerous; when heated it emits tox fumes; can react with oxidizing materials.

To Fight Fire: Alcohol foam, CO_2, dry chemical.

For further information see Vol 3, No. 4 in *DPIM Report.*

Dangerous Properties of Hazardous Materials
by: N. Irving Sax

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7333. Phosphorus Trichloride. Phosphorous chloride. Cl_3P; mol wt 137.35. Cl 77.45%, P 22.55%. PCl_3. Prepd from red phosphorus and dry chlorine in the presence of refluxing PCl_3: Forbes *et al.*, *Inorg. Syn.* 2, 145 (1946). Manuf: Faith, Keyes & Clark's *Industrial Chemicals*, F. A. Lowenheim, M. K. Moran, Eds. (Wiley-Interscience, New York, 4th ed., 1975) pp 654-657. *Review:* Payne, "Chemistry of Phosphorus Halides" in *Topics in Phosphorus Chemistry*, vol. 4, M. Grayson, E. J. Griffith, Eds. (Interscience, New York, 1967) pp 85-155.

Colorless, clear, fuming liquid. d_4^{21} 1.574 mp −112°. bp 76°. Vapor pressure: 100 mm (21°). Decomposed by water or alc. Sol in benzene, chloroform, ether, carbon disulfide. *Keep in tightly closed containers and handle with caution.*

USE: As of phosphorus oxychloride; manuf $POCl_3$, PCl_5, producing iridescent metallic deposits. *Caution:* Highly irritating and corrosive to skin, mucous membranes.

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phosphorus trichloride. (phosphorus chloride). CAS: 7719-12-2. PCl_3.

Properties: Clear, colorless, fuming liquid; decomposes rapidly in moist air; soluble in ether, benzene, carbon disulfide, and carbon tetrachloride; d 1.574; fp −111.8C; bp 76C.

Derivation: By passing a current of dry chlorine over gently heated phosphorus, which ignites. The trichloride admixed with some pentachloride distills over. A small amount of phosphorus is added and the whole distilled.

Grade: Technical, 99.9%.

Hazard: Corrosive to skin and tissue, reacts with water to form hydrochloric acid, store in tightly closed containers. TLV: 0.2 ppm in air.

Use: Making phosphorus oxychloride, intermediate for organophosphorus pesticides, surfactants, phosphites (reaction with alcohols and phenols), gasoline additives, plasticizers, dyestuffs, chlorinating agent, catalyst, preparing rubber surfaces for electrodeposition of metal, ingredient of textile finishing agents

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PHOSPHORUS CHLORIDE

CAS RN: 7719122 NIOSH #: TH 3675000
mf: Cl_3P; mw: 137.32

Clear, colorless, fuming liquid. mp: −111.8°, bp: 76°, d: 1.574 @ 21°, vap. press: 100 mm @ 21°, vap. d: 4.75. Decomp by H_2O, alc; sol in benzene, chloroform, ether.

SYNS:

CHLORIDE OF PHOSPHORUS
FOSFORO(TRICLORURO DI) (ITALIAN)
FOSFORTRICHLORIDE (DUTCH)
PHOSPHORE(TRICHLORURE DE) (FRENCH)
PHOSPHORTRICHLORID (GERMAN)
PHOSPHORUS TRICHLORIDE
TROJCHLOREK FOSFORU (POLISH)

TOXICITY DATA: 3-2

orl-rat LD50: 550 mg/kg
ihl-rat LC50: 104 ppm/4H
ihl-gpg LC50 50 ppm/4H

CODEN:

TNICS* 13,104,73
AIHAAP 25,470,64
AIHAAP 25,470,64

Aquatic Toxicity Rating: TLm96: 100-10 ppm WQCHM* 4,-,74.

TLV. Air: 0.5 ppm DTLVS* 4,340,80. OSHA Standard: Air: TWA 0.5 ppm (SCP-R) FEREAC 39,23540,74. DOT: Corrosive Material, Label: Corrosive and Poison FEREAC 41,57018,76. "NIOSH Manual of Analytical Methods" Vol 5 305#. Reported in EPA TSCA Inventory, 1980.

THR: HIGH irr to skin, eyes @ 2 ppm and mu mem and via inhal routes. MOD orl.

Fire and Explosion Hazard: Violent reactions with acetic acid, Al, $Cr(OCl)_2$, (diallyl phosphite + allyl alcohol), F_2, dimethyl sulfoxide, hydroxylamine, ICl, PbO_2, HNO_3, HNO_2, organic matter, K, Na, water.

Disaster Hazard. Dangerous; when heated to decomp it emits highly tox fumes of chlorides and PO_x; will react with water, steam or acids to produce heat and toxic and corrosive fumes; can react with oxidizing materials.

To Fight Fire: CO_2, dry chemical.

Dangerous Properties of Hazardous Materials
by: N. Irving Sax

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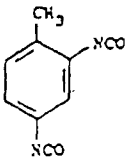
9456. Toluene 2,4-Diisocyanate. 2,4-Diisocyanatotoluene; 2,4-tolylene diisocyanate; TDI; Nacconate 100. $C_9H_6N_2O_2$; mol wt 174.15. C 62.07%, H 3.47%, N 16.09%, O 18.37%. Usually prepd from toluene-2,4-diamine and phosgene. *Review:* Astle, *Industrial Organic Nitrogen Compounds* (New York, 1961) pp 284-313; Faith, Keyes & Clark's *Industrial Chemicals*, F. A. Lowenheim, M. K. Moran, Eds. (Wiley-Interscience, New York, 4th ed., 1975) pp 831-835.



Liquid at room temperature. Sharp, pungent odor. mp 19.5-21.5°. d_4^{20} liq 1.2244. bp_{760} 251°; bp_{11} 126°. Darkens on exposure to sunlight. Reacts with water with evolution of carbon dioxide. Flash pt, open cup: 132° (270°F). Misc with alcohol (decompn), diglycol monomethyl ether, ether, acetone, carbon tetrachloride, benzene, chlorobenzene, kerosene, olive oil. Concd alkaline compds such as NaOH or *tert*-amines may cause run-away polymerization.

Caution: Vapor is irritating to eyes, skin and respiratory tract: *Clinical Toxicology of Commercial Products*, R. E. Gosselin *et al.*, Eds. (Williams & Wilkins, Baltimore, 5th ed., 1984) Section II, p 414. This substance may reasonably be anticipated to be a carcinogen: *Fourth Annual Report on Carcinogens* (NTP 85-002, 1985) p 190.

USE. In the manuf of polyurethane foams and other elastomers.

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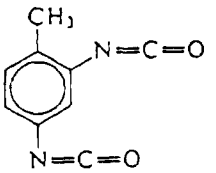
toluene-2,4-diisocyanate. (2,4-tolylene diisocyanate; m-tolylene diisocyanate; TDI).
CAS: 584-84-9. $CH_3C_6H_3(NCO)_2$.



Properties: Water-white to pale yellow liquid, sharp pungent odor, bp 251C, 120C (10 mm), flash p 270F (132C), mp 19.4–21.5C (pure isomer), d 1:22 (25/15.5C), vap press 0.01 mm at 20C. Reacts with water producing carbon dioxide; reacts with compounds containing active hydrogen (may be violent); soluble in ether, acetone, and other organic solvents. Combustible.
Derivation: Reaction of 2,4-diaminotoluene with phosgene.
Method of purification: Distillation to remove hydrogen chloride
Grade: 100% 2,4-isomer; 80% and 65% 2,4-isomer both mixed with 2,6-isomer.
Hazard: Toxic by ingestion and inhalation, strong irritant to skin and tissue, especially to eyes TLV: 0.005 ppm in air.
Use. Polyurethane foams, elastomers and coatings crosslinking agent for nylon 6.

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POTASSIUM HYDROXIDE

CAS RN: 1310583 NIOSH #: TT 2100000
mf: HKO; mw: 56.11

White, deliques pieces, lumps or sticks having crystalline fracture. mp: 360° ± 7°; bp: 1320°; d· 2.044. Violent, exothermic reaction with water.

SYNS.

CAUSTIC POTASH
HYDROXYDE DE POTASSIUM (FRENCH)
KALIUMHYDROXID (GERMAN)
KALIUMHYDROXYDE (DUTCH)
LYE
POTASSA
POTASSE CAUSTIQUE (FRENCH)
POTASSIO (IDROSSIDO DI) (ITALIAN)
POTASSIUM HYDRATE

TOXICITY DATA:	3	CODEN:
hma-rat/ast 1800 mg/kg		GANNA 254,155,63
skn-hmn 50 mg/24H SEV		TXAPA9 31,481,75
skn-rbt 50 mg/24H SEV		TXAPA9 31,481,75
skn-gpg 50 mg/24H SEV		TXAPA9 31,481,75
orl-rat LD50:365 mg/kg		TXAPA9 32,239,75

Aquatic Toxicity Rating: TLm96: 100-10 ppm WQCHM* 4,-,74.

TLV: Air: 2 mg/m3 DTLVS* 4,345,80. *Toxicology Review:* ARTODN 39,299,78. DOT: Corrosive Material, Label: Corrosive FEREAC 41,57018,76. Reported in EPA TSCA Inventory, 1980.

THR: HIGH orl. Hmn skn irr. An exper skn irr. A poison. Very corr and irr to skn, eyes and mu mem. A general-purpose food additive. See also sodium hydroxide. Ingestion may cause violent pain in throat and epigastrium, hematemesis, collapse. Stricture of esophagus may result if not immediately fatal

Incomp: Acids; ammonium hexachloroplatinate (2-), chlorine dioxide; germanium; hyponitrous acid; maleic anhydride, nitroalkanes; nitrobenzene; nitrogen trichloride, potassium peroxodisulphate, 2,2,3,3-tetrafluoropropanol, tetrahydrofuran; thorium dicarbide, 2,4,6-trinitrotoluene.

Dangerous Properties of Hazardous Materials
by: N. Irving Sax

"Reprinted from Sax's Dangerous Properties of Industrial Materials, 11th edition, 1992 by Richard J. Lewis, Sr. with permission of Van Nostrand Reinhold."

PHOSPHINE

CAS RN: 7803512 NIOSH #: SY 7525000
mf: H_3P; mw: 34.00

Colorless gas, foul odor. mp: −132.5°, bp −87.5°, d: 1.529 g/L @ 0°, autoign. temp.: 212°F, lel: 1%. Slightly sol in water.

SYNS:

FOSFOROWODOR (POLISH)
HYDROGEN PHOSPHIDE
PHOSPHORUS TRIHYDRIDE
PHOSPHORWASSERSTOFF (GERMAN)

TOXICITY DATA: 3-2

ihl-hmn LCLo:1000 ppm
ihl-rat LC50:11 ppm/4H
ihl-rbt LCLo:2500 ppm/20M
ihl-mam LCLo:1000 ppm/5M

CODEN:

GUCHAZ 6,412,73
AIHAAP 36,452,75
AEXPBL 27,314,1890
AEPPAE 138,65,28

TLV: Air: 0.3 ppm DTLVS* 4,337,80. *Toxicology Review:* AQMOAC #73-19,1973; NTIS** AD-778,725; 27ZTAP 3,114,69. OSHA Standard: Air: TWA 400 ug/m3 (SCP-O) FEREAC 39,23540,74. DOT: Poison A, Label: Flammable Gas and Poison Gas FEREAC 41,57018,76. "NIOSH Manual of Analytical Methods" VOL 5 S332#. Reported in EPA TSCA Inventory, 1980. EPA TSCA 8(a) Preliminary Assessment Information Proposed Rule FERREAC 45,13646,80.

THR: HIGH via inhal route. Phosphine is a very tox gas, but its action on the body has not been fully worked out. It appears to cause, chiefly, a depression of the CNS and irr of the lungs; autopsy findings in human cases may be entirely negative, or there may be pulmonary edema, dilation of the heart and hyperemia of the visceral organs. Inhal of phosphine causes restlessness, followed by tremors, fatigue, slight drowsiness, nausea, vomiting and, frequently, severe gastric pain and diarrhea. There is often headache, thirst, dizziness, oppression in the chest and burning substernal pain; later the patient may become dyspneic and develop cough and sputum Coma or convulsions may precede death. Most cases recover without aftereffects Chronic poisoning, characterized by anemia, bronchitis, gastrointestinal disturbances and visual, speech and motor disturbances, may result from continued exposure to very low conc

Fire Hazard: Very dangerous, by spont chemical reaction.

Explosion Hazard: Mod, when exposed to flame. Reacts violently with air, BCl_3, Br_2, Cl_2, Cl_2O, $Hg(NO_3)_2$, HNO_3, NO, NCl_3, NO_3, N_2O, HNO_2, O_2, $(K + NH_3)$, $AgNO_3$.

Explosive Range: Not known

Disaster Hazard: Dangerous; when heated to decomp it emits highly tox fumes of PO_x; can react vigorously with oxidizing materials.

To Fight Fire: CO_2, dry chemical or water spray

Dangerous Properties of Hazardous Materials
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GUIDELINES FOR THE SELECTION OF CHEMICAL PROTECTIVE CLOTHING

2nd Edition

By: A.D. Little

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.

This document presents clothing recommendations for fourteen major clothing materials and covers approximately 465 chemicals or aqueous solutions, along with more technical information.

HOW TO READ THE CHART

Single and double, upper and lower case "r's" and "n's" are used to convey the recommendations. Briefly, RR, R, rr, and r indicate various degrees of good resistance and NN, N, and n indicate various degrees of poor chemical resistance. Double characters indicate that there are test data to support the recommendations and single characters indicate that only qualitative information was available. Upper case characters indicate consensus and a relatively large amount of information, whereas lower case indicates a relatively small amount of information or inconsistencies.

A final comment pertains to the completeness of CPC product and vendor listings presented in the Appendices. The objective was to include at least one source for any given item of CPC. The listings, therefore, are extensive but are probably 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 EPA. Furthermore, the recommendations can also be modified as additional performance information becomes available to the EPA.

QUALITATIVE DESCRIPTION OF RECOMMENDATIONS

Qualitative Ratings

Quantity/ Resistance	Many/ Excellent	Volume I: Field Guide
Many/ Excellent	RR	Guidelines for the Selection of Chemical Protective Clothing 2nd Edition A.D. Schwope, Arthur D. Little, Inc. P.P. Costas, Arthur D. Little, Inc. J.O. Jackson, Los Alamos National Laboratory D.J. Weitzman, U.S Environmental Protection Agency March 1985
Few/Excellent or Few/Poor	rr	
Many/Fair or Few/Poor	nn	
Many/Poor	NN	

Text Data

None	R	r	n	N	No Recommend-ation

* Recommendations obtained by computer algorithm. See Appendix F of Volume II for rationale.

** Recommendations for these combinations were determined on basis of technical judgement rather than computer algorithm.

	BUTYL	CPE	VITON/NEOPRENE	NATURAL RUBBER	NEOPRENE	NITRILE+PVC	NITRILE	PE	PV ALCOHOL	PVC	VITON	BUTYL/NEOPRENE	OTHER MATERIALS
Hydrocarbons (cont.)													
Aromatic (292)													
Benzene	NR	nn	rr	NR	NR	NR	NR	NR	NR	NR	nn	rr	EVA(NR) TEFLON(NR) NEOP+NAT RUB(NR) NEOPRENE+SBR(n) POLYURETHANE(NR) NONWOVEN PE(NR) SARANEX(NR) SBR(R) NEOP/NAT RUB(NR) PV ACETATE(rr) SILVERSHIELD(rr) SBR/NEOPRENE(n)
p-tert-Butyl Toluene	RR				rr		rr		rr		RR		SILVERSHIELD(rr)
3-Chloro-2-methylpropene	nn								NR	NR	rr		
m-Cresol				nn	rr		rr	rr		NR			TEFLON(rr) NEOP+NAT RUB(nn) NEOP/NAT RUB(rr)
Cresols	n	r	r					nn		n		n	SARANEX(rr)
Cumene		rr	r									n	
Cymene			r									n	
Diethyl Benzene			r									n	
Diisopropyl Benzene (all isomers)			r									n	
Divinyl Benzene	RR						rr		rr		RR		SILVERSHIELD(rr)
Ethyl Benzene			r		n				nn	n		n	TEFLON(rr)
Gasoline	nn	r	rr	N	rr	NR	rr	NR	rr	NR	r	nn	NEOP+NAT RUB(NR) NEOPRENE+SBR(n) POLYURETHANE(R) SBR(n) SBR/NEOPRENE(n)

Note: Numbers in parentheses are chemical class codes -- see Table 8.1 and Appendix D.
For explanation of recommendation codes (e.g. RR,R,NR, etc.) see Table 8.3.
Source: Arthur D. Little, Inc.

	BUTYL	CPE	VITON/NEOPRENE	NATURAL RUBBER	NEOPRENE	NITRILE+PVC	NITRILE	PE	PV ALCOHOL	PVC	VITON	BUTYL/NEOPRENE	OTHER MATERIALS
Hydroxyl Compounds (cont.)													
Aromatic (316)													
Benzyl Alcohol	rr		r	r	R	r	r			R	rr	r	POLYURETHANE(n) SBR(R) SBR/NEOPRENE(r)
Benzyl Benzoate			r									r	
n-Butyl Benzoate			r									r	
Creosote	n		r	N	rr	r	R			r	rr	r	SBR(r)
Creosote, Wood					rr						rr		
m-Cresol				nn	rr		rr	rr		NN			TEFLON(rr) NEOP+NAT RUB(nn) NEOP/NAT RUB(rr)
Cresols	n	r	r					nn		n		n	SARANEX(rr)
Ethyl Benzoate			r									r	
Nonylphenol					rr		rr						
Pentachlorophenol					NN		rr		NN	rr			
Phenol	R	nn		NN	nn	n	NN	rr	nn	NN	n		TEFLON(rr) NEOP+NAT RUB(rr) NAT+NEOP+NBR(r) POLYURETHANE(r) SBR(n) NEOP/NAT RUB(rr) SBR/NEOPRENE(r)
Phenol, <30%								rr					
Phenol, >70%	RR				NN	nn	NN	rr		NN	RR		
Picric Acid	r			R	R	r	R		n	r	r		

Note: Numbers in parentheses are chemical class codes -- see Table 8.1 and Appendix B.
For explanation of recommendation codes (e.g. RR,R,NN, etc.) see Table 8.3.

Source: Arthur D. Little, Inc.

	BUTYL	CPE	VITON/NEOPRENE	NATURAL RUBBER	NEOPRENE	NITRILE+PVC	NITRILE	PE	PV ALCOHOL	PVC	VITON	BUTYL/NEOPRENE	OTHER MATERIALS
Inorganic Gases													
Inorganic Gases (350)													
Ammonia			n		r					r	n	r	
Bromine								NN					
Chlorine	n	r	rr	n	rr		n	NN		NN	rr	rr	SARANEX(rr)
Fluorine			n	r	r					r		n	
Hydrocyanic Acid	rr				r			rr		nn	r		
Hydrogen Phosphide				nn	NN			nn		nn			
Hydrogen Sulfide	r	r		n	R	r				R			POLYURETHANE(n) SBR(r) SBR/NEOPRENE(n)
Nickel Carbonyl	r	r								r			
Nitric Oxide	r	r								r			
Nitrogen Dioxide			n									n	
Nitrogen Tetroxide	nn	rr	n					rr		nn	nn	n	CHLOROBUTYL(rr) TEFLON(NN) CR 39(rr)

Note: Numbers in parentheses are chemical class codes -- see Table 8.1 and Appendix B.
For explanation of recommendation codes (e.g. RR,R,NN, etc.) see Table 8.3.
Source: Arthur D. Little, Inc.

	BUTYL	CPE	VITON/NEOPRENE	NATURAL RUBBER	NEOPRENE	NITRILE+PVC	NITRILE	PE	PV ALCOHOL	PVC	VITON	BUTYL/NEOPRENE	OTHER MATERIALS
Inorganic Salts (cont.)													
Inorganic Salts (cont.)(340)													
Potassium Dichromate	r			r	R	r				R			POLYURETHANE(n) SBR(r) SBR/NEOPRENE(r)
Potassium Bromide				r	r					r			
Potassium Chloride										r			
Potassium Cyanide										r			
Silver Nitrate				r	r					n			
Sodium Chloride										r			
Sodium Hypochlorite, 30-70%				rr	rr	rr	rr			rr			
Sodium Silicate			r									r	
Sodium Sulfide					r					r			
Sodium Thiosulfate					r					r			
Stannous Chloride	r			r	R	r				R			POLYURETHANE(r) SBR(r) SBR/NEOPRENE(r)
Isocyanates													
Isocyanates (210)													
Methyl Isocyanate	nn			NN	NN				rr		NN		
Toluene Diisocyanate	RR	rr		NN	n		rr	rr	RR	nn	RR		TEFLON(RR) SILVERSHIELD(RR)

Note: Numbers in parentheses are chemical class codes -- see Table 8.1 and Appendix B.
For explanation of recommendation codes (e.g. RR,R,NN, etc.) see Table 8.3.
Source: Arthur D. Little, Inc.

