NEW JERSEY HAZMAT EMERGENCY RESPONSE COURSE

LEVEL 3 HAZARDOUS MATERIALS **COURSE NUMBER: 06011**

TECHNICIAN

PRESENTED THROUGH:

NEW JERSEY STATE POLICE

Homeland Security Branch Special Operations Section
Technical Response Bureau Hazardous Materials Response Unit

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LEVEL 3 HAZARDOUS MATERIALS COURSE NUMBER: 06011

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NEW JERSEY STATE POLICE-HOMELAND SECURITY BRANCH
SPECIAL OPERATIONS SECTION, TECHNCIAL RESPONSE BUREAU
HAZARDOUS MATERIALS RESPONSE UNIT (HMRU)

0303

LEVEL 3
HAZARDOUS MATERIALS TECHNICIAN

PREFACE

The modules in this course are part of a series of New Jersey Hazardous Materials Emergency Response Courses. The prerequisites for the Hazardous Materials Technician Course are the New Jersey Level 1 First Responder Awareness and New Jersey Level 2 First Responder Operations Courses.

ACKNOWLEDGMENTS

This Hazardous Materials Technician Course is the result of the efforts and cooperation of a diverse group of people. The New Jersey State Police Hazardous Materials Response Unit (HMRU) wish to thank those individuals for their time and roles in the development of this course.

NEW JERSEY STATE POLICE OFFICE OF EMERGENCY MANAGEMENT HAZARDOUS MATERIALS TECHNICIAL PROGRAM REGULATIONS & INFORMATION

- PLEASE PARK IN THE DESIGNATED AREAS ONLY.
- SAFETY PROCEDURES MUST BE FOLLOWED AT ALL TIMES. This includes the operation of motor vehicles on the property. Any malicious damage or unacceptable behavior will result in dismissal from the program.
- BE PROMPT. Classes begin at 8 AM and end at 5 PM. You must sign in and be prepared to start on time.
- NO SMOKING IS PERMITTED IN CLASS. Deposit refuse in the proper containers. Smoking, including outside, is permitted only in designated areas.
- THE CLASSROOM MUST BE KEPT CLEAN. We have been given permission to use the classroom and we are expected to keep it neat and clean. Leave the classroom as you found it.
- STUDENTS WILL BE EXPECTED TO ASSIST WITH EQUIPMENT. Set up, clean up and proper storage of equipment and training aids will be completed before class dismissal.
- YOU HAVE MADE A MAJOR COMMITMENT TO THIS PROGRAM, WHICH INCLUDES:
  - Attendance at every session. If you cannot attend a session due to illness or an unavoidable situation, please notify the DP/HMERP Unit (732) 721-4040.
  - Required reading and notetaking.
  - Full participation in all hands-on evolutions.
  - Using your own SCBA and equipment. It is your responsibility to provide these items when required. The facility will not supply equipment to forgetful students.
  - Quizzes will be given periodically. They will assist the instructors in evaluating your progress in the course and your comprehension of the subject matter. Passing score on quizzes is 70%. You must pass every quiz. One make-up will be permitted.
  - Participation in practical exercises. You will be graded on your performances (pass/fail) which will be included with the written test score resulting in your final grade for certification.
  - Pass the mid-term and final written examination with a minimum grade of 70. Should you fail the final examination, you will be given one opportunity to review the material and retake the test.
- REPORT ANY ILLNESS OR INJURY TO YOUR INSTRUCTOR IMMEDIATELY. This will ensure proper treatment, reporting and insurance coverage. The New Jersey State Police Office of Emergency Management **does not** provide insurance coverage.
- TURN OFF ALL RADIOS AND PAGERS DURING CLASS. These items cause unnecessary interruptions in the class. Messages may be left by telephone. Your messages will be delivered at the earliest convenience. Emergency messages will be forwarded immediately.

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GEOGRAPHIC IDENTIFICATION CODE SCHEME

Incorporated Areas of New Jersey

Arranged Alphabetically by County and Municipality

All codes listed in this Manual will be four (4) digit codes

The first two (2) digits being the County Code, the second (2) being the Municipality Code

EXAMPLES:

Counties:
01—Atlantic County
02—Bergen County
03—Burlington County

State =0000
Federal = 9999

Municipalities:
01—Absecon City
02—Atlantic City City
03—Brigantine City

Complete Code

0101—Atlantic County, Absecon City
0201—Bergen County, Allendale Borough
0301—Burlington County, Bass River Township

ATLANTIC COUNTY—01

0101	Absecon City
0102	Atlantic City
0103	Brigantine City
0104	Buena Borough
0105	Buena Vista Twsp.
0106	Corbin City
0107	Egg Harbor City
0108	Egg Harbor Twsp.
0109	Estell Manor City
0110	Folsom Borough
0111	Galloway Twsp.
0112	Hamilton Twsp.
0113	Hammonton Town
0114	Linwood City
0115	Longport Borough
0116	Margate City
0117	Mullica Twsp.
0118	Morthfield City
0119	Pleasantville City
0120	Port Republic City
0121	Somers Point City
0122	Ventnor City
0123	Weymouth Twsp.

BERGEN COUNTY—02

0201	Allendale Borough
0202	Alpine Borough
0203	Bergenfield Borough
0204	Bogota Borough
0205	Carlstadt Borough
0206	Cliffside Park Borough
0207	Closter Borough
0208	Cresskill Borough
0209	Demarest Borough
0210	Dumont Borough
0211	Elmwood Park Borough
0212	East Rutherford Borough
0213	Edgewater Borough
0214	Emerson Borough
0215	Englewood City
0216	Englewood Cliffs Borough
0217	Fair Lawn Borough
0218	Fairview Borough
0219	Fort Lee Borough
0220	Franklin Lakes Borough
0221	Garfield City
0222	Glen Rock Borough
0223	Hackensack City
0224	Harrington Park Borough
0225	Hasbrouck Heights Borough
0226	Haworth Borough
0227	Hillsdale Borough
0228	Hohokus Borough
0229	Leonia Borough
0230	Little Ferry Borough
0231	Lodi Borough
0232	Lyndhurst Twsp.
0233	Mahwah Twsp.
0234	Maywood Borough
0235	Midland Park Borough
0236	Montvale Borough
0237	Moonachie Borough
0238	New Milford Borough
0239	North Arlington Borough
0240	Northvale Borough
0241	Norwood Borough
0242	Oakland Borough
0243	Old Tappan Borough
0244	Oradell Borough
0245	Palisades Park Borough
0246	Paramus Borough
0247	Park Ridge Borough
0248	Ramsey Borough
0249	Ridgefield Borough
0250	Ridgefield Park Village
0251	Ridgewood Village
0252	River Edge Borough
0253	River Vale Twsp.
0254	Rochelle Park Twsp.
0255	Rockleigh Borough
0256	Rutherford Borough
0257	Saddle Brook Twsp.
0258	Saddle River Borough
0259	South Hackensack Twsp.
0260	Teaneck Twsp.
0261	Tenafly Borough
0262	Teterboro Borough
0263	Upper Saddle River Borough
0264	Waldwick Borough
0265	Wallington Borough
0266	Washington Twsp.
0267	Westwood Borough
0268	Woodcliff Lake Borough
0269	Wood-Ridge Borough
0270	Wyckoff Twsp.

BURLINGTON COUNTY—03

0301	Bass River Twsp.
0302	Beverly City
0303	Bordentown City
0304	Bordentown Twsp.

0305	Burlington City
0306	Burlington Twsp.
0307	Chesterfield Twsp.
0308	Cinnaminson Twsp.
0309	Delanco Twsp.
0310	Delran Twsp.
0311	Eastampton Twsp.
0312	Edgewater Park Twsp
0313	Evesham Twsp.
0314	Fieldsboro Borough
0315	Florence Twsp.
0316	Hainesport Twsp.
0318	Lumberton Twsp.
0319	Mansfield Twsp.
0320	Maple Shade Twsp
0321	Medford Twsp.
0322	Medford Lakes Borough
0323	Moorestown Twsp.
0324	Mount Holly Twsp.
0325	Mount Laurel Twsp.
0326	New Hanover Twsp
0327	North Hanover Twsp.
0328	Palmyra Borough
0329	Pemberton Borough
0330	Pemberton Twsp.
0331	Riverside Twsp.
0332	Riverton Borough
0333	Shamong Twsp.
0334	Southampton Twsp
0335	Springfield Twsp.
0336	Tabernacle Twsp.
0337	Washington Twsp.
0338	Westampton Twsp.
0317	Willingboro Twsp
0339	Woodland Twsp.
0340	Wrightstown Borough

CAMDEN COUNTY—04

0401	Audubon Borough
0402	Audubon Park Borough
0403	Barrington Borough
0404	Bellmawr Borough
0405	Berlin Borough
0406	Berlin Twsp.
0407	Brooklawn Borough
0408	Camden City
0412	Cherry Hill Twsp.
0409	Chesilhurst Borough
0410	Clementon Borough
0411	Collingswood Borough
0413	Gibbsboro Borough
0414	Gloucester City
0415	Gloucester Twsp.
0416	Haddon Twsp.
0417	Haddonfield Borough
0418	Haddon Heights Borough
0419	Hi-Nella Borough
0420	Laurel Springs Borough
0421	Lawnside Borough
0422	Lindenwold Borough
0423	Magnolia Borough
0424	Merchantville Borough
0425	Mount Ephraim Borough
0426	Oaklyn Borough
0427	Pennsauken Twsp.
0428	Pine Hill Borough
0429	Pine Valley Borough
0430	Runnemede Borough
0431	Somerdale Borough
0432	Stratford Borough
0433	Tavistock Borough
0434	Voorhees Twsp.
0435	Waterford Twsp.
0436	Winslow Twsp.
0437	Wood-Lynne Borough

CAPE MAY COUNTY—05

0501	Avalon Borough
0502	Cape May City
0503	Cape May Point Borough
0504	Dennis Twsp.
0505	Lower Twsp.
0506	Middle Twsp.
0507	North Wildwood City
0508	Ocean City
0509	Sea Isle City
0510	Stone Harbor Borough
0511	Upper Twsp.
0512	West Cape May Borough
0513	West Wildwood Borough
0514	Wildwood City
0515	Wildwood Crest Borough
0516	Woodbine Borough

CUMBERLAND COUNTY—06

0601	Bridgeton City
0602	Commercial Twsp.
0603	Deerfield Twsp.
0604	Downe Twsp.
0605	Fairfield Twsp.
0606	Greenwich Twsp.
0607	Hopewell Twsp.
0608	Lawrence Twsp.
0609	Maurice River Twsp
0610	Millville City
0611	Shiloh Borough
0612	Stow Creek Twsp.
0613	Upper Deerfield Twsp.
0614	Vineland City

ESSEX COUNTY—07

0701	Belleville Town
0702	Bloomfield Town
0703	Caldwell Borough
0705	Cedar Grove Twsp.
0706	East Orange City
0707	Essex Fells Borough
0704	Fairfield Borough
0708	Glen Ridge Borough
0709	Irvington Town
0710	Livingston Twsp.
0711	Maplewood Twsp.
0712	Millburn Twsp
0713	Montclair Town
0714	Newark City
0715	North Caldwell Borough
0716	Nutley Town
0717	Orange City
0718	Roseland Borough
0719	South Orange Village
0720	Verona Borough
0721	West Caldwell Borough
0722	West Orange Town

GLOUCESTER COUNTY—08

0801	Clayton Borough
0802	Deptford Twsp.
0803	East Greenwich Twsp.
0804	Elk Twsp.
0805	Franklin Twsp.
0806	Glassboro Borough
0807	Greenwich Twsp.
0808	Harrison Twsp
0809	Logan Twsp
0810	Mantua Twsp.
0811	Monroe Twsp.
0812	National Park Borough
0813	Newfield Borough
0814	Paulsboro Borough
0815	Pitman Borough
0816	South Harrison Twsp.
0817	Swedesboro Borough
0818	Washington Twsp.
0819	Wenonah Borough
0820	West Deptford Twsp.
0821	Westville Borough
0822	Woodbury City
0823	Woodbury Heights Borough
0824	Woolwich Twsp.

HUDSON COUNTY—09

0901	Bayonne City
0902	East Newark Borough
0903	Guttenberg Town
0904	Harrison Town
0905	Hoboken City
0906	Jersey City City
0907	Kearny Town
0908	North Bergen Twsp.
0909	Secaucus Town
0910	Union City
0911	Weehawken Twsp.
0912	West New York Town

HUNTERDON COUNTY—10

1001	Alexandria Twsp.
1002	Bethlehem Twsp.
1003	Bloomsbury Borough
1004	Califon Borough
1005	Clinton Town
1006	Clinton Twsp.
1007	Delaware Twsp.
1008	East Amwell Twsp.
1009	Flemington Borough
1010	Franklin Twsp.
1011	Frenchtown Borough
1012	Glen Gardner Borough
1013	Hampton Borough
1014	High Bridge Borough
1015	Holland Twsp.
1016	Kingwood Twsp.
1017	Lambertville City
1018	Lebanon Borough
1019	Lebanon Twsp.
1020	Milford Borough
1021	Raritan Twsp.
1022	Readington Twsp.
1023	Stockton Borough
1024	Tewksbury Twsp.
1025	Union Twsp.
1026	West Amwell Twsp.

MERCER COUNTY—11

1101	East Windsor Twsp.
1102	Ewing Twsp.
1103	Hamilton Twsp.
1104	Hightstown Borough
1105	Hopewell Borough
1106	Hopewell Twsp.

1107	Lawrence Twsp.
1108	Pennington Borough
1109	Princeton Borough
1110	Princeton Twsp.
1111	Trenton City
1112	Washington Twsp.
1113	West Windsor Twsp.

MIDDLESEX COUNTY—12

1201	Carteret Borough
1202	Cranbury Twsp.
1203	Dunellen Borough
1204	East Brunswick Twsp.
1205	Edison Twsp.
1206	Helmetta Borough
1207	Highland Park Borough
1208	Jamesburg Borough
1210	Metuchen Borough
1211	Middlesex Borough
1212	Milltown Borough
1213	Monroe Twsp.
1214	New Brunswick City
1215	North Brunswick Twsp.
1209	Old Bridge Twsp.
1216	Perth Amboy City
1217	Piscataway Twsp.
1218	Plainsboro Twsp.
1219	Sayreville Borough
1220	South Amboy City
1221	South Brunswick Twsp.
1222	South Plainfield Borough
1223	South River Borough
1224	Spotswood Borough
1225	Woodbridge Twsp.

MONMOUTH COUNTY—13

1330	Aberdeen Twsp.
1301	Allenhurst Borough
1302	Allentown Borough
1303	Asbury Park City
1305	Atlantic Highlands Borough
1306	Avon-By-The-Sea Borough
1307	Belmar Borough
1308	Bradley Beach Borough
1309	Brielle Borough
1304	Colts Neck Twsp.
1310	Deal Borough
1311	Eatontown Borough
1312	Englishtown Borough
1313	Fair Haven Borough
1314	Farmingdale Borough
1315	Freehold Borough
1316	Freehold Twsp.
1339	Hazlet Twsp.
1317	Highlands Borough
1318	Holmdel Twsp.
1319	Howell Twsp.
1320	Interlaken Borough
1321	Keansburg Borough
1322	Keyport Borough
1323	Little Silver Borough
1324	Loch Arbour Village
1325	Long Branch City
1326	Manalapan Twsp.
1327	Manasquan Borough
1328	Marlboro Twsp.
1329	Matawan Borough
1331	Middletown Twsp.
1332	Millstone Twsp.
1303	Monmouth Beach Borough
1334	Neptune Twsp.
1335	Neptune City Borough
1337	Ocean Twsp.
1338	Oceanport Borough
1340	Red Bank Borough
1341	Roosevelt Borough
1342	Rumson Borough
1343	Sea Bright Borough
1344	Sea Girt Borough
1345	Shewsbury Borough
1346	Shewsbury Twsp.
1347	South Belmar Borough
1348	Spring Lake Borough
1349	Spring Lake Heights Borough
1336	Tinton Falls Borough
1350	Union Beach Borough
1351	Upper Freehold Twsp.
1352	Wall Twsp.
1353	West Long Branch Borough

MORRIS COUNTY—14

1401	Boonton Town
1402	Boonton Twsp.
1403	Butler Borough
1404	Chatham Borough
1405	Chatham Twsp.
1406	Chester Borough
1407	Chester Twsp.
1408	Denville Twsp.
1409	Dover Town
1410	East Hanover Twsp.
1411	Florham Park Borough
1412	Hanover Twsp.
1413	Harding Twsp.
1414	Jefferson Twsp.
1415	Kinnelon Borough
1416	Lincoln Park Borough
1417	Madison Borough
1418	Mendham Borough
1419	Mendham Twsp.
1420	Mine Hill Twsp.
1421	Montville Twsp.
1422	Morris Twsp.
1423	Morris Plains Borough
1424	Morristown Town
1425	Mountain Lakes Borough
1426	Mount Arlington Borough
1427	Mount Olive Twsp.
1428	Netcong Borough
1429	Parsippany-Troy Hills Twsp.
1430	Long Hill Twsp.
1431	Pequannock Twsp.
1432	Randolph Twsp.
1433	Riverdale Borough
1434	Rockaway Borough
1435	Rockaway Twsp.
1436	Roxbury Twsp.
1437	Victory Gardens Borough
1438	Washington Twsp.
1439	Wharton Borough

OCEAN COUNTY—15

1501	Barnegat Light Borough
1533	Barnegat Twsp.
1502	Bay Head Borough
1503	Beach Haven Borough
1504	Beachwood Borough
1505	Berkeley Twsp.
1506	Brick Twsp.
1507	Dover Twsp.
1508	Eagleswood Twsp.
1509	Harvey Cedars Borough
1510	Island Heights Borough
1511	Jackson Twsp.
1512	Lacey Twsp.
1513	Lakehurst Borough
1514	Lakewood Twsp.
1515	Lavallette Borough
1516	Little Egg Harbor Twsp.
1517	Long Beach Twsp.
1518	Manchester Twsp.
1519	Mantoloking Borough
1520	Ocean Twsp.
1521	Ocean Gate Borough
1522	Pine Beach Borough
1523	Plumsted Twsp.
1524	Point Pleasant Borough
1525	Point Pleasant Beach Borough
1526	Seaside Heights Borough
1527	Seaside Park Borough
1528	Ship Bottom Borough
1529	South Toms River Borough
1530	Stafford Twsp.
1531	Surf City Borough
1532	Tuckerton Borough

PASSAIC COUNTY—16

1601	Bloomingdale Borough
1602	Clifton City
1603	Haledon Borough
1604	Hawthorne Borough
1605	Little Falls Twsp.
1606	North Haledon Borough
1607	Passaic City
1608	Paterson City
1609	Pompton Lakes Borough
1610	Prospect Park Borough
1611	Ringwood Borough
1612	Totowa Borough
1613	Wanaque Borough
1614	Wayne Twsp.
1615	West Milford Twsp.
1616	West Paterson Borough

SALEM COUNTY—17

1701	Alloway Twsp.
1713	Carney's Point Twsp.
1702	Elmer Borough
1703	Elsinboro Twsp.
1704	Lower Alloways Creek Twsp.
1705	Pennsville Twsp.
1706	Mannington Twsp.
1707	Oldmans Twsp.
1708	Penns Grove Borough
1709	Pilesgrove Twsp.
1710	Pittsgrove Twsp.
1711	Quinton Twsp.
1712	Salem City
1714	Upper Pittsgrove Twsp.
1715	Woodstown Borough

SOMERSET COUNTY—18

1801	Bedminster Twsp.
1802	Bernards Twsp.
1803	Bernardsville Borough
1804	Bound Brook Borough
1805	Branchburg Twsp.
1806	Bridgewater Twsp.
1807	Far Hills Borough
1808	Franklin Twsp.

1809	Green Brook Twsp.
1810	Hillsborough Twsp.
1811	Manville Borough
1812	Millstone Borough
1813	Montgomery Twsp.
1814	North Plainfield Borough
1815	Peapack-Gladstone Borough
1816	Raritan Borough
1817	Rocky Hill Borough
1818	Somerville Borough
1819	South Bound Brook Borough
1820	Warren Twsp.
1821	Watchung Borough

SUSSEX COUNTY—19

1901	Andover Borough
1902	Andover Twsp.
1903	Branchville Borough
1904	Byram Twsp.
1905	Frankford Twsp.
1906	Franklin Borough
1907	Fredon Twsp.
1908	Green Twsp.
1909	Hamburg Borough
1910	Hampton Twsp.
1911	Hardyston Twsp.
1912	Hopatcong Borough
1913	Lafayette Twsp.
1914	Montague Twsp.
1915	Newton Town
1916	Ogdensburg Borough
1917	Sandyston Twsp.
1918	Sparta Twsp.
1919	Stanhope Borough
1920	Stillwater Twsp.
1921	Sussex Borough
1922	Vernon Twsp.
1923	Walpack Twsp.
1924	Wantage Twsp.

UNION COUNTY—20

2001	Berkeley Heights Twsp.
2002	Clark Twsp.
2003	Cranford Twsp.
2004	Elizabeth City
2005	Fanwood Borough
2006	Garwood Borough
2007	Hillside Twsp.
2008	Kenilworth Borough
2009	Linden City
2010	Mountainside Borough
2011	New Providence Borough
2012	Plainfield City
2013	Rahway City
2014	Roselle Borough
2015	Roselle Park Borough
2016	Scotch Plains Twsp.
2017	Springfield Twsp.
2018	Summit City
2019	Union Twsp.
2020	Westfield Town
2021	Winfield Twsp.

WARREN COUNTY—21

2101	Allamuchy Twsp.
2102	Alpha Borough
2103	Belvidere Town
2104	Blairstown Twsp.
2105	Franklin Twsp.
2106	Frelinghuysen Twsp.
2107	Greenwich Twsp.
2108	Hackettstown Town
2109	Hardwick Twsp.
2110	Harmony Twsp.
2111	Hope Twsp.
2112	Independence Twsp.
2113	Knowlton Twsp.
2114	Liberty Twsp.
2115	Lopatcong Twsp.
2116	Mansfield Twsp.
2117	Oxford Twsp.
2118	Pahaquarry Twsp.
2119	Phillipsburg Town
2120	Pohatcong Twsp.
2121	Washington Borough
2122	Washington Twsp.
2123	White Twsp.

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MODULE 1
INTRODUCTION

OUTLINE

- What is a Hazmat Technician
- NFPA 472 and other equivalent standards
- OSHA Title 29 Part 1910.120(q)
- Training Requirements
- Hazmat response procedures
- Medical surveillance

MODULE 1
INTRODUCTION

OBJECTIVES

The student will be able to:

1. Describe the role of the Haz Mat Technician in Emergency Response.
2. Describe the training requirements of Haz Mat team members.
3. Describe the medical surveillance requirements of Haz Mat team members.

HAZARDOUS MATERIALS TECHNICIAN INTRODUCTION

INTRODUCTION

"A journey of a thousand miles must begin
with a single step."
LAO-TZU

This hazardous materials technician training program is not the end of your journey but, instead, it is the beginning. A single hazardous materials technician training program is not the magic formula which makes you a haz-mat technician. The subjects covered in this course are only the BASICS of offensive haz-mat response. Due to the potential for a high level of personal risk associated with haz-mat response, there is still a need for additional training and education. You must develop response SOP's for YOUR haz-mat team. You must train with those SOP's as well as the equipment used by your team; and that training must be done often enough and well enough that you minimize the risks associated with haz-mat response.

There are other areas of specialized information which this program does not address because it is a basic program. As your haz-mat team evolves, those areas in need of additional education and training will be recognized. Both experience and knowledge develop professionalism, **do not let your experience out pace your knowledge**. Being emergency responders, we have been taught to be aggressive, to take control of the situation, and to resolve the problem. Now you are being told to stop, think, and not react instinctively, but instead, act based upon what you have discovered while comparing it with what you know.

Prior to taking this course, you have had to take awareness and operational training. Both of those programs were for defensive operations only. This technician training program is the first program which teaches the basics for offensive actions. Remember, even though this program teaches offensive actions, defensive actions may still be the best course of action in certain instances.