	BUTYL	CPE	VITON/NEOPRENE	NATURAL RUBBER	NEOPRENE	NITRILE+PVC	NITRILE	PE	PV ALCOHOL	PVC	VITON	BUTYL/NEOPRENE	OTHER MATERIALS
Cyanides													
Cyanides (215)													
Hydrocyanic Acid	rr				r			rr		nn	r		
Hylone					r					r			POLYURETHANE(r) SBR(n) SBR/NEOPRENE(n)
Potassium Cyanide										r			
Sodium Cyanide, <30%								rr					
Sodium Cyanide, 30-70%								NN					
Esters, Carboxylic													
Formates (221)													
Ethylene Acetate				n	n		n			n			
Ethyl Formate	r		n	r	R	n	R			N		n	POLYURETHANE(n) SBR(R) SBR/NEOPRENE(r)
Methyl Chloroformate	nn												
Methyl Formate			n									n	

Note: Numbers in parentheses are chemical class codes -- see Table 8.1 and Appendix B.
For explanation of recommendation codes (e.g. RR,R,NN, etc.) see Table 8.3.
Source: Arthur D. Little, Inc.

	BUTYL	CPE	VITON/NEOPRENE	NATURAL RUBBER	NEOPRENE	NITRILE+PVC	NITRILE	PE	PV ALCOHOL	PVC	VITON	BUTYL/NEOPRENE	OTHER MATERIALS
Inorganic Acids (cont.)													
Inorganic Acids (cont.)(370)													
Phosphoric Acid, <30%	r	r			r					r	r		
Phosphoric Acid, 30-70%					r						r		
Phosphoric Acid, >70%	r	r		RR	rr	rr	rr	rr		rr	r		NEOP+NAT RUB(rr) NEOP/NAT RUB(rr)
Phosphorus Oxychloride		nn			NN	nn				NN	nn		NONWOVEN PE(NN) SARANEX(nn) PV ACETATE(NN)
Phosphorus Trichloride			r									r	
Sulfuric Acid	n	RR	rr	N	rr	nn	n	rr		NN	rr	rr	CHLOROBUTYL(rr) TEFLON(nn) NEOP+NAT RUB(rr) NEOPRENE+SBR(n) NAT+NEOP+NBR(n) POLYURETHANE(n) NONWOVEN PE(NN) SARANEX(RR) SBR(n) VIT/CLORBUTL(rr) SILVERSHIELD(rr) NEOPRENE+PVC(rr) SBR/NEOPRENE(n)
Sulfuric Acid, <30%	r	r		r	R	rr	R	RR		rr	r		NEOP+NAT RUB(r) NAT+NEOP+NBR(r) NONWOVEN PE(nn) SARANEX(rr) SBR(r)
Sulfuric Acid, 30-70%	r	rr		rr	rr		rr	rr		rr	r		NEOP+NAT RUB(rr) NONWOVEN PE(NN) SARANEX(rr) NEOP/NAT RUB(rr)
Sulfuric Acid, >70%	r	r		n	n	nn	N	RR	n	NN	rr		TEFLON(rr) NONWOVEN PE(NN) SARANEX(rr) SBR(r) NEOP/NAT RUB(rr)
Sulfur Monochloride			r									n	

Note: Numbers in parentheses are chemical class codes -- see Table 8.1 and Appendix B.
For explanation of recommendation codes (e.g. RR,R,NN, etc.) see Table 8.3.
Source: Arthur D. Little, Inc.

	BUTYL	CPE	VITON/NEOPRENE	NATURAL RUBBER	NEOPRENE	NITRILE+PVC	NITRILE	PE	PV ALCOHOL	PVC	VITON	BUTYL/NEOPRENE	OTHER MATERIALS
Hydrocarbons (cont.)													
Aromatic (cont.) (292)													
JP-4, Jet Fuel					n						r		
Kerosene	n		r	nn	N	rr	rr	nn	rr	nn	r	n	NEOP+NAT RUB(nn) NEOPRENE+SBR(n) POLYURETHANE(r) SBR(n) SBR/NEOPRENE(n)
d-Limonene	rr		r		rr		rr		rr			n	
Natural Gas, Liquified			r									n	
Nitrobenzene	N	RR		NN	NN	n	NN		RR	N	RR		TEFLON(rr) NEOP+NAT RUB(n) NEOPRENE+SBR(r) POLYURETHANE(n) SBR(n) VIT/CLORBUTL(rr) SILVERSHIELD(rr) SBR/NEOPRENE(n)
Styrene	n	rr	r	NN	NN	NN	NN	NN	rr	NN	r	n	TEFLON(rr) SARANEX(nn) VIT/CLORBUTL(rr)
1,2,3,4-Tetrahydronaphthalene			r									n	
Toluene	NN	r	rr	NN	NN	nn	NN	NN	NN	NN	nn		TEFLON(rr) NEOP+NAT RUB(n) POLYURETHANE(r) SARANEX(NN) SBR(N) VIT/CLORBUTL(rr) NEOP/NAT RUB(NN) SILVERSHIELD(rr) SBR/NEOPRENE(n)

Note: Numbers in parentheses are chemical class codes -- see Table 8.1 and Appendix B.
For explanation of recommendation codes (e.g. RR,R,NN, etc.) see Table 8.3.
Source: Arthur D. Little, Inc.

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS	PERMEATION RATE UG/CM**2/MIN	TEMP DEG C	THICKNESS CM	REF NUM
000750580	BUTYL	064	117	> 8.00		23.	.01	213
				> 8.00		23.	.02	213
	BUTYL/NEOPRENE	110	117	> 8.00		23.	.02	213
	CPE	060	113	1.33 - 1.42		25.	.07	302
	NATURAL RUBBER	001	103		150.30	23.		045
			506	< .01	117.23	23.	.01	323
	NEOPRENE	018	100	1.27	10.82	23.	.06	323
		093	117	< .18		23.	.02	213
		125	103		72.14	23.		045
		138	117	.58		23.	.03	213
		139	117	.83		23.	.01	213
	NITRILE	019	103		66.13	23.		045
	PE	076	117	< .01		23.	.02	213
	PV ALCOHOL	102	100	> 8.00		23.	.04	323
	PVC	007	103		66.13	23.		045
		049	117	.05		23.	.01	213
	SARANEX	061	117	> 8.00		23.	.01	213
	SILVER SHIELD	122	118	> 8.00		23.	.01	227
	TEFLON	069	510	> 4.50	< .02	25.	.05	303
	VITON	145	117	> 8.00		23.	.01	213
	VITON/CHLOROBUTYL	112	113	1.50 - 1.75		25.	.04	302
	VITON/NEOPRENE	111	117	.75		23.	.02	213
Acetophenone								
000988620	TEFLON	069	510	> 92.00	< .02	25.	.05	303
Acetyl Chloride								
000753650	SARANEX	061	127	.62	1.10	23.		104
	TEFLON	069	510	> 3.10	< .02	23.	.05	303
Acrolein								
001070280	BUTYL	014	118	> 15.00		23.	.06	323
	CPE	060	UNK	.13		23.		142
				.92		23.		142
	NITRILE	019	100	.07	966.13	23.	.04	323
	PV ALCOHOL	102	100	.25	3.01	23.	.03	323
	VITON	009	118	< .01	432.86	23.	.02	323
	VITON/CHLOROBUTYL	112	UNK	> 3.00		23.		142
Acrylic Acid								
000791070	TEFLON	069	510	> 3.00	< .02	23.	.05	303
Acrylonitrile								
001071310	CPE	070	UNK	.28		23.	.05	004
	PE	076	127	.08	< .02	23.		104
	SARANEX	061	127	.38	< .02	23.		104
	TEFLON	069	510	.90	.08	23.		303
Allyl Alcohol								
001071860	BUTYL	014	UNK	> 8.17		25.		287
		064	117	> 8.00		23.	.02	213
				> 8.00		23.	.01	213
				> 8.00		23.	.02	213

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS		PERMEATION RATE UG/CM**2/MIN		TEMP DEG C	THICKNESS CM	REF NUM
001071860	BUTYL/NEOPRENE	110	117	>	8.00			23.	.02	213
	CPE	070	UNK		2.00			23.	.05	004
	NEOPRENE	002	UNK		2.35		1.44	25.		287
		093	117		1.58			23.	.02	213
		138	117		6.08			23.	.03	213
		139	117		3.42			23.	.02	213
	PE	076	117		1.67			23.	.01	213
	PV ALCOHOL	004	UNK		.24		33.07	25.		287
	PVC	049	117		1.75			23.	.01	213
		077	117	<	.08			23.	.01	213
	SARANEX	061	117	>	8.00			23.	.01	213
	TEFLON	069	510	>	3.10	<	.02	23.	.05	303
	VITON	145	117	>	8.00			23.	.01	213
	VITON/NEOPRENE	111	117	>	8.00			23.	.02	213
Allylamine										
001071190	BUTYL	014	118		3.92		70.14	20.	.06	323
	NATURAL RUBBER	001	250	<	.02		6,633.24	20.	.01	323
	PV ALCOHOL	102	100		.20		12,114.18	23.	.07	323
	PVC	007	100	<	.02		9,829.62	20.	.02	323
Allyl Chloride										
001070510	CPE	070	UNK		1.25			23.	.05	004
	TEFLON	069	510		1.70	<	.02	23.	.05	303
					2.76	<	.02	23.	.05	303
Ammonium Fluoride, 30-70%										
121250182	NATURAL RUBBER	017	100	>	6.00			23.	.05	107
	NEOPRENE	002	100	>	6.00			23.		107
		018	100	>	6.00			23.	.04	107
	NITRILE	019	100	>	6.00			23.	.06	107
	PVC	007	100	>	6.00			23.		107
Ammonium Hydroxide										
013362160	NATURAL RUBBER	001	210		2.00			23.		080
	NEOP+NAT RUBBER	026	121		.45		18.04	23.	.05	237
	NEOPRENE	002	210		6.00	<	.02	23.		080
	NITRILE	005	210		6.00	<	.02	23.		080
	NITRILE+PVC	057	210		3.00			23.		080
		058	100		.18			23.		107
	PE	076	100		.07			23.		107
	PVC	007	210		.75			23.		080
		077	100	>	6.00			23.		107
					.30			23.		107
Ammonium Hydroxide, <30%										
013362161	NATURAL RUBBER	001	UNK	>	1.00			23.		052
		017	100		1.75			23.	.05	107
	NEOPRENE	002	100	>	6.00			23.		107
		018	100	>	6.00			23.	.04	107
			UNK	>	1.00			23.	.06	052
				>	1.00			23.	.09	052
	NITRILE	019	100	>	6.00			23.	.06	107

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS	PERMEATION RATE UG/CM**2/MIN	TEMP DEG C	THICKNESS CM	REF NUM
013362161	NITRILE	019	UNK	> 1.00		23.	.05	052
	PVC	003	UNK	.02		23.	.02	052
		007	100	4.00		23.		107
	VITON	009	UNK	> 1.00		23.	.03	052
Ammonium Hydroxide, 30-70%								
013362162	PE	076	127	< .02	10.32	23.		104
Amyl Acetate (Pentyl Acetate)								
006286370	NATURAL RUBBER	001	210	.20	60.12	23.		080
	NEOPRENE	002	210	.25	66.13	23.		080
	NITRILE	005	210	.67	30.06	23.		080
		019	100	1.00	9.02 - 90.18	23.	.06	107
	NITRILE+PVC	057	210	.83	42.08	23.		080
	PE	076	100	< .05	9.02 - 90.18	23.		107
	PV ALCOHOL	004	100	> 6.00	< .90	23.		107
	PVC	007	210	.50	48.10	23.		080
Amyl Alcohol (Pentanol)								
000714100	BUTYL	014	118	> 8.00	< .02	23.	.07	323
	NATURAL RUBBER	017	100	.12	.90 - 9.02	23.	.05	107
	NEOPRENE	002	100	> 6.00	< .90	23.		107
		018	100	> 6.00	< .90	23.	.04	107
				5.35	.20	23.	.05	323
	NITRILE	019	100	.50	< .90	23.	.06	107
				> 8.00	< .02	23.	.04	323
	NITRILE+PVC	058	100	.08	.90 - 9.02	23.		107
	PE	076	100	.20	< .90	23.		107
	PV ALCOHOL	004	100	3.50	< .90	23.		107
	PVC	007	100	.20	< .90	23.		107
		077	100	.17 - .54	9.02	23.		107
				.17	< .90	23.		107
	VITON	009	118	> 8.00	< .02	23.	.05	323
Aniline (Benzamine)								
000625330	BUTYL	012	UNK	> 6.50	1.99	25.	.04	273
				> 6.50	1.99	25.	.04	273
				> 22.00	< .02	25.	.06	273
				> 22.00	< .02	25.	.06	273
				7.00	< .02	25.	.04	273
				7.00	< .02	25.	.04	273
				> 23.00	< .02	25.	.06	273
				> 23.00	< .02	25.	.06	273
				7.00	1 20	25.	.04	273
				7.00	< .02	25.	.04	273
				> 8.00	< .02	25.	.06	273
				> 8.00	< .02	25.	.06	273
		014	118	> 8.00		23.	.03	323
				> 8.00		23.	.04	227
		064	117	> 8.00		23.	.02	213
				> 8.00		23.	.01	213
				> 8.00		23.	.02	213
	BUTYL/NEOPRENE	110	117	> 8.00		23.	.02	213

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS	PERMEATION RATE UG/CM**2/MIN	TEMP DEG C	THICKNESS CM	REF NUM
000625330	PVC	049	117	1.25		23.	.01	213
		077	100	.33	.90 - 9.02	23.		107
				.50	.90 - 9.02	23.		107
	SARANEX	061	117	> 8.00		23.	.01	213
	SILVER SHIELD	122	118	> 8.00		23.	.01	227
	TEFLON	069	510	> 3.30	< .02	23.	.05	303
	VITON	009	118	.10	112.42	23.	.03	323
				.17	112.42	23.	.02	227
			UNK	> 1.00		23.	.03	274
		145	117	.83		23.	.01	213
	VITON/NEOPRENE	111	117	> 8.00		23.	.02	213
Benzaldehyde 001005270	BUTYL	014	118	> 9.00		23.	.07	323
	NATURAL RUBBER	017	100	.23	9.02 - 90.18	23.	.05	107
	NEOPRENE	018	100	.65	24.05	23.	.05	323
	NITRILE	019	100	.40	25.85	23.	.03	323
	PE	076	100	.17	9.02 - 90.18	23.		107
	PV ALCOHOL	004	100	> 6.00	< .90	23.		107
		102	100	> 16.00		23.	.03	323
	VITON	009	118	9.93	24.05	23.	.03	323
Benzene 000714320	BUTYL	014	118	.52	194.19	23.	.04	323
				.52	194.19	23.	.04	227
			UNK	.33		23.	.02	327
		034	UNK	1.47	130.26	22.	.08	078
		064	117	.08		23.	.02	213
				> .08		23.	.01	213
				.67		23.	.02	213
			507	1.00	90.18	22.	.06	078
			UNK	.13		23.	.04	327
	BUTYL/NEOPRENE	110	117	> 8.00		23.	.02	213
	CPE	070	UNK	.43		23.	.05	004
	EVA	074	UNK	.01		23.	.02	327
	NATURAL RUBBER	001	210	.18	396.79	23.		080
		017	100	.04	3,206.40	25.	.03	222
			120	.03	5,611.20	25.	.02	222
			502	.05	2,605.20	25.	.05	222
			504	.06	2,204.40	25.	.05	222
				.12	1,603.20	25.	.06	222
			508	.03	501.00	22.	.03	078
			UNK	.01		23.	.05	327
				.02		23.	.02	327
	NEOP+NAT RUBBER	026	102	.05	2,805.60	25.	.04	222
			121	.05	2,254.50	23.	.05	237
	NEOP/NAT RUBBER	008	114	.09	2,004.00	25.	.05	222
				.05	400.80	22.	.05	078
	NEOPRENE	002	100	.25	80.16	22.	.07	078
				.02	951.90	25.	.08	222
			120	.40	300.60	25.	.07	222
			210	.25	559.12	23.		080
			UNK	.29	517.03	22.	.11	333

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS	PERMEATION RATE UG/CM**2/MIN	TEMP DEG C	THICKNESS CM	REF NUM
000714320	NEOPRENE	002	UNK	.14	1,167.33	22.	.08	333
		010	120	.11	521.04	22.	.04	078
		018	100	.28	165.93	23.	.05	323
				.10	300.60	22.	.04	078
			120	.19	1,002.00	25.	.05	222
				.27	1,102.20	25.	.07	222
				.27	801.60	25.	.05	222
				.08	1,803.60	25.	.03	222
			UNK	.12		22.	.04	333
				.10		22.	.05	333
				.19	1,893.78	22.	.05	333
				.33		23.	.06	327
		031	UNK	3.10	50.10	22.	.24	078
				1.00	80.16	22.	.16	078
				.41	230.46	22.	.08	078
				.27	330.66	37.	.08	078
				.67	190.38	7.	.08	078
				.40	230.46	22.	.08	078
				.11	501.00	22.	.04	078
		093	117	< .08		23.	.02	213
		138	117	< .08		23.	.03	213
		139	117	> 8.00		23.	.02	213
	NITRILE	005	210	.33	901.80	23.		080
			503	.10	501.00	22.	.02	078
		019	100	.32	.03	23.	.04	323
				1.05	400.80	25.	.04	222
				.77	511.02	25.	.06	222
				.32	851.70	25.	.05	222
			181	.15	1,102.20	25.	.03	222
			503	.07	1,302.60	25.	.03	222
			UNK	.17		23.	.04	327
				.23	870.74	22.	.04	333
				.32	939.88	22.	.04	333
		033	UNK	.08	501.00	22.	.04	078
	NITRILE+PVC	057	210	.75	180.36	23.		080
		058	100	.03	901.80 - 9,018.00	23.		107
	NONWOVEN PE	071	UNK	.01		23.	.01	327
	PE	006	100	< .01	250.50	25.	.01	222
			209	< .02	350.70	22.	.01	078
			505	.07	50.10	25.	.01	222
		042	UNK	< .03		23.	.01	327
		076	100	.03	90.18 - 901.80	23.		107
			117	.08		23.	.01	213
			UNK	.01		23.	.01	327
				.02	220.44	22.	.01	078
	POLYURETHANE	050	178	.03	110.22	22.	.02	078
	PV ALCOHOL	004	100	.12	< .90	23.		107
				.17	8.02	22.	.02	078
			UNK	> 33.33		22.	.09	333
				.33		23.	.02	327
		035	UNK	.05	39.08	22.	.01	078
		102	100	.82	< .02	23.	.03	323
	PVC	003	100	< .01	1,182.56	23.	.02	323

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS	PERMEATION RATE UG/CM**2/MIN	TEMP DEG C	THICKNESS CM	REF NUM
000714320	PVC	003	120	.01	3,507.00	25.	.01	222
				.01	4,108.20	25.	.01	222
				.04	1,503.00	25.	.03	222
				.04	1,603.20	25.	.02	222
			500	< .01	4,709.40	25.	.01	222
			501	.01	3,607.20	25.	.01	222
				< .01	4,909.80	25.	.02	222
			UNK	.02		23.	.01	327
		007	210	.50	240.48	23.		080
			UNK	.30	481.96	22.	.10	333
				.17	599.20	22.	.11	333
				.31	421.84	22.	.11	333
		049	117	.10		23.	.01	213
		077	117	< .16		23.	.01	213
			168	.10	150.30	22.	.04	078
	SARANEX	061	117	.25		23.	.01	213
			UNK	.17		23.	.01	327
	SILVER SHIELD	122	118	> 8.00		23.	.01	227
	TEFLON	036	UNK	.17		23.	.01	327
		069	510	> 3.20	< .02	23.	.05	303
				> 3.00	< .02	25.	.05	303
	VITON	009	118	5.93	.07	23.	.02	323
				6.00	.07	23.	.02	227
			UNK	.50		23.	.02	327
		032	UNK	15.00	.50	22.	.16	078
		145	117	> 8.00		23.	.01	213
	VITON/NEOPRENE	111	117	3.50		23.	.02	213
Benzenesulfonic Acid								
000986790	NEOPRENE	018	100	> 20.00		23.	.05	123
	NITRILE	020	216	> 4.00		23.	.04	123
Benzethonium Chloride								
001215400	BUTYL	014	118	> 8.00	< .02	22.	.06	323
	NATURAL RUBBER	001	250	> 8.00	< .02	21.	.02	323
	NEOPRENE	018	100	> 8.00	< .02	19.	.05	323
	PVC	007	100	> 8.00	< .02	19.	.02	323
Benzonitrile								
001004700	BUTYL	014	118	> 8.00		23.	.06	323
	NATURAL RUBBER	001	506	< .01	24.05	23.	.01	323
	PV ALCOHOL	102	100	> 8.00		23.	.03	323
	VITON	009	118	.93	24.05	23.	.03	323
Benzoyl Chloride								
000988840	BUTYL	014	118	6.28	99.80	23.	.06	323
	HYPALON	108	210	.33		23.	.06	123
	NEOPRENE	018	100	.25		23.	.05	123
	PV ALCOHOL	102	100	> 8.00		23.	.05	323
	PVC	003	100	< .01	596.39	23.	.02	323
	VITON	009	118	> 8.00		23.	.02	323
				.75		23.	.03	123