"Half of the harm that is done in this world
is due to people who want to feel important."
T.S. Eliot

DEFINITION: Hazardous Material Technician

That member of the response community who, as part of a Haz Mat team, has the knowledge and skill to take appropriate offensive or defensive action, that would require level B protection, at a Haz Mat Incident.

- Most Haz Mat incidents can be handled by the technician.
- If not acting as part of a HMT then only defensive action is permitted.

The Federal OSHA law 29 CFR Part 1910.120

- Defines the “Buddy System” as a system of organizing employees into work groups in such a manner that each employee of the work group is designated to be observed by at least one other employee in the work group. The purpose of the buddy system is to provide rapid assistance to employees in the event of an emergency.
- Defines a “(HAZMAT) team” as an organized group of employees, designated by the employer, who are expected to perform work to handle and control actual or potential leaks or spills of hazardous substances requiring possible close approach to the substance. The team members perform responses to releases or potential releases of hazardous substances for the purpose of control or stabilization of the incident. A HAZMAT team is not a fire brigade nor is a typical fire brigade a HAZMAT team. A HAZMAT team, however, may be a separate component of a fire brigade or fire department.
- Defines a “Qualified person” as a person with specific training, knowledge and experience in the area for which the person has the responsibility and the authority to control.
- Requires at least 24 hours of training equal to the FRO and competency in the following areas:
  - 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 technician.
  - 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.
- Requires a medical surveillance program be instituted by the employer for all HAZMAT team members and consisting of:
  - an examination prior to assignment
  - an examination at least once every twelve months
  - an exam at the termination of employment or reassignment
  - an exam as soon as possible after signs or symptoms of overexposure
  - more frequent exams as determined necessary by the physician

HAZMAT TEAM MAKEUP

OSHA REQUIREMENTS

2 member entry team
2 member backup
1 safety officer

minimum 5 members
+ 2 Emergency medical on standby

29 CFR 1910.120 EMERGENCY RESPONSES

(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 where an emergency occurs, and who do 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 coordination with outside parties.

(ii) Personnel roles, lines of authority, training, and communication.

(iii) Emergency recognition and prevention.

(iv) Safe distances and places of refuge.

(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 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 personnel 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 or 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 to 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 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 relevant 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 technician.

(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 specialists 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 technician 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 employees who exhibit 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.

APPENDICES TO §1910.120—HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE

Note: The following appendices serve as non-mandatory guidelines to assist employees and employers in complying with the appropriate requirements of this section. However paragraph 1910.120(g) makes mandatory in certain circumstances the use of Level A and Level B PPE protection.

Appendix A—Personal Protective Equipment Test Methods

This appendix sets forth the non-mandatory examples of tests which may be used to evaluate compliance with §1910.120(g)(4)(ii) and (iii). Other tests and other challenge agents may be used to evaluate compliance.

A. Totally-encapsulating chemical protective suit pressure test

1.0—Scope

1.1 This practice measures the ability of a gas tight totally-encapsulating chemical protective suit material, seams, and closures to maintain a fixed positive pressure. The results of this practice allow the gas tight integrity of a totally-encapsulating chemical protective suit to be evaluated.

1.2 Resistance of the suit materials to permeation, penetration, and degradation by specific hazardous substances is not determined by this test method.

2.0—Definition of terms

2.1 *“Totally-encapsulated chemical protective suit (TECP suit)”* means a full body garment which is constructed of protective clothing materials; covers the wearer’s torso, head, arms, legs and respirator; may cover the wearer’s hands and feet with tightly attached gloves and boots; completely encloses the wearer and respirator by itself or in combination with the wearer’s gloves and boots.

2.2 *“Protective clothing material”* means any material or combination of materials used in an item of clothing for the purpose of isolating parts of the body from direct contact with a potentially hazardous liquid or gaseous chemicals.

2.3 *“Gas tight”* means, for the purpose of this test method, the limited flow of a gas under pressure from the inside of a TECP suit to atmosphere at a prescribed pressure and time interval.

3.0—Summary of test method

3.1 The TECP suit is visually inspected and modified for the test. The test apparatus is attached to the suit to permit inflation to the pre-test suit expansion pressure for removal of suit wrinkles and creases. The pressure is lowered to the test pressure and monitored for three minutes. If the pressure drop is excessive, the TECP suit fails the test and is removed from service. The test is repeated after leak location and repair.

4.0—Required Supplies

4.1 Source of compressed air.

4.2 Test apparatus for suit testing, including a pressure measurement device with a sensitivity of at least 1/4 inch water gauge.

4.3 Vent valve closure plugs or sealing tape.

4.4 Soapy water solution and soft brush.

4.5 Stop watch or appropriate timing device.

5.0—Safety Precautions

5.1 Care shall be taken to provide the correct pressure safety devices required for the source of compressed air used.

6.0—Test Procedure

6.1 Prior to each test, the tester shall perform a visual inspection of the suit. Check the suit for seam integrity by visually examining the seams and gently pulling on the seams. Ensure that all air supply lines, fittings, visor, zippers, and valves are secure and show no signs of deterioration.

6.1.1 Seal off the vent valves along with any other normal inlet or exhaust pipes (such as umbilical air line fittings or face piece opening) with tape or other appropriate means (caps, plugs, fixture, ect.). Care should be exercised in the sealing process not to damage any of the suit components.

6.1.2 Close all closure assemblies.

6.1.3 Prepare the suit for inflation by providing an improvised connection point on the suit for connecting an airline. Attach the pressure test apparatus to the suit to permit suit inflation from a compressed air source equipped with a pressure indicating regulator. The leak tightness of the pressure test apparatus should be tested before and after each test by closing off the end of the tubing attached to the suit and assuring a pressure of three inches water gauge for three minutes can be maintained. If a component is removed for the test, that component shall be replaced and a second test conducted with another component removed to permit a complete test of the ensemble.

6.1.4 The pre-test expansion pressure (A) and the suit test pressure (B) shall be supplied by the suit manufacturer, but in no ?????????????

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
TITLE 29 CFR PART 1910.120
HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE
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MEDICAL SURVEILLANCE PROGRAM

INITIAL EMPLOYMENT AND/OR BASELINE EXAM

Drug screen per department policy
Physical examination
Audiogram
Pulmonary function
Chest X-ray
Resting EKG
Compete blood count with differential
Blood chemistry—SMAC 21 with GGT
Urinalysis
Vision screening
Vital signs
Physical measurements
Back evaluation
Cardiac stress test
Additional testing per department policy

ANNUAL RETEST

Same testing as above although the X-ray and cardiac stress test may vary and the drug screen can be omitted.

REGULATION INDEX

Below is a list of corresponding regulations that may pertain to your operations in emergency response. The sections are broken down into state and federal, with the federal regulations further broken down into 29 CFR (OSHA), 40 CFR (EPA), and 49 CFR (DOT).

STATE

New Jersey Administrative Code (N.J.A.C.)
New Jersey Statutes Annotated (N.J.S.A.)

N.J.A.C. 12:100-4.2 Safety and Health Standards for Public Employees—Adopted the standards contained in 29 CFR 1910, General Industry Standards, as the occupational safety and health standards for the protection of public employees engaged in general operations.

N.J.A.C. 12:100-4.3 The standards contained in N.J.A.C. 12:100-4.2 shall apply according to the provisions thereof. Each employer shall protect his employees by complying with the standards prescribed in N.J.A.C. 12:100-4.2.

N.J.A.C. 12:100-9.1 Established procedures to protect employees from the hazards of entry into and work within a confined space.

N.J.A.C. 12:100-9.3 Confined Space program by employers or individuals who are responsible for sending workers into confined spaces.

N.J.A.C. 12:100-11.1 Control of Hazardous Energy Sources (Lockout/Tagout).

N.J.A.C. 12:100-9.5(d)1 Cleaning, purging, inerting, or ventilating a confined space prior to entry.

Spill Compensation and Control Act (N.J.A.C. 7:1E-5.3/N.J.S.A. 58:10-23.11e) As mandated under N.J.S.A. 58:10-23.11e and N.J.A.C. 7:1E-5.3, any person or persons responsible for a "discharge" must immediately notify the Department of Environmental Protection. A discharge was intended to mean a release into the air, water, or land of a hazardous or toxic substance. There is no threshold amount or de minimus quantity for reporting purposes; all discharges of hazardous substances to lands or waters of the State must be reported. Notification must be made within fifteen (15) minutes of the time the person knew or should have known of the discharge. Delays beyond fifteen minutes must be justifiable pursuant to N.J.A.C. 7:1E-5.6.

Under N.J.A.C. 7:1E-5.7(a), DEP is authorized to contain, clean up and remove hazardous substance discharges on its own, or to direct responsible parties to undertake removal actions and minimize damage. When DEP undertakes removal actions, the agency may draw money available from the Spill Compensation Fund for costs incurred to remove and minimize damage (N.J.S.A. 58:10-23.11f(a)). DEP may order any person to cease clean up and removal actions if the agency determines that such persons cannot properly conduct these activities (N.J.A.C. 7:1E-5.7(d)).

FEDERAL

SARA Title III (Superfund Amendments and Reauthorization Act) (42 U.S.C. §§11001-11050/Pub.L. No. 99-499)—When SARA Title III became law in 1986, it created four distinct sets of reporting and/or emergency planning requirements. Each of these requirements is discussed below.

(a) Planning Emergency Response—Defined a broad federal mandate for state and local governmental planning for response to emergencies caused by unauthorized releases of toxic and hazardous materials. It directed the EPA to prescribe threshold planning quantities (TPQs) for certain extremely hazardous substances. Facilities that handle more than TPQs of any extremely hazardous substance must submit inventory data to state and local planning bodies. New Jersey has merged this reporting requirement with its employer reporting requirements under the Right to Know Act. Under the Right to Know Act, DEP created a Community Right to Know Survey, which combines state reporting requirements with those of SARA Title III.

Title III also required that each governor designate a SERC (state emergency response commission). In New Jersey, the SERC consists of eight members co-chaired by the DEP and the New Jersey State Police. DEP manages community right-to-know reporting requirements and the State Police manages the requirements of local emergency planning.

Each local emergency planning committee was required to prepare a plan for emergency response to releases of extremely hazardous substances. Each plan is required to include:

(1) identification of facilities subject to Title III reporting requirements;

(2) transportation routes for extremely hazardous substances;

(3) identification of additional facilities contributing to, or subject to, additional risk;

(4) emergency response procedures for facilities and local government;

(5) designation of community and facility emergency response coordinators;

(6) emergency notification procedures;

(7) methods to identify releases, and the area and populations likely to be affected;

(8) inventories of emergency response equipment and facilities, and responsible personnel;

(9) evacuation plans;

(10) training programs for emergency response and medical personnel; and

(11) methods for “exercising” the plan.

(b) Reporting Leaks and Spills—Title III requires facilities to report “immediately” any discharge of an extremely hazardous substance or other CERCLA listed substance above its reportable quantity.

(c) Reporting Chemical Inventories—Title III requires reporting of hazardous materials in the workplace. New Jersey has merged SARA Title III reporting requirements with its state reporting requirements under the Right to Know Act. Businesses required to comply with the Right to Know Act need only complete a Community Right to Know Survey, which satisfies both federal and state reporting requirements.

(d) Reporting Continuous Emissions—Each July 1, reports estimating releases for the previous calendar year are submitted resulting in the Toxic Release Inventory, a compilation of data on toxic chemicals released from all reporting facilities throughout the nation.

29 CFR . . .

1910.120(q)	Emergency Response (HAZWOPER)
1910.134	Respiratory Protection
1910.146	Confined Space
1910.147(c)(7)	Lockout/Tagout
1910.1030	Bloodborne Pathogens
1910.1200	Hazard Communication Standard

40 CFR . . .

112.7(e)(10)	Spill Prevention Control and Countermeasures
112.20	Oil Spill Response Plan
311	State and Local Government HAZWOPER

49 CFR . . .

173.1	Preparation of HazMats for Transport
174.7	Transport of HazMats by Rail
175.20	Transport of HazMats by Aircraft
176.13	Transport of HazMats by Vessel
177.816	Transport of HazMats by Motor Carrier
177.825	Transport of Class 7 Radioactive Materials by Motor Carrier

OTHER LEGISLATION

STATE

Pesticide Control Act of 1971 (N.J.S.A. §13:1F-1-1F-18) Regulates the use, transportation, storage, sale and disposal of pesticides and their containers. Applicators and applicator businesses are required to notify DEP immediately of any pesticide spill or misapplication that occurs under their direct supervision or is witnessed.