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS	PERMEATION RATE UG/CM**2/MIN	TEMP DEG C	THICKNESS CM	REF NUM
003020122	NITRILE+PVC	058	100	> 6.00		23.		107
	PE	076	100	> 6.00		23.		107
	PVC	007	100	> 6.00	< .90	23.		107
		077	100	> 6.00		23.		107
				> 6.00		23.		107
	SILVER SHIELD	122	118	2.10	6.01	23.	.01	227
Hydrochloric Acid								
076470100	BUTYL	064	117	> 8.00		23.	.02	213
				> 8.00		23.	.01	213
				> 8.00		23.	.02	213
	BUTYL/NEOPRENE	110	117	> 8.00		23.	.02	213
	CPE	070	UNK	> 3.00		23.	.05	004
	NATURAL RUBBER	001	210	6.00	< .02	23.		080
	NEOP+NAT RUBBER	026	121	4.42	12.02	23.	.05	237
	NEOPRENE	002	210	6.00	< .02	23.		080
		093	117	> 8.00		23.	.02	213
		138	117	> 8.00		23.	.03	213
	NEOPRENE+PVC	127	117	> 8.00		23.	.02	213
	NITRILE	005	210	6.00	< .02	23.		080
	NITRILE+PVC	057	210	6.00	< .02	23.		080
		058	117	1.75		23.	.01	213
	PVC	007	210	6.00	< .02	23.		080
		049	117	> 8.00		23.	.01	213
				> 8.00		23.	.01	213
		053	117	5.17		23.	.02	213
		077	117	< 5.00		23.	.01	213
				2.92		23.	.01	213
		144	117	4.33		23.	.02	213
	SARANEX	061	117	5.00		23.	.01	213
	VITON	145	117	> 8.00		23.	.02	213
	VITON/NEOPRENE	111	117	> 8.00		23.	.02	213
Hydrochloric Acid, <30%								
076470101	NATURAL RUBBER	017	100	> 6.00		23.	.05	107
			102	> 8.00		23.	.05	026
				> 8.00		23.	.05	026
				> 8.00		23.	.05	026
				> 8.00		23.	.05	026
	NEOP+NAT RUBBER	026	102	> 8.00		23.	.06	026
				> 8.00		23.	.04	026
				> 8.00		23.	.05	026
	NEOP/NAT RUBBER	008	102	> 8.00		23.		026
	NEOPRENE	002	100	> 6.00		23.		107
		018	100	> 6.00		23.	.04	107
	NITRILE	019	100	> 6.00		23.	.06	107
	NITRILE+PVC	058	100	> 6.00		23.		107
	PE	076	100	> 6.00		23.		107
	PVC	007	100	> 6.00		23.		107
		077	100	> 6.00		23.		107
				> 6.00		23.		107
Hydrochloric Acid, 30-70%								

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS		PERMEATION RATE UG/CM**2/MIN.	TEMP DEG C	THICKNESS CM	REF NUM
076470102	NATURAL RUBBER	001	UNK	>	1.00		23.		052
		015	UNK	>	1.00		23.	.04	052
		017	100	>	5.00		23.	.05	107
			102	>	8.00		23.	.05	026
					5.50		23.	.05	026
				>	8.00		23.	.05	026
				>	8.00		23.	.05	026
	NEOP+NAT RUBBER	026	102	>	2.50		23.	.06	026
				>	8.00		23.	.04	026
				>	8.00		23.	.05	026
	NEOP/NAT RUBBER	008	102	>	8.00		23.		026
			UNK	>	1.00		23.		052
	NEOPRENE	002	100	>	6.00		23.		107
		018	100	>	6.00		23.	.04	107
			UNK	>	1.00		23.	.06	052
	NITRILE	019	100	>	6.00		23.	.06	107
			UNK	>	1.00		23.	.05	052
	PE	076	127		.58		23.		104
	PVC	003	UNK		.40		23.	.02	052
		007	100	>	5.00		23.		107
			UNK	>	1.00		23.		052
	SARANEX	061	127	>	46.67	< .02	23.		104
	SILVER SHIELD	122	118	>	6.00		23.	.01	227
	VITON	009	UNK	>	1.00		23.	.03	052
Hydrochloric Acid, >70%									
076470103	NATURAL RUBBER	017	102	>	6.00		23.	.05	026
					5.50		23.	.05	026
				>	6.00		23.	.05	026
					5.50		23.	.05	026
	NEOP+NAT RUBBER	026	102	>	2.50		23.	.06	026
					5.50		23.	.04	026
				>	6.00		23.	.05	026
	NEOP/NAT RUBBER	008	102	>	6.00		23.		026
Hydrocyanic Acid									
000749080	BUTYL	034	UNK		1.00	< .02	*****	.04	148
	PE	076	UNK		1.00	.12	*****	.02	148
	PVC	049	UNK		.50	.28	*****	.08	148
Hydrofluoric Acid (Hydrogen Fluoride)									
076643930	BUTYL	064	117	>	8.00		23.	.02	213
				>	8.00		23.	.01	213
					7.08		23.	.02	213
	BUTYL/NEOPRENE	110	117	>	8.00		23.	.02	213
	NEOPRENE	093	117	>	8.00		23.	.02	213
		138	117		4.25		23.	.03	213
		139	117	>	8.00		23.	.02	213
	NEOPRENE+PVC	127	117		3.50		23.	.02	213
	NITRILE+PVC	058	117		1.08		23.	.01	213
	PE	076	117		1.50		23.	.01	213
	PVC	049	117	>	8.00		23.	.01	213
					2.17		23.	.01	213

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS	PERMEATION RATE UG/CM**2/MIN	TEMP DEG C	THICKNESS CM	REF NUM
077228412	NITRILE	019	100	> 6.00		23.	.06	107
	PVC	007	100	> 6.00		23.		107
Hydrogen Phosphide (Phosphine)								
078035120	NATURAL RUBBER	087	UNK	.50	< .02	23.	.05	173
	NEOPRENE	031	UNK	.42	< .02	23.	.05	173
		093	UNK	.17	< .02	23.	.03	173
	PE	091	UNK	.33	< .02	23.	.04	173
				.42	< .02	23.	.04	173
	PVC	054	UNK	1.67	< .02	23.	.02	173
				.67	< .02	23.	.02	173
Hydroquinone								
001233190	NITRILE+PVC	058	100	> 6.00		23.		107
	PE	076	100	> 6.00		23.		107
	PVC	077	100	> 6.00		23.		107
				> 6.00		23.		107
Hydroquinone, <30%								
001233191	NATURAL RUBBER	017	100	> 6.00	< .90	23.	.05	107
	NEOPRENE	002	100	> 6.00	< .90	23.		107
		018	100	> 6.00	< .90	23.	.04	107
	NITRILE	019	100	> 6.00	< .90	23.	.06	107
	PVC	007	100	> 6.00	< .90	23.		107
Iminobispropylamine								
000561880	BUTYL	014	118	> 8.00		28.	.09	323
	NATURAL RUBBER	001	250	.10	84.17	26.	.02	323
	NEOPRENE	018	100	> 8.00		27.	.05	323
	VITON	009	118	> 8.00		27.	.04	323
b-Ionone								
149010760	BUTYL	014	118	> 9.00		23.	.06	323
	PV ALCOHOL	102	100	> 14.00		23.	.04	323
				> 8.00		23.	.03	323
			118	> 8.00		23.	.03	323
Isoamyl Acetate								
001239220	BUTYL	107	120	.03	1,903.80	25.	.02	222
	HYPALON	108	120	.50	350.70	25.	.05	222
	NATURAL RUBBER	017	100	.09	1,102.20	25.	.03	222
			502	.16	791.58	25.	.05	222
			504	.17	661.32	25.	.05	222
				.32	470.94	25.	.06	222
	NEOP+NAT RUBBER	026	102	.16	761.52	25.	.05	222
	NEOP/NAT RUBBER	008	114	.20	731.46	25.	.05	222
	NEOPRENE	002	100	.20	140.28	25.	.08	222
			120	.09	120.24	25.	.07	222
		018	118	> 1.00		25.	.08	222
			120	.50	310.62	25.	.05	222
				.27	541.08	25.	.03	222
	NITRILE	019	100	> 1.00		25.	.04	222
				> 1.00		25.	.06	222

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS		PERMEATION RATE UG/CM**2/MIN		TEMP DEG C	THICKNESS CM	REF NUM
001096600	NEOPRENE	018	120		.63		16.03	25.	.05	222
					.33		21.04	25.	.03	222
	NITRILE	005	210		6.00	<	.02	23.		080
		019	100		.03	<	.02	23.	.04	323
				>	1.00	<	2.00	25.	.04	222
				>	6.00	<	.90	23.	.06	107
				>	1.00	<	2.00	25.	.06	222
				>	1.00	<	2.00	25.	.04	222
			503		.09		10.02	25.	.03	222
	NITRILE+PVC	057	210		1.25		90.18	23.		080
		058	100		.18	9.02 -	90.18	23.		107
	PE	006	100		.01		400.80	25.	.01	222
			505		.05		70.14	25.	.01	222
		076	100		.08	90.18 -	901.80	23.		107
	PV ALCOHOL	004	100	>	6.00	<	.90	23.		107
		102	100		.25	<	.02	23.	.03	323
	PVC	003	120		.01		1,102.20	25.	.01	222
					.01		811.62	25.	.01	222
					.15		100.20	25.	.03	222
					.04		250.50	25.	.02	222
			500		.01		721.44	25.	.01	222
			501		.01		1,603.20	25.	.01	222
					.02		1,603.20	25.	.02	222
		007	210		.33		210.42	23.		080
	SILVER SHIELD	122	118	>	6.00			23.	.01	227
	VITON	009	118	>	8.00			23.	.02	323
				>	8.00			23.	.02	227
Perchloric Acid										
076019030	NATURAL RUBBER	001	210		6.00	<	.02	23.		080
	NEOPRENE	002	210		6.00	<	.02	23.		080
	NITRILE	005	210		6.00	<	.02	23.		080
	NITRILE+PVC	057	210		6.00	<	.02	23.		080
		058	100	>	6.00			23.		107
	PE	076	100	>	6.00			23.		107
	PVC	007	210		6.00	<	.02	23.		080
		077	100	>	6.00			23.		107
				>	6.00			23.		107
Perchloric Acid, 30-70%										
076019032	NATURAL RUBBER	017	100	>	6.00			23.	.05	107
	NEOPRENE	002	100	>	6.00			23.		107
		018	100	>	6.00			23.	.04	107
	NITRILE	019	100	>	6.00			23.	.06	107
	PVC	007	100	>	6.00			23.		107
Phenol (Carbolic Acid)										
001089520	CPE	060	113		3.40			23.	.05	204
					2.92		60.12	23.	.05	204
	NATURAL RUBBER	001	210		.58			23.		080
		017	100	>	1.00	<	3.01	25.	.03	222
					1.00	9.02	90.18	23.	.05	107
			120		.27		15.03	25.	.02	222

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS	PERMEATION RATE UG/CM**2/MIN	TEMP DEG C	THICKNESS CM	REF NUM
001089520	NATURAL RUBBER	017	502	> 1.67	< 3.01	25.	.05	222
			504	> 1.00	< 3.01	25.	.05	222
				> 1.00	< 3.01	25.	.06	222
	NEOP+NAT RUBBER	026	102	> 1.00	< 3.01	25.	.05	222
	NEOP/NAT RUBBER	008	114	> 1.00	< 3.01	25.	.05	222
	NEOPRENE	002	100	> 6.50	< .90	23.		107
				> 1.65	< 3.01	25.	.08	222
			210	.67		23.		080
		018	100	3.00	9.02 - 90.18	23.	.04	107
			118	> 1.00	< 3.01	25.	.08	222
			120	> 1.00	< 3.01	25.	.05	222
				> 1.00	< 3.01	25.	.07	222
				> 1.00	< 3.01	25.	.05	222
				> 1.00	< 3.01	25.	.03	222
	NITRILE	005	210	.67		23.		080
		019	100	.93	300.60	25.	.04	222
				> 1.00	< 3.01	25.	.06	222
				.53	300.60	25.	.04	222
			503	.60	> 250.50	25.	.03	222
	NITRILE+PVC	057	210	2.00		23.		080
	PE	006	100	> 1.00	< 3.01	25.	.01	222
			505	1.00	3.01	25.	.01	222
	PV ALCOHOL	004	100	.50	9.02 - 90.18	[illegible]		107
	PVC	003	120	.05	190.38	25.	.01	222
				.13	120.24	25.	.01	222
				.53	77.15	25.	.03	222
				.25	100.20	25.	.02	222
			500	.10	130.26	25.	.01	222
			501	.10	120.24	25.	.01	222
				.06	120.24	25.	.02	222
		007	100	1.25	.90 - 9.02	23.		107
			210	1.33		23.		080
	TEFLON	069	510	> 3.00	< .02	23.	.05	303
Phenol, >70%								
001089523	BUTYL	014	118	> 20.00		23.	.06	323
				> 20.00		23.	.04	227
	NEOPRENE	018	100	> 10.67		23.	.05	000
		125	103		< .02	23.		045
	NITRILE	019	103		18.04	23.		045
			118	.58	1,274.54	23.	.03	323
				.65	> 9,018.00	23.	.04	227
	NITRILE+PVC	058	100	.83	.90 - 9.02	23.		107
	PE	076	100	6.00	< .90	23.		107
	PVC	007	103		18.04	23.		045
		077	100	.50	.90 - 9.02	23.		107
				1.50	.90 - 9.02	23.		107
	VITON	009	118	> 15.00		23.	.03	323
				> 15.00	< .02	23.	.02	227
Phenolphthalein								
000770980	NATURAL RUBBER	017	506	> 8.00		23.	.02	323
	NEOPRENE	018	100	> 8.00		23.	.04	323

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS	PERMEATION RATE UG/CM**2/MIN	TEMP DEG C	THICKNESS CM	REF NUM
013363630	NEOPRENE	010	UNK	> 24.00		23.	.03	290
				> 24.00		23.	.03	290
				> 24.00		23.	.03	290
		018	100	> 24.00		23.	.04	290
				> 24.00		23.	.04	290
				24.00		23.	.04	290
				24.00		23.	.04	290
	PE	006	100	1.00		23.	.01	290
				1.00		23.	.01	290
		076	127	< 1.00	< .02	23.		104
	PV ALCOHOL	102	100	> 24.00		23.	.05	290
				> 24.00		23.	.05	290
	SARANEX	061	127	1.00 - 2.00	< .02	23.		104
				6.00		23.	.02	290
				7.00		23.	.02	290
				7.00		23.	.02	290
	TEFLON	036	UNK	> 24.00		23.	.01	290
				> 24.00		23.	.01	290
				> 24.00		23.	.01	290
	VITON	009	118	> 24.00		23.	.02	290
				> 24.00		23.	.02	290
				> 24.00		23.	.02	290
Potassium Hydroxide, 30-70%								
013105832	NATURAL RUBBER	001	210	1.33		23.		080
		017	100	> 6.00		23.	.05	107
	NEOP+NAT RUBBER	026	121	> 8.00	< .02	23.	.05	237
	NEOPRENE	002	100	> 6.00		23.		107
			210	3.00		23.		080
		018	100	> 6.00		23.	.04	107
	NITRILE	005	210	6.00	< .02	23.		080
		019	100	> 6.00		23.	.06	107
	NITRILE+PVC	057	210	6.00	< .02	23.		080
		058	100	> 6.00		23.		107
	PE	076	100	> 6.00		23.		107
	PVC	007	100	> 6.00		23.		107
			210	6.00	< .02	23.		080
		077	100	> 6.00		23.		107
				> 6.00		23.		107
Promethazinehydrochloride								
000583330	BUTYL	014	118	> 8.00	< .02	19.	.06	323
	NEOPRENE	018	100	> 8.00	< .02	19.	.02	323
	NITRILE	019	100	> 8.00	< .02	22.	.02	323
	PVC	007	100	> 8.00	< .02	20.	.05	323
beta-Propiolactone								
000575780	NATURAL RUBBER	017	508	.25 - .33	4.31	22.	.03	078
	PE	006	209	.17 - .50	1.20	22.	.01	078
	POLYURETHANE	050	178	< .08	831.66	22.	.01	078
Propionaldehyde								
001233860	BUTYL	014	118	> 13.00		23.	.06	323

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS	PERMEATION RATE UG/CM**2/MIN	TEMP DEG C	THICKNESS CM	REF NUM
001088830	PVC	007	UNK	.15	829.66	25.	.13	088
				.15	859.72	25.	.13	088
				.09	898.79	25.	.10	088
				.08	829.66	25.	.11	088
		049	UNK	.38		23.	.03	187
	SARANEX	061	127	< .08	20.04	23.		104
	SILVER SHIELD	122	118	> 6.00		23.	.01	227
	TEFLON	069	510	> 3.00	< .02	23.	.05	303
				> 18.50	< .02	25.	.05	303
	VITON	009	118	> 16.00	< .02	23.	.02	227
				.58		37.	.02	122
				> 3.30		34.	.03	122
				> 4.50		22.	.03	122
				> 7.00		22.	.03	122
			UNK	> 1.00		23.	.03	274
	VITON/CHLOROBUTYL	112	113	> 3.00		25.	.04	302
	VITON/NEOPRENE	022	216	1.67		37.	.06	122
				4.20	200.40	22.	.06	122
Toluene Diisocyanate								
264716250	BUTYL	014	118	> 8.00		23.	.04	323
				> 8.00		23.	.04	227
	CPE	070	UNK	> 3.00		23.	.05	004
	NATURAL RUBBER	017	100	.12	9.02 - 90.18	23.	.05	107
	NITRILE	005	120	> 8.00		23.	.06	236
		019	118	3.86	10.82	23.	.03	323
				3.70	10.82	23.	.04	227
	PE	076	100	1.00	.90 - 9.02	23.		107
	PV ALCOHOL	004	100	> 6.00	< .90	23.		107
		102	100	> 16.00		23.	.03	323
	SILVER SHIELD	122	118	> 8.00		23.	.01	227
	TEFLON	069	510	> 3.30	< .02	23.	.05	303
	VITON	009	118	> 16.00		23.	.03	323
				> 16.00		23.	.02	227
p-Toluenesulfonic Acid								
001041540	CPE	070	UNK	> 3.00		23.	.05	004
	NEOPRENE	018	100	> 4.00		23.	.05	123
	PVC	003	215	> 4.00		23.	.05	123
o-Toluidine								
000955340	TEFLON	069	510	> 3.30	< .02	23.	.05	303
Triallylamine								
001027050	NEOPRENE	018	100	1.05	561.12	19.	.05	323
	NITRILE	019	100	> 8.00	< .02	22.	.04	323
	PVC	007	100	.08	621.24	20.	.02	323
	VITON	009	118	> 8.00	< .02	17.	.03	323
Trichloroacetaldehyde (Chloral)								
000758760	BUTYL	014	118	3.32	50.10	23.	.07	323
	PV ALCOHOL	102	100	> 8.00	< .02	23.	.08	323
	PVC	007	100	.07	2,845.68	23.	.02	323

SUMMARY OF PERFORMANCE DETAIL TESTS
PERMEATION TEST

CHEMICAL NAME/ CASNO	RESISTANT MATERIAL	PRODUCT DESC CODE	VENDOR	BREAKTHROUGH TIME HOURS	PERMEATION RATE UG/CM**2/MIN	TEMP DEG C	THICKNESS CM	REF NUM
000758760	VITON	009	118	7.28	< .02	23.	.03	323
Trichloroacetonitrile								
005450620	BUTYL	014	118	1.98	316.23	23.	.06	323
	NEOPRENE	018	100	1.12	927.65	23.	.06	323
	PV ALCOHOL	102	100	> 8.00		23.	.06	323
	VITON	009	118	1.00	184.57	23.	.03	323
1,2,4-Trichlorobenzene								
001208210	BUTYL	014	UNK	.08		23.	.04	290
				.08		23.	.04	290
	NATURAL RUBBER	017	UNK	.08		23.	.02	290
				.08		23.	.02	290
	NEOPRENE	010	UNK	4.00		23.	.03	290
				5.00		23.	.03	290
		018	UNK	1.00		23.	.04	290
	PE	006	UNK	.17		23.	.01	290
				.17		23.	.01	290
		076	127	< .25	5.01	23.		104
	PV ALCOHOL	102	UNK	1.00		23.	.05	290
				1.00		23.	.05	290
	SARANEX	061	127	.25 1.00	.10	23.		104
			UNK	1.00		23.	.02	290
				1.00		23.	.02	290
	TEFLON	036	UNK	1.00		23.	.01	290
				8.00		23.	.01	290
	VITON	009	UNK	.17		23.	.02	290
				.17		23.	.02	290
1,1,2-Trichloroethane								
000790050	BUTYL	014	118	5.78	42.08	23.	.09	323
			UNK	.83		23.	.06	326
		064	UNK	.75		23.	.04	326
	NATURAL RUBBER	017	UNK	.02		23.	.02	326
	NEOPRENE	018	UNK	.12		23.	.06	326
	NITRILE	019	UNK	.03		23.	.02	326
	PE	042	UNK	.06		23.	.01	326
	POLYURETHANE	050	UNK	< .02		23.	.01	326
	PV ALCOHOL	102	100	> 8.00		23.	.07	323
			UNK	.25		23.	.04	326
	PVC	003	118	.03	1,238.47	23.	.02	323
	TEFLON	036	UNK	> 24.00		23.	.01	326
		044	UNK	2.92		23.	.01	326
	VITON	009	118	> 8.00		23.	.05	323
			UNK	> 24.00		23.	.03	326
2,2,2-Trichloroethanol								
001152080	SARANEX	061	127	.32	13.23	23.		104
Trichloroethylene (Trichloroethene)								
000790160	BUTYL	014	118	.23	3,308.40	23.	.06	323
				.08	> 826.65	23.	.04	291
				.08	> 826.65	23.	.04	291

SUMMARY OF PERFORMANCE DETAIL FOR MIXTURE COMPONENTS

MIXTURE: 000400289 REFERENCE: 278

001315220	4% by vol	Sodium Pentachlorophenate
013107320		Sodium Hydroxide

	PROD CODE	TEMP (C)	BREAKTHROUGH (HOURS)	PERMEATION RATE (UG/CM^2/MIN)	THICK (CM)
NATURAL RUBBER					
000400289	001	23.00	.01	.02	.16
NEOPRENE					
000400289	018	23.00	> 7.50		.04
NITRILE					
000400289	019	23.00	> 15.50		.06
PVC					
000400289	003	23.00	> 5.00		.02
000400289	007	23.00	> 15.50		.11

MIXTURE: 000400389 REFERENCE: 104

002980000	10% by wt	Methyl Parathion
000300050	6% by wt	Tenneco 500-100
000300060		Atlox 3403F
000300070		Atlox 3404F
077321850	83% by wt	Water

	PROD CODE	TEMP (C)	BREAKTHROUGH (HOURS)	PERMEATION RATE (UG/CM^2/MIN)	THICK (CM)
NONWOVEN PE					
002980000	071	23.00	< .08	20.04 - 60.12	
PE					
002980000	076	23.00	.50 - .75	.20	

MIXTURE: 000400399 REFERENCE: 104

002980000	57% by wt	Methyl Parathion
000300050	36% by wt	Tenneco 500-100
000300060	5% by wt	Atlox 3403F
000300070	2% by wt	Atlox 3404F

	PROD CODE	TEMP (C)	BREAKTHROUGH (HOURS)	PERMEATION RATE (UG/CM^2/MIN)	THICK (CM)
PE					
002980000	076	23.00	.25	.08	
SARANEX					
002980000	061	23.00	2.00 - 3.00	.02	

LEVEL B DRESSOUT EXERCISE

I. OBJECTIVES

A. Perform a checkout on a MSA IIA Ultralite SCBA.
B. The students given the proper equipment for Level B will identify the proper cleaning and storage procedures as given by the instructors.
C. Perform a series of station exercises wearing Level B protective equipment.
D. Given the tools and several drums, plug and patch several types of drum leaks.
E. Work in an assigned group to start to recognize team work concepts.

II. PROCEDURE

A. The instructor will demonstrate and discuss SCBA checkout procedures.
B. Students will don Level B protective clothing.
   1. SCBA
   2. PVC splash suit
   3. Latex or vinyl inner gloves
   4. Outer gloves
   5. Hard hat
   6. Boots

DIRECT-READING INSTRUMENTS EXERCISE

I. OBJECTIVE

A. Perform a series of air monitoring exercises while working in a controlled situation.
B. Given several draeger tubes and a pump, sample several different concentrations to determine the type of material found and the concentration range.
C. Answer several questions about monitoring from the exercise or lecture.
D. While working in small teams, gather data.
E. Determine the proper method of interpretation of data.
F. As a group with the instructor, discuss the overall findings.
G. Use five different types of air monitoring equipment.

II. PROCEDURE

The exercise has been divided into three stations. Each station will be equipped with air monitoring instruments and samples. Instructions for the instruments are found at each station. Read the complete set of instructions for a particular instrument before attempting to use the device. Remember to do the necessary calibration-check procedures before making any measurements. Record your data, and answer the questions on the data sheets at the end of this section.

Station A: Combustible Gas Indicators (CGIs)

Three gas sampling bags contain mixtures of flammable gas/vapors in air, one each at concentrations:

Below LEL
Between LEL and UEL
Above UEL

Measure each bag using both CGIs. Record concentrations on the answer sheet at the end of this exercise, page **64**.

Station B: Oxygen Indicators

Two gas sampling bags containing different concentrations of oxygen. Sample each bag with each of the two instruments. Record results on the answer sheet, page **65**.

Station C: Colorimetric Indicator Tubes and Pumps

Two gas sampling bags, one containing CO_2, the other containing an unknown. Use the draeger tubes and pumps to measure the CO_2 concentration. Also, identify and measure the concentration of the unknown bag. Record your data on the answer sheet, page **66**.

ANSWER SHEET

STATION A: CGI		
Sample Instrument Name	(1) ISC 310	(2) MSA 2A
A	$\%O_2$ _____ %LEL_____	%LEL_____
B	$\%O_2$_____ %LEL_____	%LEL_____
C	$\%O_2$_____ %LEL_____	%LEL_____

1. Which sample has a concentration less than < LEL? _____

2. Which sample has a concentration in the flammable range? LEL-UEL _____

3. Which sample has a concentration > UEL? _____

4. What effect can an oxygen-deficient atmopshere have on readings obtained from a combustible gas indicator?_____

_____

_____

_____

_____

STATION B: OXYGEN METERS	
Sample Instrument Name (1) MSA260/261	Instrument Name (2) MSA 245
A $\%O_2$ _____	$\%O_2$ _____
B $\%O_2$ _____	$\%O_2$ _____

1. List the hazardous locations, Class, Division, Group for each of the instruments used.____

_____
_____
_____
_____
_____

2. What effect can the presence of flammable gases or vapors have on the % of oxygen?____

_____
_____
_____
_____
_____

STATION C: COLORIMETRIC INDICATORS		
1. SAMPLE BAGS	CONCENTRATION	HAZARD
UNKNOWN	%_____ PPM_____	(YES / NO)
	%_____ PPM_____	(YES / NO)
	%_____ PPM_____	(YES / NO)
	CONCENTRATION	HAZARD
CO_2	%_____ PPM_____	(YES / NO)
	%_____ PPM_____	(YES / NO)
	%_____ PPM_____	(YES / NO)

2. What are the chemical interferences that could lead to erroneous results?_____

3. What additional environmental factors must be considered when using these detector tubes?_____

4. What are the contents of the unknown bag?_____

LEVEL A DRESSOUT EXERCISE

I. OBJECTIVE

A. The objective of this exercise is to teach each student systematic donning, doffing, and wearing procedures for the fully encapsulating suit (FES) and the self contained breathing apparatus (SCBA) in order to; (1) instill student confidence in this equipment as protection against toxic environments; (2) reduce risk of exposure; (3) reduce risk of damage to the FES; and (4) prevent or minimize the transfer of contaminants from suit to the wearer.

B. At the end of this exercise, the student will be able to:

1. Identify and complete the checkout procedures for the MSA IIA SCBA.
2. Identify and don the proper equipment for Level A protection.
3. Overpack a 55-gallon drum into an 85-gallon overpack, given the above equipment.
4. Perform minor plug and patch work on a flowing pipe rack.
5. Identify the difficulty in dexterity and vision while wearing Level A protection.
6. Identify the problems with communications in Level A protection.
7. Recognize user safety concerns wearing Level A protection.

II. PROCEDURE

In responding to episodes involving hazardous substances, it may be necessary for response personnel to wear self-contained breathing apparatus (SCBA) and fully encapsulating suits (FES) to protect against toxic environments. Donning/doffing of both is a relatively simple task, but a routine must be established and practiced frequently. Not only do correct procedures help instill confidence in the wearer, they reduce the risk of exposure and the possibility of damage to the suit. It is especially important to remove the equipment systematically so as to prevent or minimize the transfer of contaminants from suit to wearer.

The following procedures for donning/doffing apply to certain types of suits. They should be modified if a different suit or extra boots and gloves are worn. These procedures also assume that:

- The wearer has been trained in the SCBA.
- SCBA has been checked out.
- Appropriate decontamination steps have been taken prior to removal of the suit or other components.
- Sufficient air is available for routine decontamination and doffing of suit.

Donning/doffing an encapsulating suit is more difficult if the user has to do it alone because of the physical effort required. Also the possibility of wearer exposure to contaminants or damaging the suit greatly increases. Therefore, assistance is needed in donning/doffing the equipment.

III. DONNING

A. Before donning suit, thoroughly inspect for deficiencies that will decrease its effectiveness as the primary barrier for protecting the body. Do not use any suit with holes, rips, malfunctioning closures, cracked masks, etc. If suit contains a hoodpiece, or a hard hat is worn, adjust it to fit user's head. If suit has a back enclosure for changing air bottles, open it.

B. Use a moderate amount of talcum powder or cornstarch to prevent chafing and increase comfort. Both also reduce rubber binding.

C. Use antifog on suit and mask facepieces.

D. While sitting (preferably), step into legs, place feet properly, and gather suit around waist.

E. While sitting (preferably), put on chemical-resistant, steel toe and shank boots over feet of suit. Properly attach and affix suit leg over top of boot.

   1. For one-piece suits with heavy-soled protective feet, wear leather or short rubber safety boots inside suit.

   2. Wear an additional pair of disposable boot protectors if necessary.

F. Put on SCBA air tank and harness assembly. Don facepiece and adjust it securely yet comfortably. Do not connect breathing hose. Open valve to air tank. (The air tank and harness assembly could also be put on before stepping into legs of suit).

G. Depending on type of suit:

1. Put on inner gloves.

2. For suits with detachable gloves, secure gloves to sleeves, if this has not been done prior to entering the suit. (In some cases, extra gloves are worn over suit gloves.)

H. While standing, put arms into sleeves, and then head into hood of suit. The helper pulls suit up and over SCBA, resting hood on top of SCBA, adjusting suit around SCBA backpack and user's shoulders to assure unrestricted motion. To facilitate entry into the suit, bend at the knees as hood is placed over wearer's head. Avoid bending at the waist, as this motion tends to use up room in the suit rather than provide slack. For a tall or stout person, it is easier to put on the hood of the suit before getting into the sleeves.

I. Begin to secure suit by closing all fasteners until there is only room to connect the breathing hose. Also, secure all belts and/or adjustable leg, head, and waist bands. Connect breathing hose while opening main valve.

J. When breathing properly in SCBA, complete closing suit.

K. Helper should observe for a time to assure that wearer is comfortable and equipment is functioning properly.

IV. DOFFING

Exact procedures must be established and followed to remove the fully encapsulating suit and SCBA. Adherence to these procedures is necessary to minimize or prevent contamination (or possible contamination) of the wearer through contacting the outside surface of the unit.

The following procedures assume that before the suit is removed, it has been properly decontaminated, considering the type and extent of contamination, and that a suitably attired helper is available.

A. Remove any extraneous or disposable clothing, boot covers, or gloves.

B. If possible, wearer kicks off oversized chemical-resistant boots unassisted. To achieve this, oversized boots are often selected. Otherwise, helper loosens and removes chemical-resistant boots.

C. Helper opens front of suit to allow access to SCBA regulator. As long as there is sufficient air pressure, hose is not disconnected.

D. Helper lifts hood of the suit over wearer's head and rests hood on top of SCBA air tank. For a tall or stout person it is easier to remove the arms from the sleeves of the suit prior to removing the hood.

E. Remove external gloves.

F. To minimize contact with contaminated clothing, helper touches only the outside of the suit, and the wearer touches only the inside. Remove arms, one at a time from suit. Helper lifts suit up and away from SCBA back pack, avoiding any contact between outside surface of suit and wearer's body. Helper lays suit out flat behind wearer.

G. While sitting (preferably), remove both legs from suit.

H. After suit is completely removed, roll internal gloves off hands, inside out.

I. Walk to clean area and follow procedure for doffing SCBA.

J. Remove inner clothing, clean body thoroughly.

V. ADDITIONAL CONSIDERATIONS

A. If work is at a very dirty site or the potential for contamination is extremely high, wear disposable Tyvek or PVC coveralls over fully encapsulating suit. Make a slit in back to fit around bulge of the SCBA back pack.

B. Wear clothing inside the suit appropriate to outside temperatures. Even in hot weather, wear long cotton underwear, which absorbs perspiration and acts as a wick for evaporation, thus aiding body cooling. Long underwear also protects skin from contact with hot surface of suit, reducing the possibility of burns in hot weather.

C. Monitor wearer for heat stress.

D. If a cooling device is used, modify donning/doffing procedure.

E. If low-pressure warning alarm sounds signifying approximately 5 minutes of air remaining, follow these procedures:

1. Quickly hose off suit and scrub especially around entrance/exit zipper. (Remove any disposable clothing.)

2. Open zipper sufficiently to allow access to regulator and breathing hose.

3. Disconnect breathing hose from regulator as main valve is closed.

4. Immediately attach canister for vapor, acid gas, dust, mist, or fume to breathing hose. This provides protection against contaminants still present.

5. Continue doffing suit as in steps A through J of previous section. Take extra care to avoid contaminating helper and wearer.

DECONTAMINATION EXERCISE

I. OBJECTIVE

A. Given written documentation procedures and a given area, the students will properly establish a controlled decontamination reduction zone.

B. Given decontamination equipment and a diagram, the students establish either a Level A or a Level B decontamination line to prevent any contaminates from entering the support zone.

C. Given personal protective equipment, the students will demonstrate the proper technique in decontaminating both levels of protection while following effective decontamination procedures.

D. Demonstrate the proper disposal methods for contaminated equipment and solution according to local, state, federal regulations.

Note: Unless otherwise stated, the conditions for performance are using all reference and materials provided in this course, and the standards of performance are without error.

II. PROCEDURE

A. In the classroom the students review briefly the decon procedures outlined in the SOSG. The ability to add, combine or eliminate steps is emphasized.

B. The red/blue team is divided into two groups, one to establish Level A decon and the other to establish Level B decon. Each group is asked for two volunteers--one to don Level A or B suit and one to supervise the set up of the decon lines.

C. While the volunteers are dressing out, the remaining members of both groups must construct their decon lines applicable for their level of protection with the assistance from the instructor. A set of contamination equipment will be made available to each group in the exercise area.

D. When completed, the decontamination procedures of both groups are critiqued, the lines disassembled, and the equipment properly stored.

III. SCENARIO

Once the volunteers have dressed out and the decontamination lines have been completely set up, the members in each group must decontaminate their entry team members from the exclusion zone (hot zone) to the support zone. The instructor will walk the students through both Level A and B decon, demonstrating the differences between Level A and B.

IV. TIME LIMIT

Approximately 90 minutes.

Level A to include:

- 30 minute SCBA with facepiece
- Fully Encapsulating Suit
- Latex inner gloves
- Neoprene outer gloves
- Steel toe/shank neoprene boots
- Hard hat
- Disposable boot covers
- Taped joints at outer gloves and boots

Level B to include:

- 30 minute SCBA with facepiece
- Two-piece PVC splash gear
- Latex inner gloves
- Neoprene outer gloves
- Steel toe/shank PVC boots
- Hard hat
- Disposable boot covers
- Taped joints at outer gloves and boots

DECON CHECKLIST

1. Establish Work Zone

2. Establish Decon Line - choose the appropriate steps (not listed in order)

_____ Field Wash

_____ Redress

_____ SCBA Removal

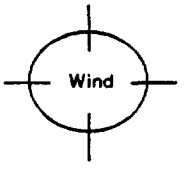
_____ SCBA Tank Change

_____ Equipment Drop

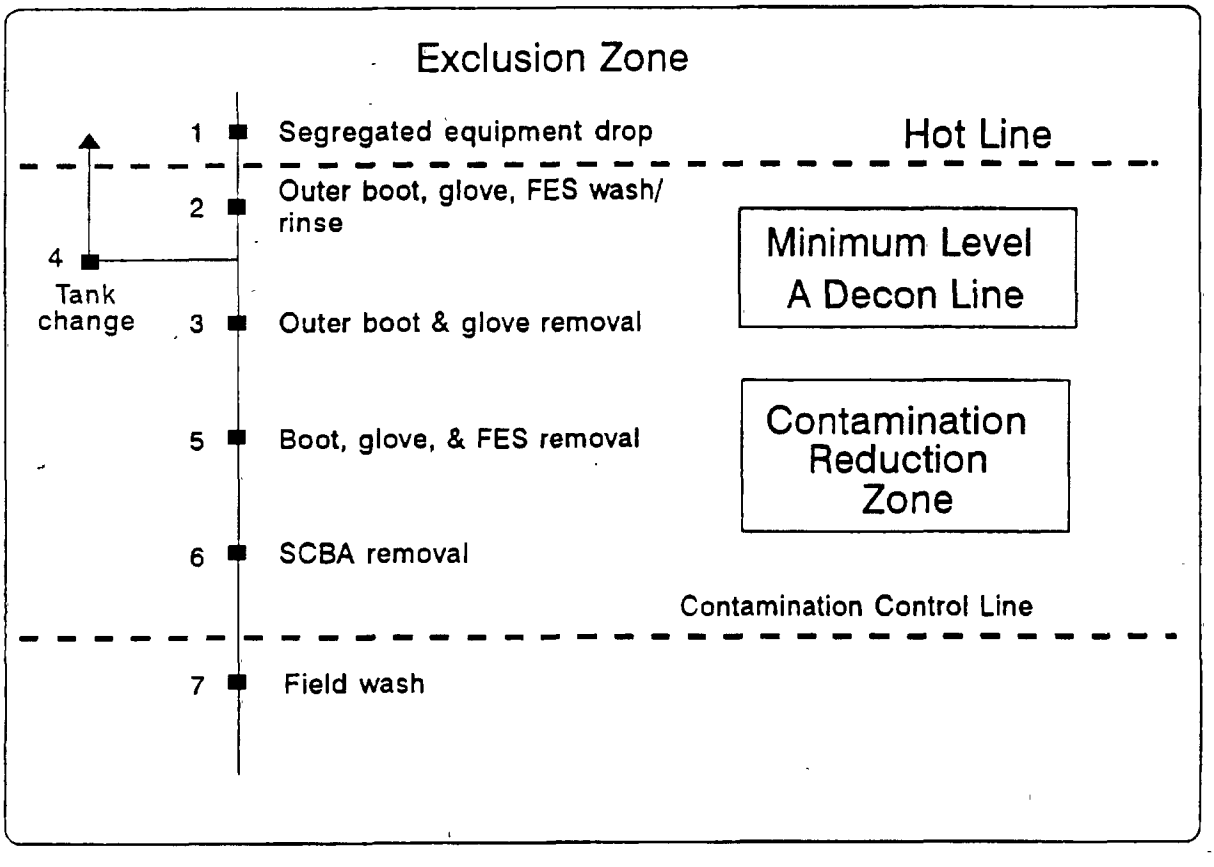
_____ Outer Boot Wash and Removal

_____ Suit Wash

_____ Boot Removal



DECON LAYOUT



Appendix D. Sample Decontamination Procedures for Three Typical Levels of Protection[a]

F.S.O.P. No. 7

Process: DECONTAMINATION PROCEDURES

INTRODUCTION

1.1 The objective of these procedures is to minimize the risk of exposure to hazardous substances. These procedures were derived from the U.S. Environmental Protection Agency, Office of Emergency and Remedial Response's (OERR), "Interim Standard Operating Safety Guides (revised Sep. 82)". This version of the guides is in a format that is more appropriate for use in the field.

1.2 Protective equipment must be worn by personnel when response activities involve known or suspected hazardous substances. The procedures for decontaminating personnel upon leaving the contaminated area are addressed for each of the EPA, OERR designated levels of protection. The procedures given are for the maximum and minimum amount of decontamination used for each level of protection.

1.3 The maximum decontamination procedures for all levels of protection consist of specific activities at nineteen stations. Each station emphasizes an important aspect of decontamination. When establishing a decontamination line, each aspect should be incorporated separately or combined with other aspects into a procedure with fewer steps (such as the Minimum Decontamination Procedures).

1.4 Decontamination lines are site specific since they are dependent upon the types of contamination and the type of work activities on site. A cooling station is sometimes necessary within the decontamination line during hot weather. It is usually a location in a shaded area in which the wind can help to cool personnel. In addition, site conditions may permit the use of cooling devices such as cool water hose, ice packs, cool towels, etc. When the decontamination line is no longer required, contaminated wash and rinse solutions and contaminated articles must be contained and disposed of as hazardous wastes in compliance with state and federal regulations.