New Jersey Radon Laws (N.J.S.A. §26:2D-59) & (N.J.S.A. §52:27D) Created an education and public information program (DEP), as well as, developed a radon hazard code to be incorporated into the State Uniform Construction Code Act (DCA).

FEDERAL

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (7 U.S.C. §§136-136y) Enacted in 1947, it constitutes the basic federal regulatory framework governing pesticides.

Toxic Substances Control Act (TSCA) (15 U.S.C. §§2601-2671) Enacted by Congress in 1976, it began the policy that adequate data should be developed regarding the effects of chemical substances and mixtures on human health and the environment. Its intent was to prevent the general environment from becoming the laboratory from which harmful effects of chemicals are discovered. It has undergone two amendments since its enactment. In 1986, the Asbestos Hazard Emergency Response Act (AHERA) was added, and in 1988, Congress added Title III of TSCA to address indoor radon abatement.

MODULE 2
BASIC CHEMISTRY

OUTLINE

- **Review of principals from Level 2 training**
- **Basic chemical, radiologic and toxicologic terminology**
- **Fahrenheit/Centigrade temperature**
- **Periodic Table**
- **Classifying compounds into categories of Chemical hazards (Inorganic and organic)**

MODULE 2

UNDERSTANDING BASIC CHEMISTRY

OBJECTIVES

The student will be able to:

1. Identify the chemical family of a compound from its name.
2. Estimate the hazardous nature of a compound based on its chemical family.
3. Identify terms dealing with chemical exposure.
4. Predict the behavior of a compound in a situation given its physical characteristics.

Before anything else, see how much you already know about haz mat chemistry. Define the following terms to the best of your ability:

PRE-SESSION SURVEY

	Term:	Definition:
1	Specific Gravity	
2	Vapor Density	
3	TWA	
4	Boiling Point	
5	pH	
6	Asphyxiant	
7	Organic	
8	Neurotoxin	
9	Ion	
10	Salt	
11	LEL	
12	Hydrocarbon	
13	Cryogenic	
14	Inorganic	
15	Carcinogen	
16	Pulmonary Edema	
17	LD_{50}	
18	PEL	
19	BLEVE	
20	IDLH	

The answers are in the glossary but no fair peeking-besides, you’re not being graded on this.

This module will help you understand the theory behind hazardous materials chemistry. Some of you are already fully conversant with the chemical concepts we will be talking about and that's fine; you can help the others deal with them.

While there are millions of chemical compounds that have been produced, there are only a limited number of ways that they can harm you. Fire science conventionally recognizes seven classes of hazardous materials:

1. **Flammable Materials:** Solid, liquid, vapor or gases that ignite easily and burn rapidly when exposed to an ignition source.
2. **Spontaneously ignitable materials:** Solid or liquid materials that ignite spontaneously without an ignition source; usually but not necessarily due to the dangerous buildup of heat during storage caused by oxidation or microbiological action.
3. **Explosives:** Substances that detonate as a result of shock, heat or some other initiating mechanism.
4. **Oxidizers:** Substances that evolve or generate oxygen at ambient conditions or when exposed to heat.
5. **Toxic materials:** Materials that, in small doses, create some deleterious health effect.
6. **Radioactive materials:** Materials that emit ionizing radiation from transformations occurring within their atomic nuclei.
7. **Corrosive materials:** Solids or liquids that burn or otherwise damage skin tissue at the site of contact.

PHYSICAL PROPERTIES OF MATERIALS

The physical properties that are listed in a handbook can help you predict how a material will behave during an incident. You will want to know the answers to questions like:

How quickly will the material vaporize and present an airborne hazard?

Will vapors collect in low-lying areas?

How can it be controlled if it reaches water supplies?

Density—is the mass per unit volume of a substance ($D = M/V$). It is usually expressed as grams per cubic centimeter (g/cc). The density of water is 1g/cc since 1 cubic centimeter of water has a mass of 1 gram.

Specific gravity—The ratio of the density of a solid of liquid to the density of water ($SG = D_1/D_{water}$). This number tells you whether the material floats or sinks in water. A number greater than 1 indicates that the substance sinks; numbers less than 1 indicate that the substance floats (assuming it to be insoluble in water).

Vapor density (V_{den})—The relative density of a vapor compared to air. It can be expressed as the formula: $V_{den} = MW/28.95$ where MW is the molecular weight of the gas or vapor and 28.95 is the average molecular weight of a sample of air. A vapor with a V_{den} of less than 1 is "lighter than air" and will rise. Vapors with densities greater than 1 will drop and collect in low-lying areas and pockets.

Vapor pressure—A measure of how readily a solid or liquid mixes with air at its surface. Higher VPs (approaching 760mm Hg) indicate a volatile substance and suggests that there will be high concentrations in the air at an incident involving that substance. Vapor pressure above 760mm Hg indicate a material that is normally a gas. The higher the vapor pressure of a liquid, the lower its boiling point.

Boiling point (BP)—The temperature at which the vapor pressure of the material being heated equals atmospheric pressure (about 760mm Hg). Attaining the boiling point is just a specific case of dealing with vapor pressure. Remember that ambient pressure varies with altitude; it also varies with the weather but this is usually negligible.

MATERIAL	VP @ °C	BP (°C)
Acetone	400mm @ 39.5°	56.5°
Acetic Acid	11.4mm @ 118.1°	118.1°
Benzene	100mm @ 20°	80.1°
CTC	100mm @ 23°	76.8°
Diethyl ether	442mm @ 20°	34.6°
Ethanol	40mm @ 19°	78.32°
Glycerine	0.0025 @ 50°	290°
Methanol	100mm @ 21.2°	64.8°
Pentane	400mm @ 18.5°	36.1°

Sublimation—going from the solid to the gaseous to the solid state (without becoming a liquid as CO_2 and Mercuric Chloride.

Critical Temperature—the temperature at which a gas can be liquefied by the critical pressure; above that temperature, the gas cannot be liquefied at any pressure.

Critical Pressure—the pressure that will condense a gas at the Critical Temperature:

Substance	CT (°C)	CP (MPa)
Helium	–268	0.229
Hydrogen	–240	1.36
Oxygen	–118	5.00
Nitrogen	–147	3.41
Chlorine	144	8.07
Carbon monoxide	-140	3.51
Carbon dioxide	31	7.38
Dinitrogen oxide	36	7.26
Ammonia	133	11.4
Water	374	22.0

Flammable (explosive) limits—The highest and lowest concentrations of a substance that can explode or burn. The upper explosive limit **(UEL)** is the richest mixture of a substance that can explode while the lower explosive limit **(LEL)** is the most lean.

EXPLOSIVE (FLAMMABLE) RANGES OF SOME COMMON MATERIALS:

Substance:	**LEL (LFL) (by percent of atmosphere)**	**UEL (UFL) (by percent of atmosphere)**
Acetone	2.6	12.8
Acetylene	1.5	81
Anhydrous ammonia	16	25
Benzine	1.1	5.9
Benzene	1.3	7.1
Gasoline (50-90 octane)	1.4	7.6
Hexane	1.1	7.5
Iso-propyl alcohol	2.0	12.0
Kerosene	0.7	5.0
Methyl alcohol	7.3	36
Toluene	1.2	7.1

Flash point (FP)—The lowest temperature at which the vapor given off by a substance forms an ignitable mixture with air. This is only a flash, not a sustained fire.

FLASH POINTS AND IGNITION TEMPERATURES OF SOME COMMON MATERIALS:

Substance:	**Flash Point (°F)**	**Ignition Temperature (°F)**
Acetone	0	1000
Aniline	158	1418
Benzine	0	550
Benzene	12	1044
Carbon disulfide	–22	212
Gasoline (50-90 octane)	–45	536
Hexane	–7	502
Iso-propyl alcohol	53	750
Kerosene	100	444
Methyl alcohol	52	867
Toluene	40	997
Fuel oil (No. 4)	130	505

Fire point—The minimum temperature where a given liquid produces vapor at a high enough rate to sustain a flame.

Ignition temperature—(Also called AUTOIGNITION TEMPERATURE) The minimum temperature required to initiate self-combustion of a material or compound.

Water solubility—The degree to which a material or its vapors dissolve in water. Materials that readily dissolve are described as "miscible".

(United States Pharmacopeia system for describing solubility*):*

DESCRIPTION	PARTS SOLVENT: 1 PART SOLUTE
Very soluble	Less than 1
Freely soluble	1-10
Soluble	10-30
Sparingly soluble	30-100
Slightly soluble	100-1000
Very slightly soluble	1000-10000
Practically insoluble or insoluble	10000+

The solvent in this chart can be any material but we are usually concerned with water.

Viscosity—internal fluid friction and somewhat temperature dependent. Ratio of shear stress to rate of shear of a fluid. Often measured by the rate of flow of the fluid through an orifice. Property of being glutinous or sticky.

Corrosivity—is measured as "pH" which stands for "potential Hydrogen ions". It is the negative logarithm of the concentration of hydrogen ions in solution. In a liter of pure water, 0.0000001% of the molecules (H_2O) will have separated into (OH) radicals and H^+ ions. The log of 0.0000001% is –7 (count the decimal places). The negative log of 0.0000001% is 7. When we add an acid to the water (HCl) it increases the concentration of H^+ ions. If the concentration is increased 10 times, it is now 0.000001% or a negative log of 6. Each time we increase the concentration of H^+ ions by a factor of 10, the pH drops by one. When we add a base to the water we increase the (OH) radical concentration which, in turn, decreases the concentration of H^+ ions. To neutralize an acid (excess H^+ ions) we add a base (excess (OH) radical) until the concentration of H^+ ions is 0.0000001%. Always use **weak acids or bases** for neutralization. The reaction is not as dramatic and if you miss pH 7, you don't miss by much and the resulting solution is not very corrosive.

PH OF SOME COMMON SUBSTANCES

SUBSTANCE	**pH**	**COMMENTS**	**CHARACTER**
	14	STRONG BASES	**BASIC**
Lye	13.5		
	13		
Household ammonia	12		
	11	WEAK BASES	
Lime water	10.5		
	10		
Borax	9.5		
	9		
Baking soda	8.5		
	8		
Blood	7.5		
Milk	7		**NEUTRAL**
Rain water	6.5	WEAK ACIDS	**ACIDIC**
	6		
Black coffee	5		
Tomatoes	4		
Soda	3.5		
	3		
Lemon juice	2	STRONG ACIDS	
Gastric fluid	1		
	0		

UNITS OF MEASURE

Our everyday system is the “English System,” based on arbitrary standards related through traditional anatomic measurements and historic precedent.

EXAMPLES:

12 inches = 1 foot
3 feet = 1 yard
2 yards = 1 fathom
5.5 yards = 1 rod
40 rods = 1 furlong
8 furlongs = 1 statute mile
1000 fathoms = 1 nautical mile

The “Metric System,” is a measurement reform originating in France based on an arbitrary standard (the Meter) with all units of measure interrelated by factors of 10.

EXAMPLES:

10 millimeter = 1 centimeter
100 cm = 1 Meter
1000M = 1 Kilometer
1 cubic Meter = 1000 liters
1L - 1000 milliliters = 1 cubic centimeter
1L of water masses = 1 Kilogram

The “nifty” feature of the metric system is that linear measurement can be so readily related to volume and mass. It makes it much easier to estimate concentrations of chemicals in a given area or estimate personnel exposure.

CONVERSIONS:

METRIC SYSTEM	ENGLISH SYSTEM
1 centimeter	0.3937 inch
2.54 centimeters	1 inch
1 Meter	39.37 inches
0.9144 Meter	1 yard
1 Kilometer	0.621 mile
1.609 Kilometers	1 mile
1 Kilogram	2.2 pounds
454 grams	1 pound
1 Liter	1.0567 qts (liquid)
946 milliliters or cc	1 quart
3.789 Liter	1 gallon

For visualization: A quarter masses 5.7 grams; a penny masses 2.5 grams

TEMPERATURE:

THERE ARE FOUR SCALES IN COMMON USE: Celsius, Fahrenheit, Kelvin and Rankine.