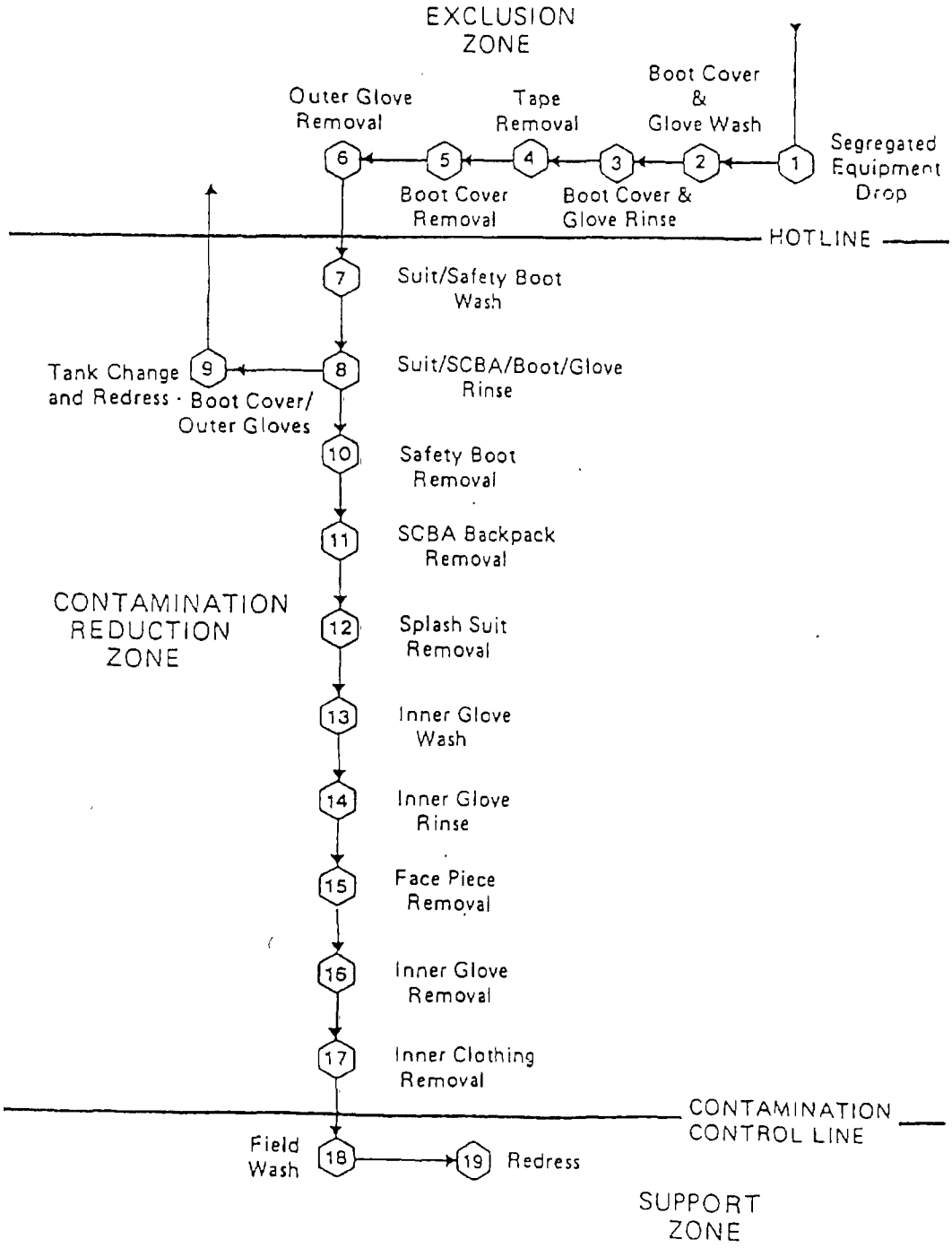
[a] Source: Excerpted from *Field Standard Operating Procedures for the Decontamination of Response Personnel (FSOP 7)*. EPA Office of Emergency and Remedial Response, Hazardous Response Support Division, Washington, DC. January 1985.

F.S.O.P. No. 7

PROCESS DECON PROCEDURES

MAXIMUM DECONTAMINATION LAYOUT

LEVEL B PROTECTION

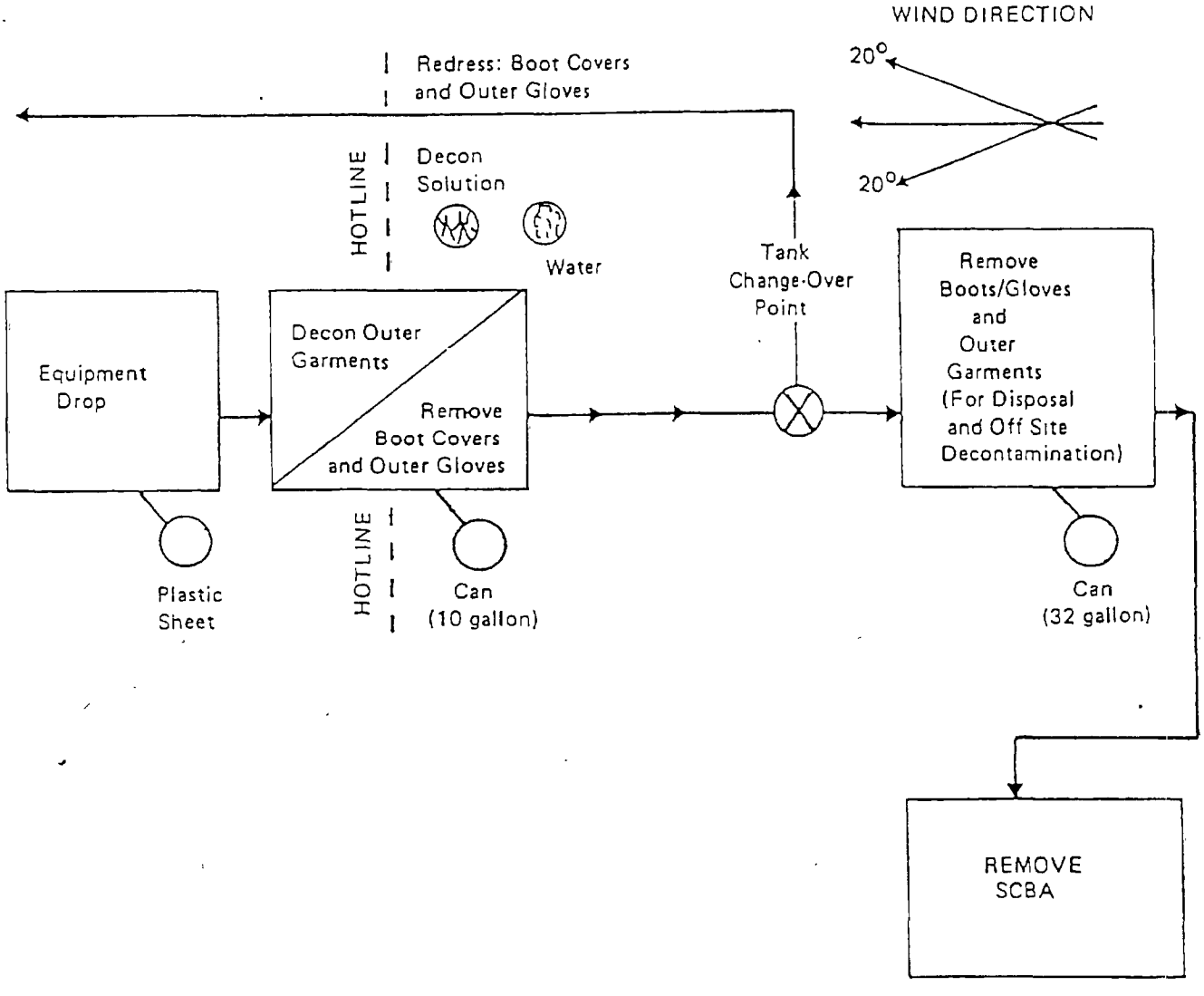


F.S.O.P. No. 7

PROCESS DECON PROCEDURES

MINIMUM DECONTAMINATION LAYOUT

LEVELS A & B PROTECTION



EQUIPMENT NEEDED TO PERFORM MAXIMUM DECONTAMINATION MEASURES FOR LEVELS A, B, AND C

Station 1:
a. Various Size Containers
b. Plastic Liners
c. Plastic Drop Cloths

Station 2:
a. Containers (20-30 Gallons)
b. Decon Solution or Detergent Water
c. 2-3 Long-Handled, Soft-Bristled Scrub Brushes

Station 3:
a. Containers (20-30 Gallons)
OR
High-Pressure Spray Unit
b. Water
c. 2-3 Long-Handled, Soft-Bristled Scrub Brushes

Station 4:
a. Containers (20-30 Gallons)
b. Plastic Liners

Station 5:
a. Containers (20-30 Gallons)
b. Plastic Liners
c. Bench or Stools

Station 6:
a. Containers (20-30 Gallons)
b. Plastic Liners

Station 7:
a. Containers (20-30 Gallons)
b. Decon Solution or Detergent Water
c. 2-3 Long-Handled, Soft-Bristled Scrub Brushes

Station 8:
a. Containers (20-30 Gallons)
OR
High-Pressure Spray Unit
b. Water
c. 2-3 Long-Handled, Soft-Bristled Scrub Brushes

Station 9:
a. Air Tanks or Face Masks and Cartridge Depending on Level
b. Tape
c. Boot Covers
d. Gloves

Station 10:
a. Containers (20-30 Gallons)
b. Plastic Liners
c. Bench or Stools
d. Boot Jack

Station 11:
a. Rack
b. Drop Cloths
c. Bench or Stools

Station 12:
a. Table

Station 13:
a. Basin or Bucket
b. Decon Solution
c. Small Table

Station 14:
a. Water
b. Basin or Bucket
c. Small Table

Station 15:
a. Containers (20-30 Gallons)
b. Plastic Liners

Station 16:
a. Containers (20-30 Gallons)
b. Plastic Liners

Station 17:
a. Containers (20-30 Gallons)
b. Plastic Liners

Station 18:
a. Water
b. Soap
c. Small Table
d. Basin or Bucket
e. Field Showers
f. Towels

Station 19:
a. Dressing Trailer is Needed in Inclement Weather
b. Tables
c. Chairs
d. Lockers
e. Cloths

EQUIPMENT NEEDED TO PERFORM MINIMUM DECONTAMINATION MEASURES FOR LEVELS A, B, AND C

Station 1:
a. Various Size Containers
b. Plastic Liners
c. Plastic Drop Cloths

Station 2:
a. Containers (20-30 Gallons)
b. Decon Solution
c. Rinse Water
d. 2-3 Long-Handled, Soft-Bristled Scrub Brushes

Station 3:
a. Containers (20-30 Gallons)
b. Plastic Liners
c. Bench or Stools

Station 4:
a. Air Tanks or Masks and Cartridges Depending Upon Level
b. Tape
c. Boot Covers
d. Gloves

Station 5:
a. Containers (20-30 Gallons)
b. Plastic Liners
c. Bench or Stools

Station 6:
a. Plastic Sheets
b. Basin or Bucket
c. Soap and Towels
d. Bench or Stools

Station 7:
a. Water
b. Soap
c. Tables
d. Wash Basin or Bucket

FSOP 7: MAXIMUM MEASURES FOR LEVEL A DECONTAMINATION

Station 17:	Inner Clothing Removal	17. Remove clothing and place in lined container. Do not wear inner clothing off-site since there is a possibility that small amounts of contaminants might have been transferred in removing the fully-encapsulating suit.
Station 18:	Field Wash	18. Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.
Station 19:	Redress	19. Put on clean clothes.

FSOP 7: MINIMUM MEASURES FOR LEVEL A DECONTAMINATION

Station 1:	Equipment Drop	1. Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths. Segregation at the drop reduces the probability of cross contamination. During hot weather operations, cool down stations maybe set up within this area.
Station 2:	Outer Garment, Boots, and Gloves Wash and Rinse	2. Scrub outer boots, outer gloves and fully-encapsulating suit with decon solution or detergent and water. Rinse off using copious amounts of water.
Station 3:	Outer Boot and Glove Removal	3. Remove outer boots and gloves. Deposit in container with plastic liner.
Station 4:	Tank Change	4. If worker leaves Exclusion Zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer gloves and boot covers donned, joints taped, and worker returns to duty.
Station 5:	Boot, Gloves and Outer Garment Removal	5. Boots, fully-encapsulating suit, inner gloves removed and deposited in separate containers lined with plastic.
Station 6:	SCBA Removal	6. SCBA backpack and facepiece is removed (avoid touching face with fingers). SCBA deposited on plastic sheets.
Station 7:	Field Wash	7. Hands and face are thoroughly washed. Shower as soon as possible.

FSOP 7: MAXIMUM MEASURES FOR LEVEL B DECONTAMINATION

Station 17.	Inner Clothing Removal	17 Remove inner clothing. Place in container with liner. Do not wear inner clothing off-site since there is a possibility that small amounts of contaminants might have been transferred in removing the fully-encapsulating suit.
Station 18.	Field Wash	18 Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.
Station 19:	Redress	19. Put on clean clothes.

FSOP 7: MINIMUM MEASURES FOR LEVEL B DECONTAMINATION

Station 1:	Equipment Drop	1. Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths. Segregation at the drop reduces the probability of cross contamination. During hot weather operations, cool down station may be set up within this area.
Station 2:	Outer Garment, Boots, and Gloves Wash and Rinse	2. Scrub outer boots, outer gloves and chemical-resistant splash suit with decon solution or detergent water. Rinse off using copious amounts of water.
Station 3:	Outer Boot and Glove Removal	3. Remove outer boots and gloves. Deposit in container with plastic liner.
Station 4:	Tank Change	4. If worker leaves exclusive zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer gloves and boot covers donned, joints taped, and worker returns to duty.
Station 5:	Boot, Gloves and Outer Garment Removal	5. Boots, chemical-resistant splash suit, inner gloves removed and deposited in separate containers lined with plastic.
Station 6:	SCBA Removal	6. SCBA backpack and facepiece is removed. Avoid touching face with finger. SCBA deposited on plastic sheets.
Station 7:	Field Wash	7. Hands and face are thoroughly washed. Shower as soon as possible.

FIELD USE OF AIR MONITORING INSTRUMENTS EXERCISE

I. OBJECTIVE

The objective of this exercise is to familiarize students with the operation of radiation survey instruments. Students then use these instruments, under controlled conditions, to (1) determine the type of radiation being emitted; (2) interpret instrument readings; and (3) learn safe radiation survey techniques.

II. INSTRUMENTS

A wide variety of monitoring instruments are available for survey. Although each instrument is unique in its uses and limitations, many features are common to all instruments. Therefore, familiarity with the operation of one instrument should transfer to other instruments.

III. FIELD USE OF AIR MONITORING INSTRUMENTS

A. Instructions

Students in this exercise, while wearing Level B protective clothing, will use a radiation meter and a series of monitoring instruments in a field setting.

The exercise will be divided into three stations:

STATION 1 Participants will use a radiation meter to determine any sources of radiation.

STATION 2 Participants using pH paper will take readings of 3 liquids to determine pH levels.

STATION 3 Participants using combustible gas indicators (CGIs) will take air samples from bung space of barrels to determine % of LEL. Additionally, using colorimetric tubes, the participants will determine the contents of the containers.

B. Field Exercise Data Sheet

STATION 1 RADIATION	
WHAT IS THE BACKGROUND READING_____u/R	CONTAINER A_____u/R CONTAINER B_____u/R CONTAINER C_____u/R
Is there a hidden radiation source? Yes_____ No_____ What is the location of the hidden source? _____ _____	What is the reading at: 1-FT_____u/R 2-FT_____u/R 3-FT_____u/R At Source_____u/R

STATION 2
LIQUID #A pH_____
LIQUID #B pH_____
LIQUID #C pH_____

STATION 3	
CGI READING AT DRUM OPENING_____ %LEL_____ %O_2 _____	LEL IS IN WHICH RANGE _____< LEL _____= LEL-UEL _____> UEL
Colorimetric Tubes: What product or products are in the container? ACETONE % _____ PPM _____ ALCOHOL % _____ PPM _____ TOLUENE % _____ PPM _____	

APPENDIX I

Hazardous Materials Response Forms

HAZARDOUS MATERIALS RESPONSE FORMS

CONTENTS

INCIDENT COMMANDER 87
- a. Command Structures: Warehouse (2 pages) and Transportation (2 pages)
- b. Defining Hazardous Materials Problems
- c. The Chemtox Hot Line
- d. Hazardous Materials Information Sources
- e. Hazardous Materials Tactical Command Sheet
- f. Scene Overview

RECORDER 97
- a. Unit log (4 pages)
- b. Hazardous Materials Incident Report: Fixed Facility and Transportation

PUBLIC INFORMATION OFFICER 105
- a. Hazardous Materials Incident Summary Statement for Media

OPERATIONS 107
- a. Operation Officer Worksheet
- b. Pre-entry Checklist
- c. Briefing and Debriefing Forms (3 pages)

SAFETY OFFICER 113
- a. Safety Officer Worksheet
- b. Scene Safety Plan (12 pages)
- c. Atmopheric Hazard Guideline
- d. Air Monitoring Instrumentation Daily Report Log
- e. HazMat Incident Medical Evaluation Chart
- f. Personnel Protection and Exposure Chart

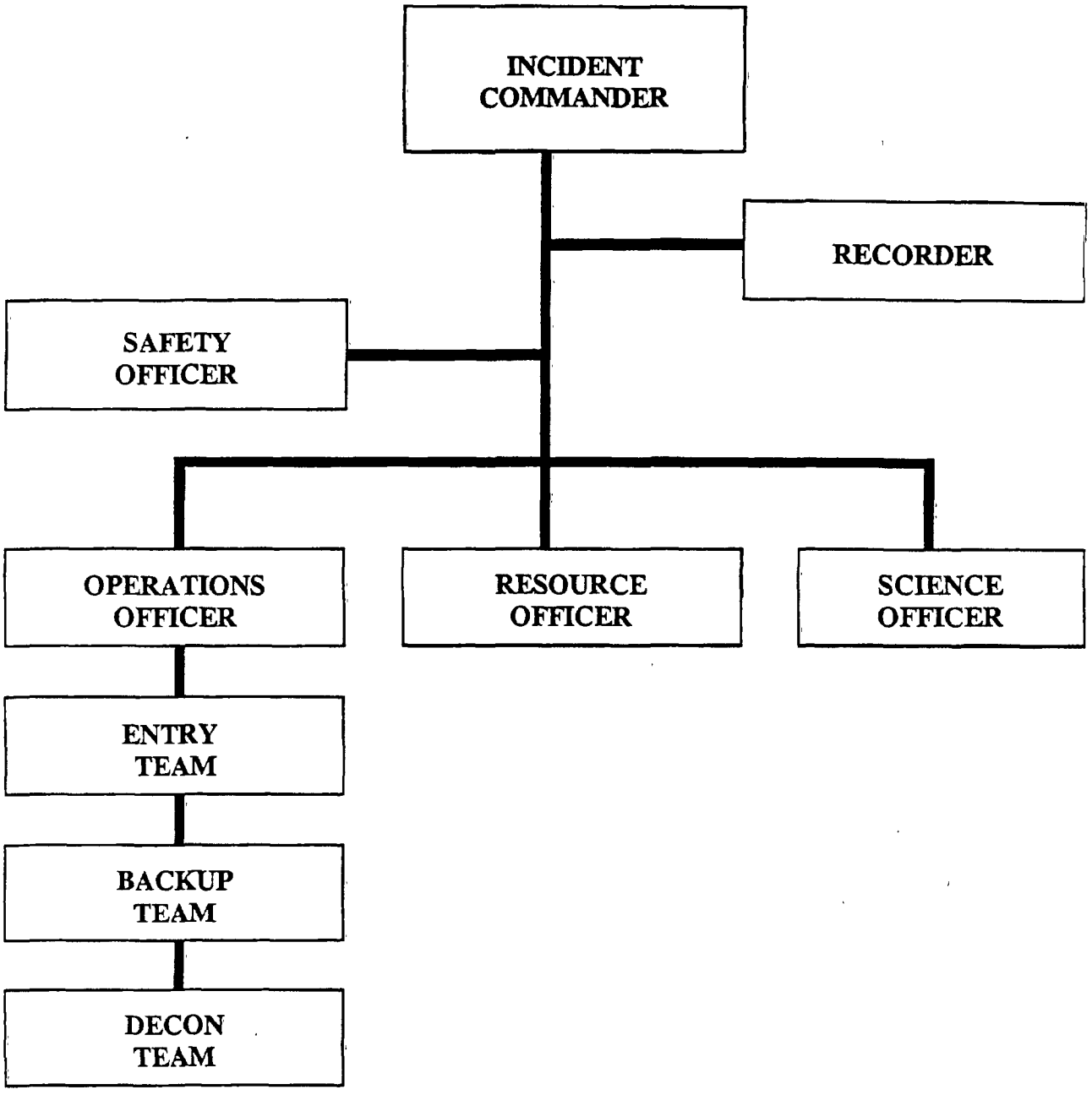
SCIENCE OFFICER 133
- a. Hazardous Substance Data Sheet (3 pages)
- b. Hazardous Materials Response Form (2 pages)

RESOURCE OFFICER 141
- a. Hazardous Materials Incident Cost Recovery Form (2 pages)
- b. Resource List for Warehouse and Transportation Exercises
- c. Local resource list (2 pages)

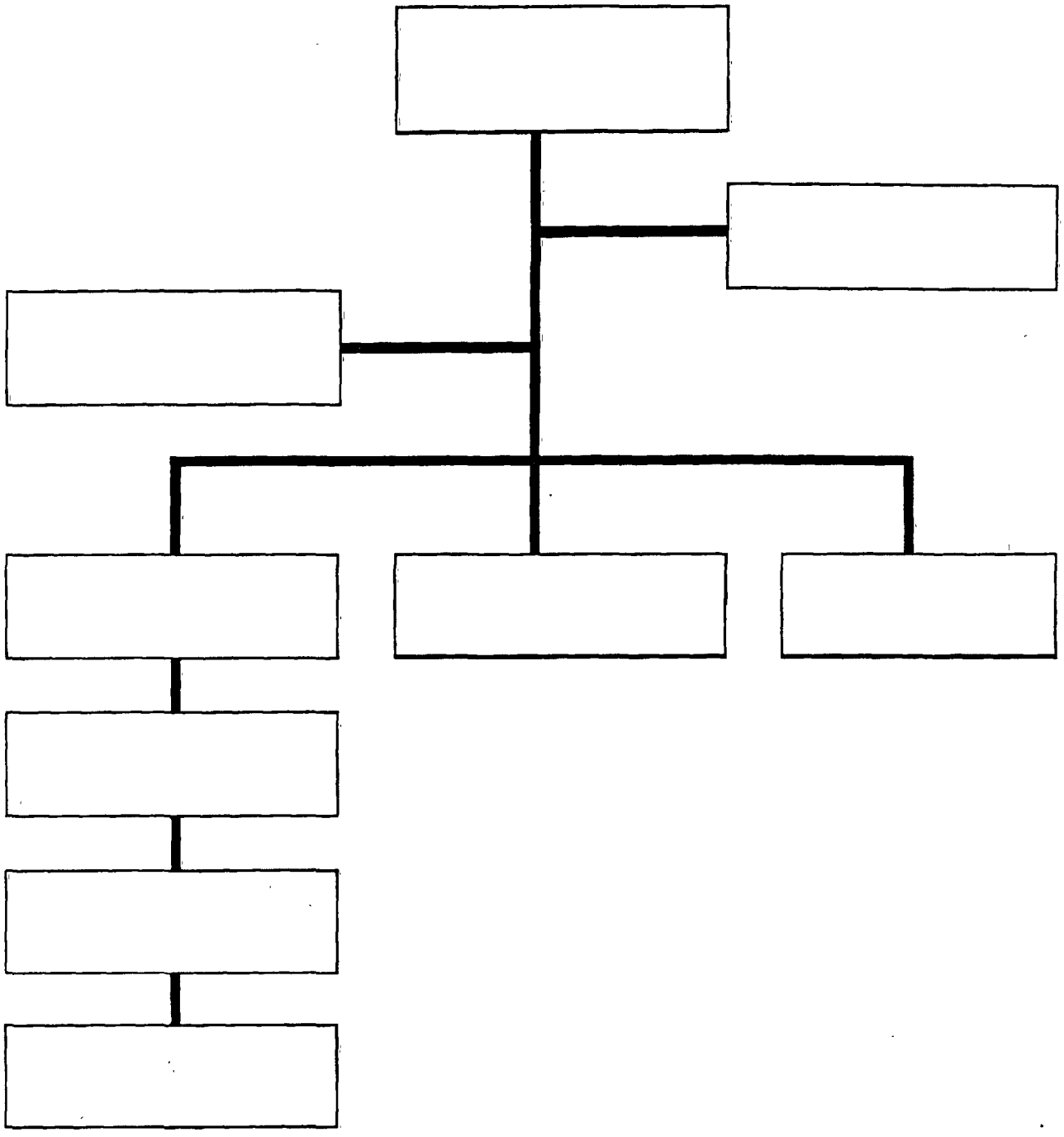
DECONTAMINATION TEAM 149
- a. Decontamination Checklist
- b. Team needs to write out and develop their own decontamination plan and chart

ENTRY AND BACK-UP TEAM 151
- a. Entry and Back-up Team Checklist

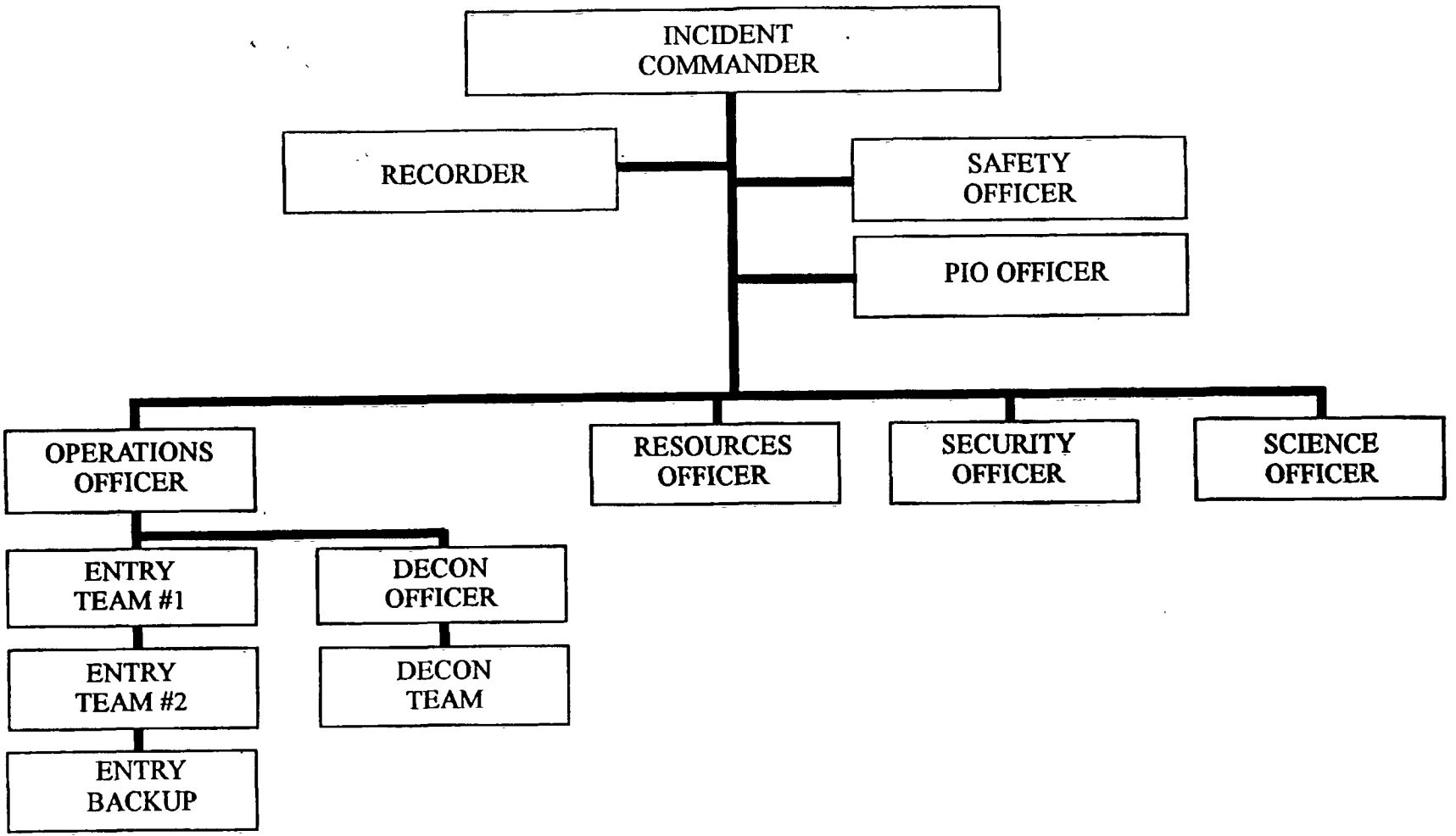
Incident Commander



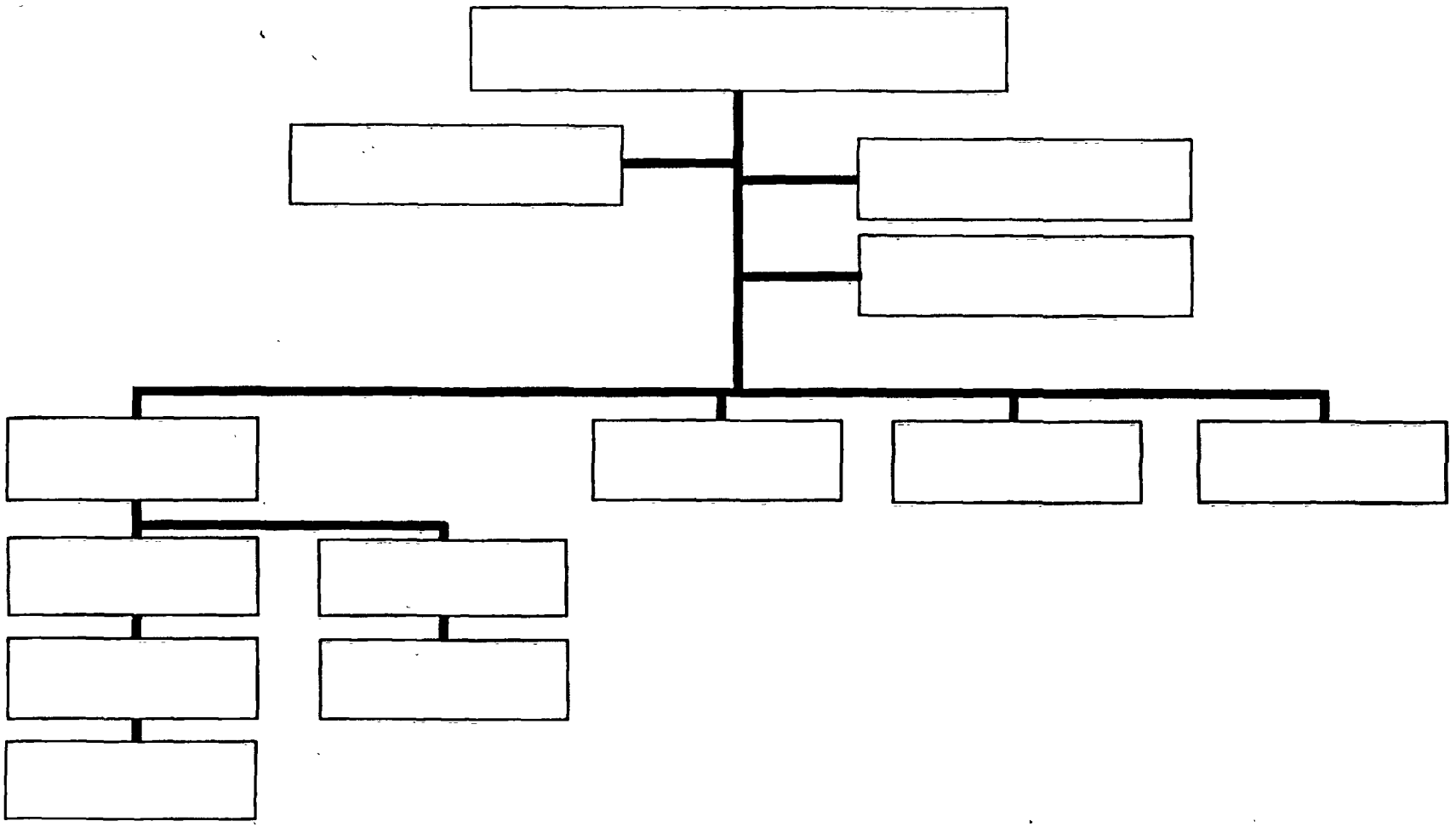
COMMAND STRUCTURE
WAREHOUSE EXERCISE



COMMAND STRUCTURE
WAREHOUSE EXERCISE



COMMAND STRUCTURE TRANSPORTATION EXERCISE



COMMAND STRUCTURE
TRANSPORTATION EXERCISE

DEFINING HAZARDOUS MATERIALS PROBLEMS

Do I have an emergency involving hazardous materials?
- Clues:
  - Occupancy and location
  - Container shapes
  - Markings and colors
  - Placards and labels
  - Shipping papers
  - Senses

What is the name of the hazardous material(s) (shipping/chemical name)?
- Sources:
  - Shipping papers
  - Markings and colors
  - Shipping/consignee contact
  - CHEMTREC

What are the characteristics and behavior of the hazardous material(s)?
- Resources:
  - Printed materials
  - Verbal resources

How are the containers stressed?
- ☐ Thermal
- ☐ Mechanical
- ☐ Chemical

What will the stress do?

To the container?

To the contents?

How will the container react to the stress?

How will the container breach?
- ☐ Disintegration
- ☐ Runaway cracking
- ☐ Attachments open up
- ☐ Punctures
- ☐ Splits or tears

How will the contents escape from the container?
- Release events:
  - ☐ Detonation
  - ☐ Violent
  - ☐ Rapid relief
  - ☐ Spill or leak

What will be jumping out at you?
- ☐ Energy
- ☐ Matter
  - ☐ Solids
  - ☐ Liquids
  - ☐ Gases
  - ☐ Liquified gases
  - ☐ Organisms

What form will the contents be in?
- ☐ Energy
  - ☐ Infrared rays (thermal)
  - ☐ Gamma rays
  - ☐ Pressure waves
- ☐ Matter
  - ☐ Dusts or powders
  - ☐ Fragments, shrapnel or chunks
  - ☐ Organisms
  - ☐ A or B radiation
  - ☐ Pourable liquids
  - ☐ Vapors
  - ☐ Gases
  - ☐ Vaporizing liquids

What will cause the hazardous material to move?
- ☐ Thermal differential
- ☐ Self propelled
- ☐ Air entrainment
- ☐ Personal transport
- ☐ Gravity
- ☐ Vapor diffusion
- ☐ Gaseous diffusion
- ☐ Boiling

What path will be the hazardous material follow?
- ☐ Linear
- ☐ Radial
- ☐ Random
- ☐ Follow contour
- ☐ Upward from source
- ☐ Outward from source

What dispersion pattern will the hazardous material likely form?
- ☐ Cloud
- ☐ Plume
- ☐ Cone
- ☐ Stream
- ☐ Irregular deposit

What actual area will the hazardous materials dispersion cover?

When will the hazardous material get there?

What exposure will be impinged upon by the hazardous materials (container)?
- ☐ People?
- ☐ Systems?
- ☐ Property?

How long will the impingement last?
- ☐ Short term (transient)
- ☐ Medium term (lingering)
- ☐ Long term (permanent)

What exposure route of entry will the hazardous materials impinge on?
- ☐ Respiratory
- ☐ Ingestion
- ☐ Dermal

What type of harm will the hazardous material (container) create?
- ☐ Thermal (heat or cold)
- ☐ Radiation
- ☐ Asphyxiation
- ☐ Toxic
- ☐ Corrosive
- ☐ Etiologic
- ☐ Mechanical

What will the likely outcome be?
- ☐ Deaths _____
- ☐ Injuries _____
- ☐ Property damage _____
- ☐ Environmental damage _____
- ☐ System disruption _____

THE CHEMTOX HOT LINE

ENVIRONMENTAL

EPA Hotline 1-202-382-4770
EPA RCRA Superfund, Hazardous Waste Hotline, Office of Solid Waste and Emergency Response 1-800-424-9346
Chemical Emergency Preparedness Hotline, CERCLA (SARA, Title III) 1-800-535-0202
EPA Small Business Hotline 1-800-368-5888
Safe Drinking Water Hotline 1-800-426-4791
Office of Air Quality Planning and Standards 1-919-541-5517
EPA Regional Offices
I 617-565-3715 VI 214-655-6444
II 212-264-2525 VII 913-236-2800
III 251-597-9800 VIII 303-293-1603
IV 404-347-4727 IX 415-974-8071
V 312-353-2000 X 206-442-5810

EMERGENCY RESPONSE

CHEMTREC (24-hr Emergency Number) 1-800-424-9300
Department of Transportation (U.S. DOT) Hotline Information on CFR 49 Federal Regulations 1-202-366-4488
DOT National Response Center for Oil and Hazardous Materials Spills 1-800-424-8802
(U.S. Coast Guard) Association of American Railroad, Bureau of Explosives (24-hr Emergency Number) 1-202-639-2222
Dupont 1-800-441-9475
EPA Regional Emergency Response Offices
I 617-861-6700 VI 214-767-2720
II 201-321-6657 VII 913-236-3888
III 215-597-9492 VIII 303-234-6069
IV 404-881-3931 IX 415-974-7511
V 312-353-2102 X 206-442-1263
National Science Foundation 1-202-632-7970
National Academy of Sciences 1-202-334-2100

OCCUPATIONAL HEALTH AND SAFETY

OSHA 1-202-523-6091
OSHA Laboratory (Cincinnati) 1-513-684-2531
OSHA Analytical Laboratory (Salt Lake City) 1-801-524-5287
OSHA Regional Offices
I 617-223-6710 VI 214-767-4731
II 212-944-3426 VII 816-374-5861
III 215-596-1201 VIII 303-837-3883
IV 404-881-3573 IX 415-556-0584
V 312-353-2220 X 206-442-5930
NIOSH Headquarters (Rockville, MD) 1-303-443-2140
NIOSH (Cincinnati) 1-513-684-8236
NIOSH Regional Offices
I 617-565-1161 VI 214-767-3301
II 212-264-4600 VII 816-374-2821
III 215-596-6492 VIII 303-887-3373
IV 404-221-2422 IX 415-556-6746
V 312-353-5160 X 206-442-0420

OTHER VERY IMPORTANT NUMBERS

TSCA (Toxic Substance Control Act) 1-800-424-9065
TSCA Hotline 1-202-554-1404
Inspector General's Whistleblower Hotline 1-800-424-4000
Fraud, Waste, and Mismanagement Hotline Federal Emergency Management Agency (FEMA) 1-800-424-5454
Texas Tech University Pesticide Hotline 1-800-858-7378
National Animal Poison Control Center, 24-hr Hotline Operated at the University of Illinois 1-217-333-3611
U.S. Army Corps of Engineers 1-202-272-0001

GENERAL CHEMICAL INFORMATION

Public Information Center 1-800-828-4445
Department of Health and Human Services 1-202-245-6296
National Resources Defense Council, INFOLINE on Household Chemicals 1-800-648-6762
(in New York State) 1-202-687-6862

THE CHEMTOX SYSTEM
Division of Resource Consultants, Inc.
7121 CrossRoads Boulevard
P.O. Box 1848
Brentwood, Tennessee 37024-1848
1-615-373-5040 in Tennessee
1-606-737-9009 in New Jersey

ASSOCIATIONS

Chemical Manufacturers Association (CMA) 1-202-887-1100
CMA Chemical Referral Center (Non-Emergency Chemical Information) 1-800-CMA-8200
National Safety Council (NSC) 1-312-527-4800
American Society of Safety Engineers (ASSE) 1-312-692-4121
National Fire Protection Association (NFPA) 1-617-770-3000
American Industrial Hygiene Association (AIHA) 1-216-762-7294
American Conference of Governmental Industrial Hygienists (ACGIH) 1-513-742-2020
American Trucking Association (ATA) 1-800-ATA-LINE

U.S. GOVERNMENT PRINTING OFFICE: 1991-548-187/2562

HAZARDOUS MATERIALS INFORMATION SOURCES

(Selected listings)

AGENCY	TELEPHONE
Office of Emergency Preparedness (in your area)	
Department of Environmental Control (in your area)	
Fire Marshal's Office (in your area)	
CHEMTREC	1-800-424-9300
Bureau of Explosives	1-202-853-9500
National Response Center (NRC)(USCG & EPA)	1-800-424-8802
Department of Defense Nuclear Accident Center	1-505-264-4667
U.S. Army Explosive Ordinance Disposal	1-301-667-5182
Center for Disease Control	1-404-663-5315
National Poison Control Center	1-402-390-5400
ACFX Rail Car Manufacturer	1-314-724-7850
GATZ Rail Car Manufacturer	1-312-621-6200
NATX Rail Car Manufacturer	1-312-648-4000
American Petroleum Institute	1-202-457-7000
Association of American Railroads	1-202-293-4048
Chlorine Institute	1-212-682-4324
Compressed Gas Association	1-212-354-1130
Dow Chemical Company	1-517-636-4400
DuPont Corporation	1-302-774-7500
U.S. Department of Transportation	1-202-426-1830
National Transportation Safety Board	1-800-424-0201
U.S. Railroad Administration	1-202-426-4000
U.S. Fish and Wildlife Services	1-202-343-5634
U.S. Corps of Engineers	1-202-646-4600
Federal Emergency Management Agency (FEMA)	1-202-646-4600
U.S. Department of Agriculture	1-202-447-2791

HAZARDOUS MATERIALS TACTICAL COMMAND SHEET

ADDRESS	TIME OF ALARM
OCCUPANCY	UNDER CONTROL

UNITS			COMMAND ASSIGNMENTS	
COs	MEN	ASSIGNMENT	IC	
			SAFETY	
			RECORDER	
			OPERATIONS	
			DECON	
			RESOURCES	
			SECURITY	
			PIO	
			SCIENCE	
			ENTRY	
			BACKUP	
			DECON TEAM	

PRESENT WEATHER CONDITIONS

WIND SPEED MPH DIRECTION FROM	TEMP. °F SKY CONDITION HUMIDITY	RAIN ☐ SNOW ☐ DRY ☐

FORECAST WEATHER

WIND SPEED MPH DIRECTION FROM	TEMP. °F SKY CONDITION HUMIDITY	RAIN ☐ SNOW ☐ DRY ☐

NOTES

SCENE OVERVIEW

SHOW ISOLATION / COMMAND POST / INDICATE NORTH / WIND DIRECTION

Recorder

UNIT LOG	INCIDENT NAME	DATE	TIME

IC	RECORDER	INCIDENT TIME

PERSONNEL ROSTER ASSIGNED

NAME	ICS POSITION	LOCATION

ACTIVITY LOG (Continue on next page)

TIME	MAJOR EVENTS

UNIT LOG TIME	MAJOR EVENTS
DATE	PREPARED by (name and position)

UNIT LOG TIME	MAJOR EVENTS
DATE	PREPARED by (name and position)

UNIT LOG TIME	MAJOR EVENTS
DATE	PREPARED by (name and position)

HAZARDOUS MATERIAL INCIDENT REPORT - TRANSPORTATION

DATE: _____ TIME IN: _____ TIME OUT: _____ WIND DIRECTION AND SPEED____

TYPE OF INCIDENT: _____

LOCATION/ADDRESS: _____
CARRIER/SHIPPER: _____
MANUFACTURER: _____
TYPE OF CONTAINER: _____ CAPACITY: _____
NUMBER OF CONTAINER(s) LEAKING: _____
QUANTITY SPILLED: _____