Celsius and Fahrenheit both use the freezing and boiling points of water as their references.

SCALE	WATER FREEZES:	WATER BOILS:
CELSIUS	0 DEGREES	100 DEGREES
FAHRENHEIT	32 DEGREES	212 DEGREES

Conversion Formulas:

$°F = [1.8 \times t(°C)] + 32$ $°C = 0.5556 \times [t(°F) - 32]$

Kelvin and Rankine scales are modifications of the Celsius and Fahrenheit scales (respectively) that use "absolute zero" as their reference points. "Absolute zero" is the limit beyond which it is impossible to cool matter.

The Kelvin temperature of something is its Celsius temp. plus 273.15.

The Rankine temperature of something is its Fahrenheit temp. plus 459.69.

SCALE	WATER FREEZES:	WATER BOILS:
KELVIN	273.15 DEGREES	373.15 DEGREES
RANKINE	491.69 DEGREES	671.69 DEGREES

K is the international standard for temperature measurement.

When you look up information in various sources, be aware of which scale is being used. Be consistent in your own reporting; choose a scale and stick with it.

EXPANSION RATIOS OF COMMON LIQUIFIED GASES AND CRYOGENIC MATERIALS:

The basic principle is that gases that are stored under pressure, as pressurized liquids or as cryogenic materials expand tremendously when they are released from their containers. In chemistry, the term cryogenic refers to materials at temperatures from –150°F down to absolute zero (–459.7°F). This causes some confusion as DOT uses a boiling point of less than –130°F to define "cryogenic" (49 CFR 173.115).

LIQUIFIED GAS or cryogenic liquid	EXPANSION RATIO (liquid > gas)	BOILING POINT °Fahrenheit
Argon	1:840	–302
Helium	1:400	–452
Hydrogen	1:850	–423
LNG	1:635	–289 (CH_4)
Nitrogen	1:700	–320
Oxygen	1:850	–297
Propane	1:270	–42.1
Fluorine	1:980	–306
Krypton	1:695	–243
Neon	1:1445	–411
Xenon	1:560	–163

EXPANSION RATIOS OF LIQUIDS

One of the problems we run into is that liquids are relatively incompressible AND they expand when heated. If a liquid expands beyond the capacity of its storage vessel, the vessel will rupture. Always allow room for expansion when filling a tank—gases are readily compressible—but remember the rated pressure of the vessel.

COEFFICIENT OF VOLUME EXPANSION OF SOME COMMON LIQUIDS:

	coefficient of expansion per degree	
Liquid:	**Fahrenheit**	**Celsius**
Acetic acid	0.000594	0.001071
Acetone	0.000825	0.001487
Benzene	0.000686	0.001236
Carbon tetrachloride	0.000687	0.000237
Diethyl ether	0.000919	0.001656
Ethyl alcohol	0.000622	0.001120
Gasoline	0.000599	0.001080
Glycerine	0.000280	0.000505
Methyl alcohol	0.000665	0.001199
Pentane	0.000892	0.001608
Turpentine	0.000541	0.000973
Water	0.000115	0.000207

The coefficient of expansion (C) is plugged into the following formula to determine the volume of a product after it is heated:

$$V_2 = (((T_2 - T_1) * C)\ V_1) + V_1$$

Where V_1 is the initial volume of the product, V_2 is the final volume, T_1 is the initial temperature of the product and T_2 is the final temperature of the product. The formula can be worked with either Fahrenheit or Celsius temperature but note that there are different coefficients for the two scales.

Take a break and get some coffee.

INTRO TO TOXICOLOGY:

Toxicology is the study of the effects of hazardous materials on living organisms. It is based on the assumption that there is a relationship between the dose (amount) of an agent and the response of the exposed individual.

You will depend on data published by various groups to determine what a "safe" exposure level is to different chemicals. Chiefly, you will look to the publications of the American Conference of Governmental Industrial Hygienists (ACGIH), the National Institute of Occupational Health Sciences (NIOSH) and the Occupational Safety and Health Administration (OSHA). All three groups publish data concerning the ". . . time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect." But they derive their numbers by differing means.

The ACGIH bases their **TLV-TWA** (Threshold Limit Values-Time Weighted Average) numbers based on studies of worker's diseases in typical industrial environments. The **TLV-STEL** (Short Term Exposure Limit) is the concentration that workers can endure for short periods (four 15 minute exposures per day with an hour rest in between) provided the **TLV-TWA** is not exceeded. The **TLV-C** (Ceiling) is the concentration that should not be exceeded at any point during the work day.

NIOSH publishes a book of RELs (Recommended Exposure Limits) for workers based on laboratory studies with animals. The **REL** is an eight hour average exposure (TWA) just like the TLV. You will also find references to **IDLH** (Immediately Dangerous to Life or Health) concentrations, a concentration that will cause irreversible health effects or escape impairing symptoms in 30 minutes.

OSHA determines the **PELs** (Permissible Exposure Limits), the legal requirement for workplaces based on data collected from all published sources and factoring in the cost of compliance and publishes the resulting numbers as 29 CFR 1910.1000.

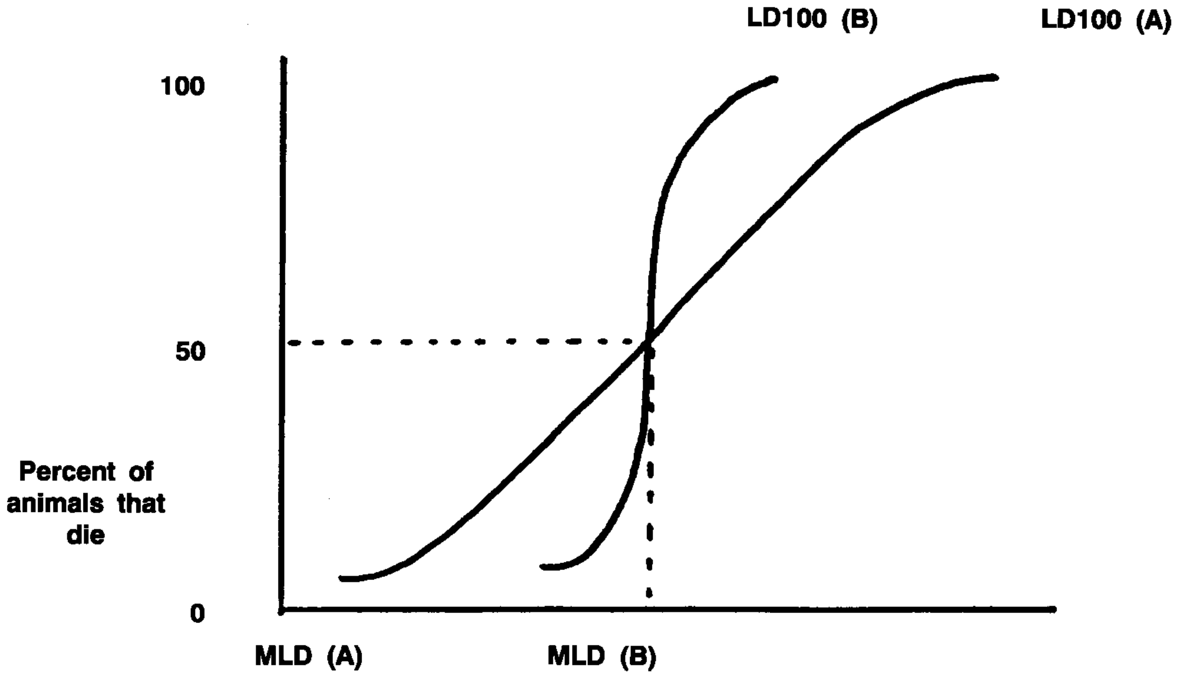
Toxicity data for new chemicals is usually obtained in the laboratory by administering the chemical to lab animals. Two of the numbers that come out of the statistical analysis of the data obtained are:

LD_{50}—the dose expected to be lethal to 50% of an experimental group

LD_{50}—the airborne concentration expected to be lethal to 50% of an experimental group exposed for a specified time period

The LD and LC numbers provide an index of comparative toxicity for a chemical. Animal data provides information on effects that can be expected in humans and is often the only data available.

The slope of the curve (dose-response curve) plotted from the MLD (Minimum Lethal Dose) to LD_{100} (100% Lethality) suggests the range between the no-effect level and absolute lethality. That range is referred to as the margin of safety. If the dose-response curve is steep, the margin of safety is small.



LD values are expressed as a ratio: grams of product to Kilograms of body weight. The larger this number, the smaller the problem you have. For example, the LD_{50} of saccharin, the artificial sweetener, is 2000g/Kg (or 2Kg/Kg). This means that the median lethal dose is roughly twice your body weight. By comparison, the LD_{50} of sarin (neurotoxin) is about 0.01mg/Kg or 1/100,000 of your body weight. In other words, a pile of saccharin won't cause much of a problem but a drop of sarin will kill.

LC values (airborne hazards) are usually reported as ppm (parts per million in the air) or mg/m^3 (milligrams in a cubic meter of air). Again, the larger the number, the less toxic the product. The conversion equations are:

TLV in mg/m^3 = {(TLV in ppm)(gram molecular wt of substance)}/24.45

TLV in ppm = {(TLV in mg/m^3)(24.45)}/(gram molecular wt of substance)

Toxicity is a major factor determining the hazard and risk associated with a substance. Toxicity is the level of a material's ability to cause injury to living tissue in a given situation. It is dependent on the route of exposure, metabolization, excretion and speed of action. These factors affect how quickly the material will build up in the body and how long it will stay there.

An emergency responder's exposure to a hazardous material may occur as an acute, chronic or subacute dose. The size of the dose will be affected by the physical characteristics of the substance.

Acute toxicity is the sudden onset of symptoms after short term exposure. Often reversible in 24 hours.

Chronic toxicity is long or permanent duration effects or symptoms. Local toxicity refers to symptoms that show at the site of exposure. Systemic toxicity refers to absorption and transport via bloodstream to a susceptible or "target" organ.

TERMS TO DESCRIBE TOXICITY: HOW POISONOUS IS IT?

COMMON TERM	LD (SINGLE ORAL DOSE FOR RAT) g/Kg	VAPOR EXPOSURE (30-60% LETHAL IN 6-RAT GROUP) PPM	LD (SKIN EXPOSURE IN RABBITS g/Kg	PROBABLE LETHAL DOSE IN MAN
Extremely Toxic	0.001 or less	<10	0.005 or less	Taste (1 grain)
Highly Toxic	0.001-0.05	10-100	0.005-0.043	1 tsp (4cc)
Moderately Toxic	0.05-0.5	100-1,000	0.044-0.340	1 oz (30g)
Slightly Toxic	0.5-5.0	1,000-10,000	0.35-2.81	1 pt (250 g)
Practically Nontoxic	5.0-15.0	10,000-100,000	2.82-22.6	1 qt
Relatively Harmless	15.0	100,000	22.6	1 qt

What animals get used for skin tests? It used to be rabbits; now it's guinea pigs. Primates are too expensive so we look for animals with similar metabolic systems to humans.

To complicate the issue, two or more chemicals can interact with each other once they enter your body. That interaction can take one of the following forms:
—Synergists—combined toxicity is greater than the additive effect
—Potentiation—chemical with no particular toxicity that increases the toxicity of another
—Antagonistic—chemical that diminishes the toxicity of another

Topical and inhalation are the two most common exposure routes in industrial settings with "contact dermatitis" (skin irritation or damage) being the most prevalent chemically induced disease in the workplace. In other words, people forget to wear their protective gloves and get stuff on their hands.

As a rule of thumb: LD(skin) = 10XLD(oral) = 100XLD(intrauenous). Where LD(skin) = LD(oral) = LD(iv); this tells you that the material is EASILY skin absorbable.

Your total exposure can be expressed by the formula:

$$TWA = [(C1 \times T1) + (C2 \times T2) + (C3 \times T3) \ldots]/8$$

Where Cn is the concentration of a substance, Tn is the time you are exposed and "8" is a typical 8-hour work shift.