HOW DAMAGED: _____
MATERIAL(s) INVOLVED: _____
GAS ____ LIQUID ____ SOLID ____

PROPERTIES OF MATERIAL(s): _____
DID MATERIALS LEAK ON TRUCK OR VEHICLE? _____
IF SO, DID MATERIALS COME IN CONTACT WITH:
WOOD ____ METAL ____ COMBINATION ____

LOCATION OF CONTAMINATION: _____
DAMAGE CONTAINED TO: TRUCK ____ TRAILER ____ VEHICLE ____ RAILCAR ____

OTHER FREIGHT INVOLVED: _____

PROXIMITY TO POPULATED AREA(s): _____

STREAM OR SEWER SYSTEM: _____

LIST COMPANIES RESPONDED: _____

_____

_____

LIST NAMES OF HAZMAT PERSONNEL ON-SCENE: _____

_____

_____

WAS ANYONE EXPOSED TO CONTAMINATION: YES ____ NO____ IF YES, EXPLAIN: _____

_____

_____

_____

PREPARED by (name and position) DATE

_____ _____

HAZARDOUS MATERIAL INCIDENT REPORT - FIXED FACILITY

DATE:_____ TIME IN:_____ TIME OUT:_____

NAME OF FACILITY: _____
LOCATION/ADDRESS: _____
FACILITY REPRESENTATIVE: _____

MATERIAL(s) INVOLVED: _____
GAS____ LIQUID____ SOLID____

PROPERTIES OF MATERIAL(s): _____
QUANTITY INVOLVED: _____

WIND DIRECTION AND SPEED: _____ AMOUNT OF SPILLAGE _____

PROXIMITY TO POPULATED AREA(s): _____

STREAM OR SEWER SYSTEM: _____

LIST COMPANIES RESPONDED: _____

_____

_____

LIST NAMES OF HAZMAT PERSONNEL ON-SCENE: _____

_____

_____

WAS ANYONE EXPOSED TO CONTAMINATION: YES ____ NO____ IF YES, EXPLAIN:

_____

_____

_____

_____

CONDITION AT SCENE AND ACTION TAKEN: _____

_____

_____

_____

_____

PREPARED by (name and position) DATE

_____ _____

Public Information Officer

HAZARDOUS MATERIALS INCIDENT SUMMARY STATEMENT FOR MEDIA

At approximately _____a.m./p.m. today, a spill/release/fire/other _____ of a potentially hazardous substance was reported to our emergency services (911) by a private citizen/city employee/other_____ . _____ fire units immediately responded and police units were dispatched to cordon off the area and direct traffic. The material has been identified/ has not been identified/was later determined to be _____, which is a hazardous/harmless chemical/substance/material/gas that, upon contact, may produce symptoms of _____. Precautionary evacuation of the immediate/x-block____ area surrounding the spill was requested/required by _____ agency. Approximately _____ persons were evacuated and relocated to _____. Clean-up crews from _____ agency/private vendor were dispatched to the scene, and normal traffic has resumed/will resume by _____, at which time residents will be/were allowed to return to their homes. There were no injuries reported OR _____ persons, including _____ fire and _____ personnel were treated at area hospitals for _____ and _____ all OR _____ (number) were released. Those remaining in the hospitals are in good/fair/critical/other _____ condition. Response agencies involved were _____

_____

_____

_____

_____

Additional comments: _____

_____

_____

_____

_____

Operations Officer

OPERATIONS OFFICER WORKSHEET

ENTRY TEAM #____ ENTRY TEAM MEMBERS: _____

BACK-UP TEAM #____ BACK-UP TEAM MEMBERS: _____

SPECIFIC TASKS BRIEFED: _____

_____

EQUIPMENT: _____

EMERGENCY WITHDRAWAL SIGNAL: _____

EMERGENCY EVACUATION ROUTE: _____

SIGNS AND SYMPTOMS OF EXPOSURE: _____

_____

EMERGENCY PROCEDURES FOR PERSONAL EXPOSURE: _____

_____

MEDICAL EVACUATION COMPLETED: _____

INITIAL ENTRY SUIT LEVEL: _____ MATERIAL: _____

VISUAL SUIT INSPECTION: _____ INSPECTOR: _____

DECONTAMINATION SET-UP / TYPE: _____

WORKING TIME BRIEFED: _____

TIME ON AIR: _____ TIME OFF AIR: _____ TOTAL TIME IN SUIT: _____

ADDITIONAL REMARKS: _____

_____

_____

BRIEFING FORM

Briefing shall be accomplished with all Command Staff and Officers present. All personnel that are present must sign below:

Incident Commander _____ Safety Officer _____

Operations Officer _____ Decon Officer _____

Recorder _____ Science _____

Resource _____

BRIEFING TOPICS:

1. UNKNOWN HAZARDS: _____

_____

_____

_____

2. KNOWN HAZARDS: _____

_____

_____

_____

3. GOALS AND OBJECTIVES: _____

_____

_____

_____

_____

_____

4. LEVEL OF PROTECTION FOR:

ENTRY TEAM _____ BACKUP TEAM _____ DECON TEAM _____

5. NUMBER OF:

ENTRY TEAM _____ BACKUP TEAM _____ DECON TEAM _____

BRIEFING FORM (cont.)

6. HOW ARE WORK AND CONTROL ZONES ESTABLISHED: _____

_____
_____
_____
_____

7. WHAT EQUIPMENT IS NEEDED FOR ESTABLISHING ZONES: _____

_____
_____
_____

8. WHAT EQUIPMENT IS NEEDED FOR ENTRY TEAM TO ACCOMPLISH THEIR GOALS AND OBJECTIVES: _____

_____
_____
_____
_____
_____
_____
_____

9. WHAT DECON LAYOUT IS NEEDED: _____

_____
_____
_____

10. WET OR DRY DECON? IF WET, WHAT SOLUTION? _____. Ensure decon line is set up and personnel are dressed out before entry is made.

11. SAFETY AND OPS BRIEF ENTRY AND BACKUP TEAM WITH SAME INFORMATION AS ABOVE.

12. Ensure Backup Team is in ready position, conduct radio check, give instructions as to amount of time with no communication before you will check on them or send in the Backup Team, zip up suit, place Entry Team on air (record time), have Safety Officer do final check, send Entry Team in, and place Backup Team in Support Zone near entry point in ready position.

DEBRIEFING FORM

After the Entry Team has completed their goals and objectives or enters the decon line for whatever reason, any information retrieved from the Hot Zone must be decontaminated before it can come through the Warm Zone (e.g., diagram board, shipping papers).

While Entry Team is going through decon, go over any information retrieved from the Hot Zone and compare it with the notes that were taken during entry. Write down questions for the Entry Team to use to conduct the debriefing.

1. If paperwork was retrieved, was the information the same as you already have? YES _ NO _

2. If diagram was made, have Entry Team explain information.

3. If meter readings were recorded, how much and where? _____

   _____

   _____

   _____

4. Was problem fixed? YES ____ NO ____ If "NO," list Entry and Backup Teams recommendations:

   _____

   _____

   _____

5. Have briefing with Command Staff and Officers to go over information retrieved from first entry.

6. Were goals and objectives met? YES __ NO __ If "NO," what are the next Entry Teams goals and objectives? _____

   _____

   _____

   _____

7. If new goals and objectives are to be established, go back to briefing form and answer briefing topics again.

PRE-ENTRY CHECKLIST

1. ____ Ensures entry team briefing is completed.
2. ____ Establish communication frequency.
3. ____ Establish Entry Team members.
4. ____ Establish Backup Team members.
5. ____ Take team's baseline vitals and record them.
6. ____ Take off all personal accessories (e.g., badges, buckles, pins, watches, rings).
7. ____ Assemble and check all clothing and equipment needed.
8. ____ Check on what type of monitoring equipment is needed and make sure it works properly.
9. ____ Verify location of:
   - ____ a. Hot, Warm, and Cold Zone.
   - ____ b. Decon corridor.
   - ____ c. Emergency access corridor.
   - ____ d. Equipment corridor.
   - ____ e. Working radio communication.
10. ____ Don protective clothing to waist.
11. ____ Don self-contained breathing apparatus (SCBA).
12. ____ Attach radio to SCBA and conduct radio check.
13. ____ Final safety and escape instructions.
14. ____ Final briefing on assignment.
15. ____ Verify both teams' readiness.
16. ____ Complete donning of protective clothing.
17. ____ Record time zero (from when first on air) and notify IC.
18. ____ Entry Team on air, Backup Team off air (on air if connected to air line)
19. ____ Backup Team at standby location.
20. ____ Entry Team makes entry and notifies IC.
21. ____ Maintain radio and/or visual contact, if possible, with Operations Officer.
22. ____ Record all information.
23. ____ Track and notify Entry Team of elapsed time.
24. ____ Entry team exit notify IC.
25. ____ Decon Team follow Entry Team members through decon.
26. ____ Record postentry baseline vitals and hydrate team members.
27. ____ Make sure Entry and Backup Teams do personal decon (field wash) before leaving site.
28. ____ Debrief Entry and Backup Teams.
29. ____ Complete all documentation on Incident Termination and Demobilization plan.

Safety Officer

SAFETY OFFICER WORKSHEET

ENTRY TEAM MEMBER NAMES: _____

OPERATIONS CHIEF: _____

PRODUCT IDENTIFICATION: _____

LEVEL OF PROTECTION: _____

SUIT COMPATIBLE: _____ (DOUBLE CHECKED): _____

AIR MONITORING FOR ZONES ESTABLISHED: _____

TYPE OF DECON: _____

HAZARD AND PROCEDURES BRIEF CONDUCTED BY: _____

MEDICAL EVACUATION COMPLETED BY: _____

PERSONAL ITEMS (removed, tagged, and secured): _____

COMMUNICATIONS CHECKED BY: _____

POSITIVE PRESSURE AIR CHECKED: _____

BACK-UP AIR SUPPLY CHECKED: _____

VISUAL CHECK OF SUITS: _____

ZIPPER SECURED / PROPERLY SEALED: _____

OVERGLOVED / DOUBLE OF GLOVES / BOOTS: _____

DECON PROCEDURES: _____

DECON LINE READY: _____

OUTSIDE TEMPERATURE: _____

WORKING TIME: _____

FINAL RADIO CHECK: _____

TWO ESCAPE ROUTES: _____

SCENE SAFETY PLAN

PLAN PREPARATION:

DATE:_____ TIME:_____ PERSON: _____

REVIEW:

Incident Safety Officer _____

APPROVALS:

Incident Commander: _____

Operations Officer: _____

Science Officer: _____

Incident Number: _____ Incident Name: _____

HAZARDOUS SUBSTANCES: (Known or suspected, contaminated media, or in storage container, obvious leaks, spills or obvious breaches, physical damage.)

RESPONDING AGENCIES:

1._____
2._____
3._____
4._____
5._____
6._____
7._____
8._____
9._____
10._____
11._____
12._____
13._____
14._____

All contractor and government personnel who are exposed to hazardous levels of chemicals or who use respirators must be enrolled in a medical monitoring program.

GENERAL SAFETY RULES AND EQUIPMENT:

1. There will be no eating, drinking, or smoking in the exclusion zone (Hot Zone) or the Contamination Reduction Zone (Warm Zone).

2. All personnel exiting the Exclusion Zone (Hot Zone) must pass through the Contamination Reduction Corridor (Decon line), to the Contamination Reduction Zone (Warm Zone), before entering the Support Zone (Cold Zone).

3. At a minimum, any personnel working the Contamination Reduction Zone (Warm Zone) must be in one level of protection lower than that of the entry teams.

4. All decontamination equipment and systems must be in place before an entry can be made.

5. At the end of each entry, each entry team member will at least do a field wash or take a full body shower.

6. All breathing air shall be certified as Grade D or better.

7. Where practical, all tools shall be of the nonsparking type.

8. If flammable/combustible atmosphere, the fire department will be on scene to establish a safe area to set up fire suppression line and/or foam capabilities away from the contaminated area. This is a separate water source than the decontamination line water source.

9. Because incident evacuation may be necessary if an explosion, fire, or other release occurs, an individual shall be assigned to sound an alert and notify the incident command staff, all personnel, and public officials, if required. For example, the evacuation signal may be two long blasts on an air horn every 30 seconds until all personnel are known to be evacuated.

10. An adequately stocked first aid kit shall be on scene at all times. By law, emergency medical personnel must be on scene with transportation at all times.

11. The nearest emergency medical facility shall be notified of a working hazardous materials incident.

12. As soon as possible, the emergency medical facility shall receive information on the type of chemical and number of personnel or civilians that may be exposed.

GENERAL SAFETY BRIEFING:

Before any incident actions are taken, a briefing from the COMMAND STAFF will be accomplished with all officers present. Personnel will sign a log sheet, attesting to being present at the pre-incident briefing. Topics discussed should include 1) known and unknown hazards; 2) the goals and objectives of the operation; 3) level of protection for entry, backup, and decon teams; 4) number of entry team personnel; 5) how to establish work and control zones; 6) equipment needed for establishing zones and 7) equipment needed by entry teams to complete goals and objectives.

Then OPS and Safety brief entry and backup teams using the briefing form.

EMERGENCY ACTION CONDITIONS:

CODE GREEN: All conditions are normal and incident work may continue.

CODE RED: All or specific work activities must cease at once due to the following conditions:

SCENE SAFETY PLAN (page 4 of 12)

1. If indications of emissions from the incident are present, such as continuous CGI readings of 25% or greater, less than 19.5% oxygen or greater than 23% oxygen, or greater than 1 mR/hr of ionizing radiation, withdrawal must be considered.

2. Current or projected meteorological data indicate that a probable impact on working conditions could occur.

3. If background readings obtained during initial site survey worsen, reassessment of the findings should be confirmed by continuing to monitor perimeters. Actions to lower levels of contaminant or contingencies for further incident monitoring must take place.

4. If this condition exists, incident personnel will immediately notify all agencies that are affected and follow the area's contingency plan.

Officials making evacuation/public health decisions will address the need for a public health advisory to potentially affected areas because incident control methods will not reduce the source of contamination or the threat to the general public.

If needed, a temporary relocation plan should be considered until levels of contamination are reduced or contained to levels deemed safe by all Incident Command Staff. Confirmation of safe levels will be done by generally approved monitoring methods agreed to by Incident Command Staff.

LIST OF AUTHORIZED PERSONNEL (OUTSIDE AGENCIES):

COMPLY WITH SECTION _____ OF SOPs, HEALTH DEPARTMENT, EMERGENCY SERVICES, AND INDUSTRIAL RESPONSE TEAMS.

_____

_____

_____

SPECIALIZED TASK ASSIGNMENTS:

COMPLY WITH SECTION _____ OF SOPs, CERTIFIED HEAVY EQUIPMENT OPERATOR, CHEMICAL SPECIALIST, TANK CAR SPECIALIST, AND RAILCAR SPECIALIST.

_____

_____

_____

SCENE SAFETY PLAN (page 5 of 12)

LEVELS OF PROTECTION SELECTED:

Initial Site Survey:	(A)	(B)	(C)	(D)
Entry Team:	(A)	(B)	(C)	(D)
Backup Team:	(A)	(B)	(C)	(D)
Decon Team:	(A)	(B)	(C)	(D)

ATTACH PLOT PLAN TO END OF THIS PLAN!

In the event of potential fire or explosion:

COMPLY WITH SECTION OF SOPs. ENTRY TEAM MUST WEAR FLASH PROTECTION. MONITOR WITH CGI/O2 METER. IF METER READINGS ARE AT OR ABOVE ACTION LEVELS (25%), ENTRY TEAM MUST RETREAT. MUST HAVE A FIRE SUPPRESSION TEAM WITH HOSE LINE IN PLACE; MAY NEED FOAM CAPABILITIES. ESTABLISH A SECONDARY EXIT FOR EMERGENCY.

In the event of potential or actual ionizing radiation exposure:

COMPLY WITH SECTION OF SOPs. MONITOR WITH METER MEASURING IN mR/hr. IF METER READS AT OR ABOVE 1 mR/hr, RETREAT AND CALL A HEALTH PHYSICIST.

In the event of spread of contamination beyond the boundaries of the incident:

COMPLY WITH SECTION OF SOPs. MONITOR ALL WORK ZONES AT ALL TIME FOR THE POSSIBLE SPREAD OF CONTAMINANT. USE GOOD WORK PRACTICES TO HELP KEEP THE CONTAMINANT TO A CONTROLLED AREA. FOLLOW LOCAL, COUNTY, STATE, AND FEDERAL PLANS TO NOTIFY PROPER AGENCIES IF THE INCIDENT DOES SPREAD.

EMERGENCY SERVICES:

Emergency Medical Facility: LIST THE NEAREST FACILITY THAT CAN HANDLE CONTAMINATED VICTIM(S) AND A SECONDARY FACILITY FOR OVERFLOW, IF NECESSARY.

Ambulance Service: LIST EMS UNIT AVAILABLE. BY LAW, ONE UNIT WITH EMERGENCY MEDICAL PERSONNEL MUST BE ON SCENE FOR RESPONSE PERSONNEL. IF ANOTHER UNIT IS NEEDED FOR THE POSSIBILITY OF CIVILIAN EXPOSURES, ONE SHOULD BE CALLED. HAVE A SECONDARY AGENCY AVAILABLE TO NOTIFY IF NECESSARY.

Fire Department: LOCAL, PRIVATE, COUNTY, STATE, AND FEDERAL AGENCIES TO SUPPLY MANPOWER AND EQUIPMENT AS NECESSARY.

Police Department: LOCAL, PRIVATE, COUNTY, STATE, AND FEDERAL AGENCIES TO SUPPLY MANPOWER TO SECURE THE INCIDENT AND CONDUCT ANY EVACUATION, IF NECESSARY.

Poison Control Center: CAN BE SAME AS EMERGENCY MEDICAL FACILITY OR AN AGENCY TO PROVIDE TOXICOLOGICAL DATA. IF DIFFERENT FROM EMERGENCY MEDICAL FACILITY, IT MUST BE WRITTEN IN.

PERSONNEL POTENTIALLY EXPOSED TO HAZARDOUS MATERIALS:

NAME	POSITION	DATE & TIME

DECONTAMINATION PROCEDURES (Contaminated personnel, surfaces, materials, instruments, other equipment):

COMPLY WITH SECTION OF SOPs. LAYOUT NUMBER 1 IS MAXIMUM, LAYOUT NUMBER 2 IS MINIMUM. IF LAYOUT DIFFERS FROM THESE, THE REASON FOR THE CHANGE MUST BE EXPLAINED IN WRITING AND A DIAGRAM MUST BE PROVIDED.

DECONTAMINATION SOLUTIONS USED:_____

_____

_____

Decon was DRY _____ WET _____ Justification:_____

_____

_____

DISPOSAL PROCEDURES (Contaminated equipment, supplies, disposable, wastewater):

DECON TEAM MUST CONTAIN ALL CONTAMINATED ITEMS ON THE DIRTY SIDE OF THE DECON LINE AS CLOSE TO THE HOT ZONE AS POSSIBLE. DECON OFFICER MUST PROVIDE A LIST OF ALL CONTAMINATED ITEMS AND AMOUNT OF WASTE SOLUTION FOR DISPOSAL. ASK CLEANUP CONTRACTOR IF THEY WANT THE DECON LINE LEFT SET UP OR BROKEN DOWN. RESPONSIBLE PARTY (RP) IS RESPONSIBLE FOR CALLING A CLEANUP CONTRACTOR. IF NO RP, IC CAN, BUT YOU MAY HAVE TO PAY IN ADVANCE. OPERATIONS OFFICER MUST PROVIDE A LIST OF ALL HAZARDOUS SUBSTANCE(S) THE CLEANUP CONTRACTOR NEEDS TO REMOVE.

EMERGENCY PROCEDURES (In the event of personnel exposure):

COMPLY WITH SECTION _____ OF SOPs. ALL EXPOSED PERSONNEL MUST GO THROUGH DECON, MINIMUM WASH WITH SOAP AND WATER AND RINSE, REMOVE ALL CLOTHING IF NECESSARY AND REDRESS. MEDICAL MONITORING MUST BE COMPLETED AND PERSONNEL MUST BE SENT TO MEDICAL FACILITY FOR EVALUATION.

EMERGENCY PROCEDURES (In the event of personnel injury):

COMPLY WITH SECTION _____ OF SOPs. IF OPEN WOUND, COVER INJURED AREA WITH A STERILE DRESSING. IF CHEMICALS ARE IN WOUND, BLOT UP CHEMICAL AND COVER WITH A STERILE DRESSING. WRAP WITH PLASTIC MATERIAL TO KEEP OUT WATER. PERSONNEL MUST GO THROUGH DECON, BE STRIPPED OF ALL CLOTHING (THROW AWAY), REDRESS OR PACKAGE PLACED ON A GURNEY, SEND TO A EMERGENCY MEDICAL FACILITY FOR TREATMENT. MAKE SURE TO SEND INFORMATION ABOUT CHEMICAL(S), IF KNOWN. IF NOT KNOWN, SEND INFORMATION AS SOON AS POSSIBLE SO PERSONNEL CAN GET PROPER TREATMENT.

SCENE SAFETY PLAN (page 9 of 12)

HAZARD ASSESSMENT:

Attach hazardous materials substance data sheet for chemicals involved.