CATEGORIES OF TOXIC MATERIALS

Toxic materials can be sorted into categories according to their general effects. As you look up information on various chemicals there are other terms you must bear in mind in order to reasonably assess the risk you are facing.

Irritants are those corrosive materials that attack the mucous membranes of the body. They can also be fatal if encountered in high enough concentrations.

> **Water-soluble irritants** are very soluble in water and will dissolve in the first moisture they encounter, usually the eyes, mouth, nose and upper respiratory tract. They include: halogen acid gases (HCl, HF, HBr, HI), sulfur dioxide (SO_2) and ammonia (NH_3). Although these substances are considered "nonflammable" by DOT, ammonia will burn at concentrations of 16%-25% in air.
>
> **Moderately water soluble irritants** do not dissolve as readily in water so their effects are felt further down that respiratory tract, in the upper respiratory tract and the lungs. They include the halogens (F_2, Cl_2, Br_2 & I_2), ozone (O_3), phosphorus trichloride (PCl_3) and phosphorus pentachloride (PCl_5).
>
> **Slightly water soluble irritants** affect the lungs and destroy the alveoli by chemical action. They can be fatal with delayed effects (4-48 hours) in high concentrations. They include oxides of nitrogen, phosgene ($COCl_2$) and trichloroethylene (C_2HCl_3).

Asphyxiants are substances that interfere with the oxidation process in living tissue.

> **Simple asphyxiants** are materials that may not be toxic of themselves but will kill you by displacing air and the oxygen you need to breath. The most common is carbon dioxide (CO_2). While carbon dioxide is considered mildly toxic, it usually causes death by acting as a simple asphyxiant. It is heavier (V_{den} about 1.5) than air and will accumulate in low-lying areas, especially below-grade rooms and basements. The noble gases and saturated hydrocarbon gases and vapors can also act in this mode.
>
> **Blood asphyxiants** are materials that combine with red blood cells and render them incapable of transporting oxygen to the cells of your body. The most common blood asphyxiant is carbon monoxide (CO) which binds to hemoglobin 250 times more strongly than oxygen. Two other examples are aniline ($C_6H_5NH_2$) and nitrobenzene ($C_6H_5NO_2$). Both are toxic by inhalation, ingestion and absorption.
>
> **Tissue asphyxiants** are carried by the blood cells to the cells of the body and render them incapable of ever accepting oxygen. The most common is hydrogen cyanide (HCN). HCN is produced when plastics and organic materials are burned.
>
> **Respiratory paralyzers** are materials that affect the respiratory nervous system and stop your breathing. The most common is hydrogen sulfide (H_2S) which first, paralyzes the olfactory nerves (so you cease to smell its characteristic rotten-egg odor) then paralyzes the nerves controlling your breathing. Other respiratory paralyzers include carbon disulfide, and materials having narcotic or anesthetic effect like acetylene, ethylene, diethyl ether, acetone and ethyl alcohol.

Systemic poisons are materials that interfere with any vital bodily process. They can be separated into groups according to their "target organs."

> Liver and kidney poisons (hepatotoxins and nephrotoxins) include arsenic, heavy metals and halogenated hydrocarbons.
>
> Bone marrow poisons affect the marrow's ability to produce red blood cells resulting in anemia or, if acting as carcinogens, leukemia. Benzene is the most common bone marrow toxin and has been identified as a human carcinogen. It is commonly found in gasoline. Other suspected bone marrow toxins are toluene, xylene and naphthalene.

Muscle poisons attack muscle tissue causing spasms. Strychnine is the muscle toxin you will generally encounter. It has no use except as a poison and causes muscle spasms severe enough to break most of the victim's bones before death ensues.

Nerve poisons (neurotoxins) interfere with nerve impulses. The largest group of neurotoxins are the organic phosphates, commonly used in pesticides, carbon disulfide (also a respiratory paralyzer) and methyl alcohol (wood alcohol—specifically attacks the optic nerve).

SPECIFIC DESCRIPTORS FOR PARTICLES THAT MIGHT BE INHALED:

Measurement—(1mm (micron) = 1/1000mm = 1/25000in)

Dust—airborne particles 0.1-25mm (microns) diameter. >5mm settle out of air quickly. From mechanical process.

Fumes—solid particle from condensation of gas. <1mm. Often metals from oxidation, smelting, welding, brazing, soldering or burning.

Smoke—carbon or soot <0.1mm from incomplete combustion. Can be droplets or dry particles.

Aerosols—droplets or solid particles dispersed in air, fine enough to remain suspended for a period of time.

Mist—condensation or dispersal of liquid from splashing, atomizing or foaming.

Gas—formless fluid; changes to liquid or solid by the effect of temperature or pressure.

Vapor—gaseous form of a substance normally found in liquid or solid state. Changes to liquid or solid by the effect of temperature or pressure.

Fog—dispersion of liquid particles, many of which are visible.

FRESHMAN CHEMISTRY 101
INORGANIC

Chemistry is simple to deal with if you break it down and take it one step at a time. We can start by breaking chemistry into two parts: **ORGANIC CHEMISTRY** (Carbon based chemistry) and **INORGANIC CHEMISTRY** (all the rest). We'll start with inorganic chemistry; it's the simpler of the two.

Let's cover the basics:

MATTER is anything that has mass and occupies space. Matter can exist in three forms: **SOLIDS, LIQUIDS,** and **GASES**.

SOLIDS have a definite volume, a rigid shape, and resist efforts to change their structure. They have a high density and expand slightly when heated.

LIQUIDS have a fixed volume but no fixed shape. Liquids are nearly incompressible and expand a small amount when heated.

GASES have no definite volume or shape. They expand to fill their container and can be readily compressed. Gases expand when heated.

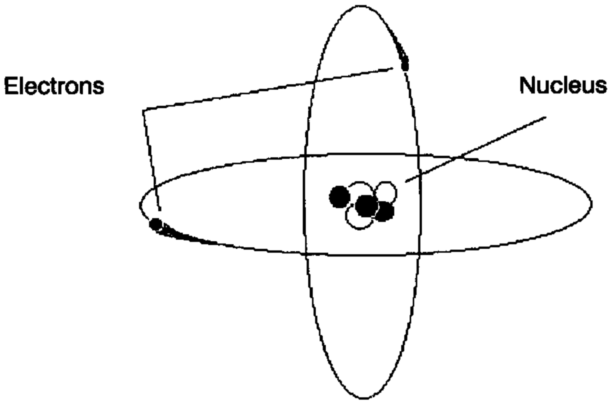
Certain terms are used to describe the change of matter from one state to another:

Vaporization: liquid or solid to a gas
Condensation: gas to liquid or solid
Freezing: liquid to solid
Distilling: liquid to gas to liquid
Melting: solid to liquid
Sublimation: solid to gas to solid

All matter is composed of **ATOMS**. Atoms are made of three particles: **ELECTRONS, NEUTRONS,** and **PROTONS**. These particles are arranged as a central **NUCLEUS** (protons and neutrons) surrounded by orbits or shells containing the electrons. Atoms are held together by electrical charge. You remember the old law "Opposite Charges Attract"? Well, the protons in the nucleus of an atom carry a positive electrical charge and attract an equal number of electrons which carry a negative charge. Neutrons have no charge and are part of the nucleus of the atom. Their mass holds the protons in the nucleus against the repulsive force of their electrical charge.

How many protons and electrons are in an atom and what difference does it make anyway?

ATOMIC STRUCTURE:
(conventional diagram)



Many of the questions we have about the structure of atoms can be found in the **PERIODIC TABLE**. Atoms are sorted into groups or **FAMILIES** according to their structure. One of the criteria for sorting is the number of electrons in an atom's outer shell. The outer electron shell of an atom does not have more than eight electrons. Atoms with the same number of atoms in their outer shells tend to react in similar ways and are sorted into the same column or **CHEMICAL FAMILY**. The roman numeral at the head of each column tells us how many electrons are in the outer shell of that column's atoms. In family **I**, sodium metal reacts violently with water and so will K, Li, Rb, Cs, and Fr. The members of family **VII** (Cl, Br, etc.) are all oxidizing agents.

Refer to the PERIODIC TABLE

What do all those letters mean?

The letters on the periodic table are abbreviations of the names of the **ELEMENTS** (but not necessarily in English). For example, the abbreviation for Sodium, "Na," stands for the Greek name of that chemical: "Natrium." Elements are the smallest unit of a substance that cannot be reduced by classical chemical processes.

You don't have to remember what ALL of the letters stand for; just be familiar with the "Top 25," which will appear in most hazardous materials:

SYMBOL	ELEMENT	SYMBOL	ELEMENT
H	Hydrogen	Al	Aluminum
Li	Lithium	C	Carbon
Na	Sodium	Sn	Tin
K	Potassium	Pb	Lead
Mg	Magnesium	N	Nitrogen
Ca	Calcium	P	Phosphorus
Ba	Barium	O	Oxygen
Cr	Chromium	S	Sulfur
Fe	Iron	F	Fluorine
Co	Cobalt	Cl	Chlorine
Cu	Copper	Br	Bromine
Hg	Mercury	I	Iodine
B	Boron		

Atoms are of different sizes and their relative size is indicated by their position in the table. As you read DOWN a column, elements are larger, heavier, and more likely to be a solid. As you read ACROSS a row (from left to right) elements get smaller, lighter, and more likely to be a gas. There are a few other rules to remember:

Family VIII is the very **STABLE**, (i.e. non-reactive) **NOBLE GASES**.

METALS are in the left portion of the table and are solids with a few exceptions (like Hg).

NONMETALS are in the right portion of the table and can be solids, liquids, or gases but more than half are gases.

METALLOIDS are the elements located along the division between metals and non-metals. They combine characteristics of metals and non-metals. They include SEMI-CONDUCTORS (Silicon, Germanium).

ACIDIC properties of elements increase as you read from left to right.

BASIC properties of elements increase as you read from right to left.

IONIZATION ENERGY increases as you go from left to right.

HYDROGEN doesn’t really fit in with any family.

PERIODIC TABLE OF THE ELEMENTS

1 2 (new style) IA (old style)	3 IIA	4 IIIB	5 IVB	6 VB	7 VIB	8 VIIB	9 VIII	10 VIII	11 VIII	12 IB	13 IIB	14 IIIA	15 IVA	16 VA	17 VIA	18 (new style) VIIA (old style)	
1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.179
11 **Na** 22.99	12 **Mg** 24.305											13 **Al** 26.98	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.453	18 **Ar** 39.95
19 **K** 39.102	20 **Ca** 40.08	21 **Sc** 44.956	22 **Ti** 47.9	23 **V** 50.941	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.847	27 **Co** 58.933	28 **Ni** 58.71	29 **Cu** 63.546	30 **Zn** 65.37	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.22	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** 98.906	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.4	47 **Ag** 107.87	48 **Cd** 112.40	49 **In** 114.82	50 **Sn** 118.69	51 **Sb** 121.75	52 **Te** 127.6	53 **I** 126.90	54 **Xe** 131.3
55 **Cs** 132.91	56 **Ba** 137.34	57 **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.09	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.37	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (210)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.03	89 **Ac** (227)	104 **Unq** (261)	105 **Unp** (262)	106 **Unh** (263)	107 **Uns** (262)											

Lanthanides (*or Lanthanoids inc. La*)	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (147)	62 **Sm** 150.4	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
Actinides (*or Actinoids inc. Ac*)	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	94 **Pu** 239.05	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (245)	98 **Cf** (248)	99 **Es** (254)	100 **Fm** (253)	101 **Md** (256)	102 **No** (254)	103 **Lw** (257)

The NOBLE GASES have a complete valence shell of eight electrons and so are very stable or non-reactive.

The ATOMIC NUMBER is the digit in the upper left corner of each block. It tells you the number of protons in an atom. Since atoms have an overall neutral charge, this is also the number of electrons. Note that each atomic number is a whole number and unique. The number of protons in an atom's nucleus determines its identity.

The ATOMIC WEIGHT is the number at the bottom of each block. It represents the average weight (in Atomic Mass Units, AMUs) of an average atom of a given element. It is the weight of an atom's number of protons plus number of neutrons. Electrons have negligible mass and are ignored in this calculation. Atoms of a non-average weight for a given element are called **ISOTOPES**. They have a different weight because they have a non-average number of neutrons in their nucleus. (Remember: it is the number of PROTONS that determines an atom's identity.)