MONITORING PROCEDURES:

Monitoring the incident for identity and concentration of contaminants in all media. List the instruments to be used and the areas to be monitored.

HOT ZONE _____

_____

_____

WARM ZONE (CRZ) _____

_____

_____

COLD ZONE (SUPPORT ZONE) _____

_____

_____

MEDICAL MONITORING (What procedures are to be used to monitor personnel for evidence of personal exposure):

COMPLY WITH SECTION OF THE SOPs. ALL PERSONNEL THAT ARE REQUIRED TO DON A LEVEL OF PROTECTION OF LEVEL "C" OR HIGHER AND WORK IN THE WARM OR HOT ZONES MUST HAVE AN ON-SCENE MEDICAL MONITORING COMPLETED BEFORE DONNING AND AFTER DOFFING PPE. PERSONNEL HEALTH AND WELFARE MUST BE MONITORED AT ALL TIMES THROUGHOUT THE INCIDENT TO ENSURE PERSONNEL ARE NOT EXPOSED TO ANY HAZARDOUS SUBSTANCE(S).

RESPONSE SAFETY CHECK-OFF SHEET

AFTER RESPONSE:

Response: Dates: _____ Time: _____

Incident City: _____ State: _____

TYPE OF RESPONSE:

Highway: LOCAL, COUNTY, STATE

Railway: TRACKS OR OFF SETTINGS

Residential: LOCAL, COUNTY, STATE

Industrial: EMERGENCY RESPONSE TEAM

Marine: WATERWAYS OR STREAMS GOING IN TO

Other: AIRCRAFT, OWN RESPONSE TEAM

Specify: COMPLY WITH SECTION OF SOPs. IF DIFFERENT AGENCIES ARE RESPONSIBLE FOR SEPARATE LOCATION(S), THEIR EMERGENCY RESPONSE PLAN MUST BE FOLLOWED. IF THE INDUSTRY HAS THEIR OWN HAZ MAT TEAM, THEY MUST BE LISTED IN YOUR PLAN. IF A RAIL SYSTEM HAS A HAZ MAT PROCEDURE, IT MUST BE FOLLOWED. IF ANY HAZARDOUS SUBSTANCE ENTERS A WATERWAY OR THREATENS A WATERWAY, THE U.S. COAST GUARD MUST BE NOTIFIED.

TYPE OF SAFETY PLAN:

Federal_____ State_____

Local_____ Other_____

Specify: _____

_____

_____

_____

_____

_____

_____

SCENE SAFETY PLAN (page 11 of 12)

SUSPECTED CHEMICALS INVOLVED:

1._____ 6._____
2._____ 7._____
3._____ 8._____
4._____ 9._____
5._____ 10._____

INITIAL LEVEL OF PROTECTION: (Level D must be justified)

(A) (B) (C) (D)

_____

INITIAL MEDICAL SCREENING COMPLETED: Yes _____ No _____

If No, justify: _____

POST RESPONSE:

Levels of protection used: (A) (B) (C) (D)

Justify:_____

SCENE SAFETY PLAN (page 12 of 12)

EQUIPMENT DECONTAMINATION:

		(A) Protective Clothing	(B) Respiratory Protection	(C) Monitoring Equipment
Disposed:	_____	_____	_____	_____
Cleaned:	_____	_____	_____	_____
No Action:	_____	_____	_____	_____

ANY OTHER EQUIPMENT: _____

TOTAL APPROXIMATE TIME IN:

HOT ZONE: _____ DAYS _____ HOURS
WARM ZONE: _____ DAYS _____ HOURS

DATE PREPARED: _____ Reviewer: _____

Assistance in preparing the Scene Safety Plan can be obtained from the instructors.

ATMOSPHERIC HAZARD GUIDELINE

Monitoring Equipment	Hazard	Ambient Level	Action
Combustible gas indicator	Explosive atmosphere	10% LEL 10%–25% 25% LEL	Continue investigation Continue on-site monitoring with extreme caution as higher levels are encountered. Explosion hazard: withdraw from area immediately.
Oxygen concentration	Oxygen	<19.5% 19.5%–25% 25.0%	Monitor wearing SCBA. *Note:* Combustible gas reading are not valid in atmospheres with 19.5% oxygen. Continue investigation with caution. SCBA not needed based on oxygen content only. Discontinue inspection; fire hazard potential. Consult specialist.
Radiation survey	Radiation	<1 mR/hr > 1 mR/hr	Continue investigation. If radiation is detected above background levels, this signifies the presence of possible radiation sources; at this level, more thorough monitoring is advisable. Consult with a health physicist. Potential radiation hazard; evacuate site. Continue monitoring only upon the advice of a health physicist.

AIR MONITORING INSTRUMENTATION

Daily Report Log

DATE	OPERATOR
INCIDENT	INCIDENT NUMBER
LOCATION	TEMP
HUMIDITY	WIND CONDITIONS

GENERAL WEATHER CONDITIONS
SITE CONDITIONS

INSTRUMENT:	MSA/ISC CGI	MSA/ISC OXY	LUDLUM RAD
MODEL NUMBER:	260 / LTX 310	245 / LTX 310	19
TIME			
BACKGROUND			
TIME			
READING # 1			
TIME			
READING # 2			
TIME			
READING # 3			
TIME			
READING # 4			
TIME			
READING # 5			

COMMENTS:

OPERATOR SIGNATURE_____ DATE_____

HAZMAT INCIDENT MEDICAL EVALUATION CHART

INCIDENT_____ DATE_____ TIME_____ ENVIRONMENT:

INCIDENT COMMANDER _____
OPERATION OFFICER _____
SAFETY OFFICER _____

SKY:_____
TEMP:_____
WIND:_____
PRECP:_____

POSITION/NAMES	INITIAL BASELINE						COMPLETED BASELINE				
ENTRY TEAM	AGE	TIME	B/P	PULSE	RESP	TEMP	TIME	B/P	PULSE	RESP	TEMP
BACK-UP TEAM											
DECON TEAM											

ADDITIONAL NOTES:_____

PERSONNEL PROTECTION AND EXPOSURE CHART

NAME	POSITION	LEVEL OF PROTECTION	ZONE	TIME IN	TIME OUT

CHAIN-OF-COMMAND:

INCIDENT COMMANDER: _____

SAFETY OFFICER: _____

OPERATIONS OFFICER: _____

DECON OFFICER: _____

Science Officer

HAZARDOUS SUBSTANCE DATA SHEET

NAME OF SUBSTANCE:_____
COMMON:_____ CHEMICAL:_____ SOURCE:_____

1. PHYSICAL/CHEMICAL PROPERTIES:

NORMAL PHYSICAL STATE: __GAS __LIQUID __SOLID _____

MOLECULAR WEIGHT	_____		_____
DENSITY	_____	gm/ml	_____
SPECIFIC GRAVITY	___@___	°F/°C	_____
SOLUBILITY:WATER (ppm)	___@___	°F/°C	_____
SOLUBILITY: _____	___@___	°F/°C	_____
BOILING POINT	_____	°F/°C	_____
MELTING POINT	_____	°F/°C	_____
VAPOR PRESSURE (mmHg)	___@___	°F/°C	_____
VAPOR DENSITY	___@___	°F/°C	_____
FLASHPOINT OC/CC	_____	°F/°C	_____

2. HAZARDOUS CHARACTERISTICS

A. TOXICOLOGICAL HAZARD

	HAZARD	CONCENTRATION	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	_____	_____

HAZARDOUS SUBSTANCE DATA SHEET (cont.)

B. FIRE HAZARD

COMBUSTIBILITY	YES NO	_____	_____
TOXIC BY-PRODUCTS	YES NO	_____	_____
OTHER:_____	YES NO	_____	_____
FLAMMABLE/ EXPLOSIVE	YES NO	_____	_____
LFL/LEL	YES NO	_____	_____
UFL/UEL	YES NO	_____	_____

C. REACTIVITY

	HAZARD	CONCENTRATION	SOURCE
WATER	YES NO	_____	_____
OTHER:_____	YES NO	_____	_____

D. CORROSIVE HAZARD

	HAZARD	pH	SOURCE
ACID	YES NO	_____	_____
BASE	YES NO	_____	_____
NEUTRALIZING AGENT:_____			_____

E. RADIOACTIVE HAZARD

	HAZARD	UNIT DOSE RATE	SOURCE
BACKGROUND	YES NO	_____	_____
ALPHA PARTICLES	YES NO	_____	_____
BETA PARTICLES	YES NO	_____	_____
GAMMA RADIATION	YES NO	_____	_____

3. INCIDENT RELATED:

QUANTITY INVOLVED: _____

RELEASE INFORMATION: _____

_____

_____

MONITORING/SAMPLING RECOMMENDED: _____

_____

HAZARDOUS SUBSTANCE DATA SHEET (cont.)

4. RECOMMENDED PROTECTION:
PUBLIC:

ENVIRONMENT:

WORKER:

RECOMMENDED SCENE CONTROL:

EXCLUSION ZONE:

CONTAMINATION REDUCTION ZONE:

SUPPORT ZONE:

HAZARDOUS SUBSTANCE DATA SHEET (cont.)

6. DECONTAMINATION SOLUTIONS RECOMMENDATIONS: _____

_____
_____
_____
_____
_____
_____
_____
_____
_____

HAZARDOUS MATERIAL RESPONSE FORM

LOCATION: _____ WIND SPEED_____
DIRECTION: _____ TEMPERATURE _____ HUMIDITY_____

IDENTIFIED MATERIAL	DOT ID NUMBER	GUIDE NUMBER	MISCELLANEOUS

MATERIAL KNOWN - CONTACT CHEMTREC:
1-800-424-9300

LEVEL OF PROTECTION REQUIRED:

1. FULLY ENCAPSULATED SUIT_____
2. SCBA/FIRE GEAR_____
3. FIRE GEAR ONLY_____

EVACUATION DISTANCE Spill or leak from small container or tank: isolate in all directions		INITIAL EVACUATION Large spill from a container or tank:
WIND DIRECTION:____ FEET:_____	First, isolate in all directions FEET:_____	Then, evacuate in a downwind direction width:_____mi. length:_____mi.

TRANSPORTATION COMPANY:_____
ADDRESS:_____

LICENSE NO:_____TRAILER OR CAR NO:_____
TELEPHONE NUMBER:_____

SHIPPER: _____
ADDRESS: _____
RECEIVER NAME: _____
ADDRESS: _____
TELEPHONE NUMBER: _____
SIZE OF CONTAINER: _____ TYPE OF CONTAINER: _____
QUANTITY RELEASED:_____

MATERIALS UNKNOWN - CONTACT CHEMTREC WITH ABOVE INFORMATION

HAZARDOUS MATERIALS RESPONSE FORM (cont.)

FLASH POINT: _____ BOILING POINT: _____
ODOR THRESHOLD: _____ FLAMMABLE RANGE: _____
WATER SOLUBILITY: _____ TLV: _____
VAPOR DENSITY: _____ WATER REACTIVE: _____
IDLH: _____ SPECIFIC GRAVITY: _____
NATURAL STATE: _____ COLOR: _____

FIXED FACILITY
PREPLAN _____ DRAINAGE _____ UTILITIES SHUT OFF _____

PLANT MANAGER: _____

CONTROL MEASURES:

NEUTRALIZE: _____ ABSORB: _____
DIKE: _____ EXTINGUISH: _____

RESOURCES NEEDED TO CONTROL THE INCIDENT [On-scene or called for; physical (acid suits, heavy equipment, lime, etc.)]:

_____
_____
_____
_____

OTHER AGENCIES REQUESTED AND ASSIGNED TASK (Police, medical, DNR, etc.):

_____
_____
_____
_____

STAGING AREA:

_____
_____
_____
_____

COMMENTS:

_____
_____
_____
_____

Resource Officer

HAZARDOUS MATERIALS INCIDENT COST RECOVERY FORM

HAZ-MAT UNIT RESPONDED_____ DATE_____

TYPE OF INCIDENT_____ TIME_____

LOCATION_____ INCIDENT #_____

DESCRIPTION	QUANTITY OF MATERIALS USED	DECON	
		YES	NO

PAGE ___ OF ___

HAZARDOUS MATERIALS INCIDENT COST RECOVERY FORM

HAZ-MAT UNIT RESPONDED_____ DATE_____

TYPE OF INCIDENT_____ TIME_____

LOCATION_____ INCIDENT #_____

DESCRIPTION	QUANTITY OF MATERIALS USED	DECON	
		YES	NO

PAGE ___ OF ___

HAZARDOUS MATERIALS INCIDENT COST RECOVERY FORM (cont.)

INVOLVED PARTIES

NAME OF BUSINESS OR CARRIER: _____

ADDRESS: _____

_____

CONTACT NAME: _____

PHONE # _____

VEHICLE ID # _____

DRIVER/RESPONSIBLE _____

NAME OF SUPPLIER: _____

ADDRESS: _____

_____

CONTACT NAME: _____

PHONE # _____

VEHICLE ID # _____

DRIVER/RESPONSIBLE _____

ADDITIONAL INFORMATION:

_____

_____

_____

_____

_____

_____

_____

****

THIS FORM IS TO BE COMPLETED AS SOON AS POSSIBLE AFTER THE INCIDENT HAS OCCURRED IN ORDER TO REPLACE USED MATERIALS. THIS FORM IS TO BE COMPLETED AND KEPT IN THE ORDER BOOK TO SHOW WHAT WAS USED DURING THE INCIDENT. THIS IS A WORKING FORM; IT DOES NOT REPLACE THE EQUIPMENT REQUEST FORM.

****

OPERATIONS OFFICER
AT THE INCIDENT: _____
NAME (print) SIGNATURE

INCIDENT COMMANDER: _____
NAME (print) SIGNATURE

RESOURCE LIST FOR TRANSPORTATION EXERCISE

DATE:_____ INCIDENT NAME: _____

RESOURCE	EQUIPMENT USED AND SECTOR ALLOCATED TO	EQUIPMENT IN RESERVE AND LOCATION
20 FES SUITS		
10 WHITE BOARDS		
2 MEGAPHONES		
1 TACTICAL BOARD		
1 BOX REFERENCE BOOKS		
1 ROLL pH PAPER		
10 FLASHLIGHTS		
10 RADIOS W/ 4 FREQ.		
1 PAIR BINOCULARS		
18 SCBA + CYLINDERS		
SIX 2-GALLON SPRAYERS		
6 SPONGES		
6 DECON BRUSHES		
4 STEP STOOLS		
20 TRAFFIC CONES		
6 DECON POOLS		
TWO 20 X 40 TARPS		
1 LUDLUM MODEL 19		
1 DRAEGER PUMP = TUBES BY CHEMICAL ONLY		
1 ISC 310 / SP 402		
1 MSA 260 DRI		
14 COMMAND VESTS		

RESOURCE LIST FOR WAREHOUSE EXERCISE

DATE:_____ INCIDENT NAME: _____

RESOURCE	EQUIPMENT USED AND SECTOR ALLOCATED TO	EQUIPMENT IN RESERVE AND LOCATION
10 FES SUITS		
5 WHITE BOARDS		
1 MEGAPHONES		
1 TACTICAL BOARD		
1 BOX REFERENCE BOOKS		
1 ROLL pH PAPER		
5 FLASHLIGHTS		
5 RADIOS W/ 2 FREQ. RED 1 & 2 = BLUE 3 & 4		
1 PAIR BINOCULARS		
9 SCBA + CYLINDERS		
THREE 2-GALLON SPRAYERS		
3 SPONGES		
3 DECON BRUSHES		
3 STEP STOOLS		
10 TRAFFIC CONES		
3 DECON POOLS		
ONE 20 X 40 TARP		
1 LUDLUM MODEL 19		
1 DRAEGER PUMP = TUBES BY CHEMICAL ONLY		
1 ISC 310 / SP 402		
1 MSA 260 DRI		
7 COMMAND VESTS		

LOCAL RESOURCES

MEDICAL SUPPORT

___ Mass Casualty Units: _____
___ Hospital Medical Teams: _____
___ Disaster Services: _____
___ Aircraft - Helicopter, Fixed Wing: _____
___ Civil Defense: _____
___ Coroner: _____
___ Other: _____

EVACUATION SUPPORT

___ Transportation: _____
___ Shelters: _____

UTILITY COMPANIES

___ Building Department: _____
___ Electric: _____
___ Gas: _____
___ Water/Sewer: _____
___ Telephone: _____
___ Cable TV: _____
___ Other: _____

PERSONNEL SUPPORT

___ Rehab Units: _____
___ Food and Drink: _____
___ Toilets: _____
___ Red Cross: _____
___ Salvation Army: _____
___ Other Canteen Units: _____
___ Other: _____

APPARATUS SUPPORT

___ Fuel (diesel, gasoline): _____
___ Mechanic: _____
___ Towing: _____
___ Other: _____

LOCAL RESOURCES (cont.)

FIRE SUPPORT

___ Mobile Command Posts: _____
___ Communications Units: _____
___ SCBA/Air Units: _____
___ Portable Light Units: _____
___ Portable Generators: _____
___ Foam Supplies: _____
___ Tankers/Portable Tanks: _____
___ Aerial Trucks: _____
___ Photo Units: _____
___ Other: _____

RESCUE SUPPORT

___ Urban Heavy Rescue Units: _____
___ Shoring/Rigging: _____
___ Heavy Equipment (i.e., Cranes, Bulldozers, etc.): _____

_____

___ Trench/Below-Grade Rescue Units: _____
___ Confined Space Rescue Units: _____
___ Tactical Rope/High Angle Rescue Units: _____
___ Water Rescue Units/Boats: _____
___ SCUBA and Rescue Teams: _____
___ Search and Rescue Units: _____
___ Canine Search Teams: _____
___ Helicopters: _____
___ Other: _____

HAZARDOUS MATERIALS SUPPORT

___ Hazardous Materials Units: _____
___ Decontamination Units: _____
___ CHEMTREC: 1-800-424-9300
___ National Response Center: 1-800-424-8802
___ Pesticide Information: 1-800-858-7378
___ Local Agencies: _____
___ County Management: _____
___ State Management: _____
___ Federal Government: EPA OSC: _____ USCG OSC: _____
___ Other: _____

Decon Team

DECONTAMINATION CHECKLIST

1. ____ Obtain briefing from Operation Officer, Safety Officer, and Decon Team Leader.
2. ____ Select Decon Team members.
3. ____ Obtain decontamination information for Safety Officer or Operation Officer.
4. ____ Establish Contamination Reduction Corridor in accordance with procedures.
5. ____ Verify appropriate decon solution with Decon Team Leader and Command Staff.
6. ____ Brief Decon Team on type of decon procedures.
7. ____ Ensure baseline vitals are taken.
8. ____ Select and don appropriate protective clothing.
9. ____ Confer with Operations Officer and identify any normal or special needs.
10. ____ Verify that all zones are marked and logistical support needs are in place.
11. ____ Ensure adequate air supply is in reserve.
12. ____ Contact Operations Officer when Contamination Reduction Corridor is operational.
13. ____ Ensure that all contaminated equipment and supplies are decontaminated or package them for disposal. Make sure Resource Officer gets list of items.
14. ____ Decon Team "MUST DECON THEMSELVES" before leaving Contamination Reduction Corridor.
15. ____ Ensure all equipment not able to be decontaminated is bagged and marked for disposal or for offsite decontamination.
16. ____ Assemble an inventory of equipment and clothing used.
17. ____ Debrief Decon Team members.
18. ____ Debrief Operations Officer.
19. ____ Complete all documentation.

Entry and Back-up Team

ENTRY AND BACK-UP TEAM CHECKLIST

1. ____ Obtain briefing from OperationS Officer and Safety Officer.
2. ____ Establish radio frequency.
3. ____ Assemble and check all clothing and equipment needed.
4. ____ Attend incident strategy briefing.
5. ____ Determine plan of action with Staff Officers.
6. ____ Implement strategy/tactics plan.
7. ____ Access situation and identify existing/impending hazard(s).
8. ____ Have baseline vitals taken by medical personnel and record them.
9. ____ Take off all personal accessories (e.g., badges, belt buckles, watches, rings, or anything else that might damage the suit).
10. ____ Don proper level of protection to the ready position.
11. ____ Receive final briefing from OPS and Safety Officers, verifying:
    - ____ Emergency access corridor
    - ____ Equipment decon corridor (if established)
    - ____ Decon procedures
    - ____ Check radio communication
    - ____ Establish work durations
    - ____ Establish work time with no contact
12. ____ Enter Hot Zone/achieve tactical objective(s):
    - ____ Data collection
    - ____ Reevaluate as situation dictates
    - ____ Mitigation
13. ____ Keep OPS informed of any special conditions or activities.
14. ____ Exit Hot Zone via Decon Corridor.
15. ____ At Decon, remember to do the following:
    - ____ Drop off tools and equipment
    - ____ Do gross decon yourself or with your partner
    - ____ Decon worker will decon you through the stations
    - ____ Check with OPS to see if you are to change tank or come out
    - ____ If coming out, after final rinse pull out arm from sleeves on suit and show decon your hands
    - ____ Remember, do not touch the outside of the suit; assist decon worker by pushing from the inside
    - ____ You can disconnect your radio and waist strap while still inside the suit
16. ____ Do at least a field wash if a shower is not possible.
17. ____ Put on a fresh set of clothing.
18. ____ Replenish body fluids as necessary.
19. ____ Have vitals taken.
20. ____ Have a debriefing with OPS and Safety.

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