Comparison of Sub-Atomic Particles

PARTICLE	**CHARGE**	**MASS**
Proton	+1	1 AMU
Neutron	0	1 AMU
Electron	–1	0 AMU

CHARGED ATOMS (IONS)

While they normally have a neutral charge, atoms can become electrically charged or **IONIZED**. If an atom loses an electron, it will have one more proton than electron and so will have a net positive charge. We refer to this atom as a **CATION**. If an atom gains an electron, it now has a net negative charge and we refer to it as an **ANION**. The size of an atom determines whether it gains or loses an electron.

We describe the tendency of atoms to gain or lose electrons as **ELECTRONEGATIVITY** (tends to gain electrons) or **ELECTROPOSITIVE CHARACTER** (tends to lose electrons). The tendency to gain electrons (electronegativity) **increases** as the size of the atom **decreases**. Referring back to the period table, electronegativity increases (atom size decreases) as you go from left to right across a row (or up a column).

Electropositive character **increases** as the size of the atom **increases**. On the periodic table, electropositive character increases (size increases) as you go from right to left across a row (or down a column).

RADIOACTIVITY

The nucleus of an atom is made of protons and neutrons, as we stated earlier. We would expect the protons to repel each other, each being of a +1 charge, unless they are held together by some other force. This force, the "strong atomic force" is supplied by neutrons. In smaller atoms, atomic number 20 and below, the nucleus is stable with an equal number of protons and neutrons. With larger atoms, stability is only achieved with a greater number of protons than neutrons. The ratio of neutrons to protons to achieve stability increases until above $_{83}$Bi209 where there are no completely stable atoms. For any element there is a range of atomic weights that will form a stable nucleus (see ISOTOPES). If an atom has a weight outside of its stable range (right number of protons, wrong number of neutrons), it must do something to gain stability. That "something" is to emit a particle or energy in the form of IONIZING RADIATION. The Rate at which this energy and particle emission takes place is called the **rate of radioactive decay** and usually expressed as the **half-life (t$_{1/2}$)** of the nucleus.

Half-life is the time required for half of the atoms in a given amount of a radioactive substance to emit energy or particles and reduce themselves, or "decay" into a more stable state. For the radioactive nitrogen isotope, the half-life is 10.1 minutes. This means that for any group of these nitrogen isotopes, half will have decayed at the end of 10.1 minutes; half of the remainder will decay during the 10.1 minutes after that; and so-on.

SOME COMMON ISOTOPES AND THEIR HALF-LIVES (t$_{1/2}$)				
ISOTOPE	**HALF-LIFE (T$_{1/2}$)**		**ISOTOPE**	**HALF-LIFE (T$_{1/2}$)**
Thorium 232	13,900,000,000 years		Polonium 210	138.3 days
Uranium 238	4,490,000,000 years		Strontium 89	53 days
Uranium 235	713,000,000 years		Barium 140	12.8 days
Chlorine 36	310,000 years		Iodine 131	8.1 days
Uranium 233	162,000 years			
Nickel 59	80,000 years		Bromine 82	35.3 hours
Plutonium 239	24,360 years		Copper 64	12.8 hours
Carbon 14	5,745 years		Potassium 42	12.4 hours
Celsium 137	30 years			
Cobalt 60	5.3 years			
Cesium 134	2.9 years			

Certain isotopes and elements are unstable as they occur in nature and are called "natural radio nuclides." Others occur as the result of man-made nuclear reactions and are called "artificial radio nuclides."

Particles and rays (ionizing radiation) are, generally, emitted in three forms during radioactive decay: **alpha** and **beta particles**, or **gamma rays**.

Alpha particles (α) are, essentially, helium nuclei: two protons and two neutrons. They are massive and travel only three or four inches from a radioactive source. Very little shielding is required to stop alpha particles; several sheets of paper are enough. Alpha particles are dangerous because sources of alpha radiation can be inhaled causing internal organ exposure and possible cancer risks.

Beta particles (β) are more energetic and less massive than alpha particles. They can be either electrons, carrying a negative electrical charge, or positrons, carrying a positive charge. Beta particles can travel up to one hundred feet from their source and can penetrate firefighter's turnout gear. They can be stopped by one millimeter of aluminum.

Gamma rays (γ) or photons are not particles but are a form of pure energy. They are like X-rays and can travel great distances from their source. Gamma rays can only be attenuated by massive shielding: three inches of lead.

As radioactive isotope emits radiation to gain stability, it will loose mass and form decay products (or daughter products) that may, in turn, be radioactive. Radium, for example, emits alpha particles to become radon as follows:

$$_{88}\mathrm{Ra}^{226} \text{ -> } _{86}\mathrm{Rn}^{222} + {}_{2}\mathrm{He}^{4}\ (\alpha)$$

We measure radiation doses in terms of roentgens, rads, and relative biological effectiveness.

A **roentgen** is the amount of radiation produced by a specific size electrical discharge in a unit of dry air. It actually only applies to gamma radiation or X-rays.

A **REM** (**R**oentgen **E**quivalent in **M**an) is a measure of the amount of radiation you have received. Along with the rad, the REM is a unit of measure that is of more concern to the health physicist. Usually the REM is too large a unit to conveniently deal with so it is divided into **millirems** (mrem) each of which is 1/1000 of a REM.

A **rad** is the energy imparted to matter by any ionizing radiation.

The metric system is replacing our current units to measure ionizing radiation. The International System of Units (SI) radiation units are related to the system current usage in the United States as follows:

Current Units	SI Units
1 curie (ci)	3.7 x 1010 Becquerel (Bq)
1 Roentgen	2.58 x 10-4 coulomb/Kg of air
1 rad	0.01 Gray (Gy)
1 rem	0.01 Sievert (Sv)

Relative biological effectiveness (RBE) is a ratio that relates the absorbed dose of different types of ionizing radiation to produce similar biological effects. The RBE of a given radiation is the ratio of the absorbed dose (rads) of gamma radiation to the absorbed dose of the given radiation required to produce the same biological effect. If an absorbed dose of 0.2 rad of slow neutron radiation produces the same biological effect as an absorbed dose of 1 rad of gamma radiation, the RBE for slow neutrons would be:

RBE = 1 rad/0.2 rad = 5

The value of the RBE for a particular type of nuclear radiation depends on several factors, such as the energy of the radiation, the kind and degree of the biological damage, and the nature of the tissue under consideration.

RBE for different types of radiation

Radiation	RBE
X-ray or gamma	1
Beta	1
Alpha	10
Proton	10
Fast Neutron	10
Fast Neutron	5

Radioactive contamination (like chemical contamination) occurs when we discover the material in question in an undesired location. Fixed contamination is a source which is not easily removed by touching the object or surface. Loose contamination is readily removed by touching the object or surface. Airborne contamination is a suspension of particles of radioactive material in the air. Dust can be washed off but if improper respiratory protection is worn, there is a chance that radioactive dust may be inhaled.

Inhaled, ingested, or absorbed radioactive contamination can cause internal exposure to radiation. The total radiation dose received by a worker is the external dose (measured by film badge and reported as “whole body dose”) plus the dose from internal sources. Since the most common source of internal radiation in emergency service people is inhalation of contaminated particles in air, an air monitoring program and respiratory protection should be established when there is a chance of radioactive contamination.

After entering the body, radioactive materials migrate to “target organs” depending on their biochemistry. Uranium, for instance, migrates to the bones where it remains for a long time, being slowly excreted from the body by way of the kidneys. Radioactive iodine is deposited in the thyroid glands.

Internal dose cannot be measured by film badges or dosimeters carried by workers. It must be estimated by indirect methods such as calculation from the amount of containment found in the air, measurement of excreted radiation in stool and urine, or measuring the radiation emitted by a workers body.

The effect of radiation on you is related to your total accumulated dose. Acute effects usually have an observed minimum dosage below which there is no evidence of any effect. There is, however, increasing evidence that there is no threshold for chronic (long-term) effects; i.e. ANY DOSE, NO MATTER HOW SMALL PRODUCES SOME DAMAGE.

The biological effects of heavy particle ionizing radiation are approximately proportional to what is called **Absorbed Dose** (or simply dose). This is measured with instruments which detect the average energy deposited inside a small test volume.

The current unit of dose is the **gray** (abbreviated **Gy**) which represents the absorption of an average of one joule of energy per kilogram of mass in the target material. This new unit has officially replaced the **rad**, an older unit (but still seen a lot in the radiation literature). One gray equals 100 rads. Absorbed Dose was originally measured for x-rays and gamma radiation. When used in predicting biological damage, a further distinction must be made as to the "quality" of the radiation.

Although the Absorbed Dose of some radiation may be measured, another level of consideration must be made before the biological effects of this radiation can be predicted. The problem is that although two different types of heavy charged particle may deposit the same average energy in a test sample, living cells and tissues do not necessarily respond in the same way to these two radiations. This distinction is made via the concept of **Relative Biological Effectiveness (RBE)** which is a measure of how damaging a given type of particle is when compared to an equivalent dose of x-rays. The Quality Factor of a given type of radiation is determined in the following way: A group of RBE measurements are made using a variety of cells and/or tissue (these experiments aren't cheap to perform and the number that are done is driven by the overall interest in the radiation being studied). Basically, the RBE is determined by comparing the damage of the radiation to the cells/tissue of interest to that with an equal dose of gammas or x-rays. Once the RBE data are in hand, a committee of radiation experts meets and considers all the available data and then assigns a Quality Factor to the radiation.

For example, the RBE of alpha particles has been determined (by committee) to be 20 (apparently not very dependent on the energy of these particles). This means that 1 Gy of alphas is equivalent to 20 Gy of gammas/x-rays. Another way to say this is to use a new unit, the **sievert (Sv)** which measures Dose Equivalent (the old unit is the **rem**; 1 sievert = 100 rem). Thus 1 GV absorbed dose of alpha particles is 20 Sv dose equivalent.

Given that, usually, only moderate doses of radiation are encountered (and thus acute effects are not seen) the long-term effects of radiation become more important to consider. The passage of an energetic charged particle through a cell produces a region of dense ionization along its track. The ionization of water and other cell components can damage DNA molecules near the particle path but a "direct" effect is breaks in DNA strands. Single strand breaks (SSB) are quite common and Double Strand Breaks (DSB) are less common but both can be repaired by built-in cell mechanisms. "Clustered" DNA damage, areas were both SSB and DSB occur can lead to cell death. For most cell types, the death of a single cell is no big deal—cells continually die and are replaced by normal processes. A more dangerous event may be the non-lethal change of DNA molecules which may lead to cell proliferation, a form of cancer.

Every day, you receive a radioactive dose from natural, medical, or occupational sources. Annually, the average person receives a dose of nearly 200 mrems (0.2 Roentgens) which is 0.2 times the dose (1R) that is expected to produce 1 additional death from cancer per 10,000 people (1 in 10^4 risk). The expected cancer rate for a group of 10,000 from all causes is 1640 so you can see that this is a risk assessment surrounded by controversy. For comparison, a worker in the nuclear industry is allowed to receive a dose of 5 rems per year; a member of the general public is allowed no more than 0.5 rems per year.

Time exposed, **distance** from a radioactive source, and **shielding** used all combine to limit the dose of radiation you receive at a radiation incidence. It should be obvious that the shorter the time you are at a site, the less radiation your body can absorb. In this way, exposure to individuals can be controlled by work schedules.

Your exposure to radioactive particles and rays (measured in roentgens) changes with the **distance** from a radioactive source. The rate that radiation drops according to distance from its source is described by the "inverse square law." A source that is measured as releasing a dangerous concentration of radiation in its immediate proximity may pose no threat to workers outside of the incident hot zone.

Shielding is another way to limit exposure to radiation. Shielding is any material or equipment designed to limit the penetration of radioactive particles or energy. Shielding can be had in the form of "portable," lead-filled shields that look like sections of office cubicle walls; transparent, lead impregnated plastics; and lead-lined or impregnated clothing.

ESTIMATED DOSE RATES IN THE UNITED STATES (1970)	
SOURCE	AVERAGE DOSE RATE (mrem/year)
Environmental	
natural	102
fallout	4
nuclear power	0.003
Medical	
diagnostic	72
radiopharmaceuticals	1
Occupational	0.8
Miscellaneous	2
TOTAL	**182 mrem**

MIXTURES AND COMPOUNDS

Mixtures are blends of substances that do not chemically bond and can be readily separated by physical means. For example, sugar is soluble in water but the mixture can be separated by boiling off the water to leave sugar crystals behind. Compounds are formed when atoms of elements bond chemically and cannot be readily separated as when hydrogen and oxygen bond to form water. This chemical bonding is really a matter of sharing or trading electrons (and electrical charges) between atoms.

BONDAGE

Now, if we were to place an electropositive atom near an electronegative atom, the larger atom would lose an electron to the smaller atom and become a cation. The smaller atom would gain an electron from the larger and become an anion. The two ions would **BOND** together to form a **MOLECULE**. The type of bond formed between oppositely charged ions is called an **IONIC BOND** and the compounds formed by this type of bond are called **SALTS**.

SALTS tend to be:
1) solids
2) water soluble
3) conduct electricity when dissolved in water
4) non-combustible (though some are strong oxidizers)

Salts are formed when nonmetal atoms bond with metal atoms (see periodic table). An example is table salt. It is made of equal portions of sodium and chlorine (metal + nonmetal) and its chemical formula is NaCl.

A second type of atomic bond you should be aware of is the sharing or **COVALENT BOND**. If two atoms of similar electronegative or electropositive character bond together, neither atom will be able to lose or gain an electron. The atoms will share their electrons. Atoms that come together with a covalent bond form **NONSALT** molecules.

NONSALTS tend to be:
1) liquids and gases
2) insoluble in water

3) non-conductors of electricity when dissolved in water
4) **FLAMMABLE**

Nonsalts are formed when nonmetals bond with nonmetals (see periodic table).

To summarize:

METAL + NONMETAL = SALT (ionic bonds)

NONMETAL + NONMETAL = NONSALT (covalent bonds)

SPOT QUIZ I

1) The anion, IODINE, is needed and used by the thyroid gland, why does the radioactive anion ASTATINE, if ingested, tend to isolate in the thyroid gland?

2) Of these elements, which are nonmetals?

C; Ba; O; F; Na; As

3) Which of these compounds is a salt and which is a nonsalt?

a) C_6H_6
b) $MgCl_2$
c) $Mg(NO_3)_2$
d) Na_2O

OCTET LAW

All atoms lose, gain, or share electrons to complete their outer (valence) electron shell with eight electrons. In doing this, they bond together to form molecules of compounds. As a general rule, metals lose electrons and become cations. Nonmetals gain electrons to become anions.

MOLECULES

As atoms are the smallest units of elements, molecules are the smallest units of compounds. Molecules are described in chemical **FORMULAS** and are electrically neutral in charge. Refer to the periodic chart while going over the following examples:

COMPOUND 1:

loses 1 electron		gains 1		+1-1		
Na	+	F	=	NaF	=	NaF
				(balanced)		(formula)

COMPOUND 2:

loses 3 elec.		gains 1		+3-1		+3 (3x-1 = -3)		
Al	+	Cl	=	AlCl	=	Al 3Cl	=	$AlCl_3$
				(unbalanced)		(balanced)		(formula)

COMPOUND 3:

loses 2 elec. gains 3 +2-3 (3x + 2 = 6) (2x - 3 = 6)
Mg + N = MgN = 3Mg 2N = Mg_3N_2
(unbalanced) (balanced) (formula)

A balanced formula for a compound tells you how many atoms of each element are in a molecule of that compound.

Metals tend to lose electrons and become positively charged. **Nonmetals tend to gain electrons** to complete their outer shell octet and become negatively charged. The transition elements (heavy metals) of families IB-VIIIB can be variable in charge:

SYMBOL:	**CHARGE:**	**NAME:**
Fe	+3	Iron III
Fe	+2	Iron II
Co	+2	Cobalt II
Co	+1	Cobalt I
Mn	+3	Manganese III
Mn	+2	Manganese II
Cr	+3	Chromium III
Cr	+2	Chromium II
Ni	+2	Nickel
Cu	+2	Copper II
Cu	+1	Copper I
Hg	+2	Mercury II
Hg	+1	Mercury I

So far, all of the compounds we have looked at contained only two elements but salts can be made of more than two elements. Some salts contain **RADICAL ANIONS** which are covalently bonded (sharing bonded) nonmetals that act as a single atom.

The radical anions (or RADICALS) are:

1) The **HYDROXIDE** Anion: $(OH)^{-1}$

2) The **PEROXIDE** Anion: $(O_2)^{-2}$

3) The **OXY Anions:** (several—watch the word endings)

   A) Normal Oxy-state:

$(CO_3)^{-2}$	Carbon**ate**
$(PO_4)^{-3}$	Phosph**ate**
$(NO_3)^{-1}$	Nitr**ate**
$(SO_4)^{-2}$	Sulf**ate**
$(ClO_3)^{-1}$	Chlor**ate**
$(IO_3)^{-1}$	Iod**ate**
$(BrO_3)^{-1}$	Brom**ate**
$(MnO_3)^{-1}$	Mangan**ate**

B) Varied Oxystates:

Number of O^{-2}:	General case:	Example:
1	$(XO)^{-2}$ -hypo state	$(ClO)^{-1}$ **Hypo**chlor**ite**
2	$(XO_2)^{-2}$ -ite state	$(ClO_2)^{-1}$ Chlor**ite**
3	$(XO_3)^{-2}$ -ate state	$(ClO_3)^{-1}$ Chlor**ate**
4	$(XO_4)^{-2}$ per- state	$(ClO_4)^{-1}$ **Per**chlor**ate**

Elements among the nonmetals that form common OxyAnion radicals are C, N, P, S, Cl, Br, and I. These OxyAnion radicals combine with metals to form OxySalts.

Some examples of **OxySalts** are:

$Na^{+1}\ SO_4^{-2}$	=	Na_2SO_4	Sodium Sulfate
$Ca_{+2}\ PO_3^{-3}$	=	$Ca_3(PO_3)_2$	Calcium Phosphate
$Al^{+3}\ ClO^{-1}$	=	$Al(ClO_3)$	Aluminum Hypochlorite
$Fe_{+3}\ SO_3^{-2}$	=	$Fe_2(SO_3)_3$	Iron III Sulfite

NOW: Let's look at the different families of salts and the general hazards associated with each group.

1) **BINARY**

General Formula: Metal + Nonmetal (ex. Oxygen)
Name: ends in -ide

There are no general guidelines for this group. Look up each compound and treat the group with respect.

Examples:

Sodium Fluoride	Rat Poison
Sodium Chloride	Table Salt
Aluminum Trichloride	Reacts violently with water and produces Hydrogen Chloride gas
Calcium Carbide	Reacts violently with water and produces Acetylene gas

When ANY salt reacts with water, heat is produced. There may be enough heat to ignite nearby combustible materials, like Acetylene gas.

2) **METAL OXIDES**

Formula: Metal + Oxygen
Name: ends with oxide

General Guidelines: They react with water producing heat and caustic solutions which can cause severe skin burns.

Examples:

Sodium Oxide
Magnesium Oxide
Iron III Oxide (Rust)

3) **HYDROXIDES**

Formula: Metal + Hydroxide Radical
Name: ends in hydroxide

General Guidelines: React with water and produce VERY caustic solutions.

Examples:

Potassium Hydroxide (Lye)
Sodium Hydroxide
Calcium Hydroxide

OXIDIZING AGENTS—A substance that has the potential to release oxygen (usually accompanied by heat). An **OXIDIZER**

4) **PEROXIDES**

Formula: Metal + O2-2 (peroxide radical)
Name: ends in peroxide

General Guidelines: Strong oxidizing agents. Unstable and react violently with water, producing heat and oxygen.

Examples:

Sodium Peroxide
Magnesium Peroxide

SAFETY TIP:

In general, don't add water to salts;
most release heat and produce corrosive solutions.

5) **OXYSALTS** (Unstable Oxidizers)

Formula: Metal + oxyradical
Name: ends in -ate or -ite

General Guidelines: **VERY UNSTABLE** compounds!! Use **EXTREME CARE** when working with them. They do not react with water but will dissolve in it.

Examples:

Potassium Nitrate	Used in gunpowder
Potassium Permanganate	Strong oxidizer
Sodium Perchlorate	Used in explosives and jet fuel

When unstable oxidizers come into contact with a **CHEMICAL** (water) or **ENERGY** (flame, spark, heat, or pressure) **ACTIVATOR**, they can easily decompose, and release large amounts of heat and oxygen. Even sunlight can be an energy activator of some oxidizers so they are stored in opaque or amber colored containers. As you remember, salts are non-flammable but they can ignite other materials around them and some produce flammable decomposition products.

SPOT QUIZ II

1) What is the octet law of bonding?

2) "Balance" the following salt formulas:

a) NaF	d) CaO
b) SnF	e) $NaSO_2$
c) CuS	f) MgN

3) Identify these salts as a) binary, b) oxide, c) hydroxide, d) peroxide, or e) oxysalt.

a) Na_2O	c) $Mg(NO_3)_2$	e) KOH	g) $Sn(ClO)_2$
b) $Ca(OH)_2$	d) Li_2O_2	f) $Ca(BrO_4)_2$	h) K_2S

4) Why are amber colored jars sometimes used to store salt type oxidizing agents?

CONGRATULATIONS!!!
You have just completed Chemistry 101 and now, it's time for a break!

SOPHOMORE CHEMISTRY 201
ORGANIC

Before the break, we were talking mainly about salts (metal + non-metal). Now we're going to deal with the non-salts (non-metal + non-metal), especially **HYDROCARBONS** (compounds containing only carbon and hydrogen) and **HYDROCARBON DERIVATIVES** (compounds developed from hydrocarbons). NonSalts are a group that includes many hazardous materials.

NonSalts tend to be:
1) gases and liquids
2) insoluble in water
3) very toxic
4) reactive with air or oxidizers
5) flammable

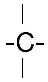
Remember: definition for a nonsalt is:
NONMETAL + NONMETAL = NONSALT

They are held together by covalent (sharing) bonds

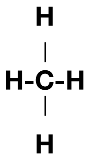
In order to understand nonsalts, we must have a way of examining their structure in addition to their formula. We'll start by looking at a common gas: methane (CH_4).

Let's look at a molecule using the DASH MODEL ("Kekule Model").

1) A dash will represent an electron that an atom needs to complete its outer shell:

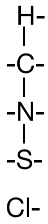
H- (needs one electron)  $-\overset{|}{\underset{|}{C}}-$ (needs four electrons)

2) A dash will also represent an electron paired by two atoms; so with the dash method, methane (CH_4) is:



$$\begin{array}{c} H \\ | \\ H-C-H \\ | \\ H \end{array}$$

Some other atoms are represented:

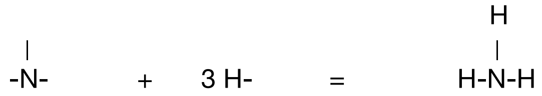


H (Family I) .... H-
C (Family IV) .... -C-
N (Family V) .... -N-
S (Family VI) .... -S-
Cl (Family VII) .... Cl-

We will be using the Kekule model for the rest of this section.

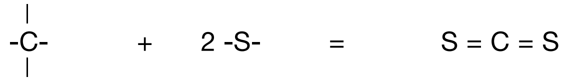
Some other examples of the Kekule method for representing molecular structure are:

Compound 1:



$-\overset{|}{N}- \quad + \quad 3\ H- \quad = \quad H-\overset{\overset{H}{|}}{N}-H$ NH_3 Ammonia gas

Compound 2:



$-\underset{|}{\overset{|}{C}}- \quad + \quad 2\ -S- \quad = \quad S = C = S$ CS_2 Carbon Disulfide

Compound 3:

$-\underset{|}{\overset{|}{C}}- \quad + \quad -\overset{|}{N}- \quad = \quad H-C = N$ HCN Hydrogen Cyanide

Three covalent bonds is the greatest number of bonds any two atoms can share.

We use the formula of a substance to reveal its structure. Knowing the structure of a molecule is important in determining the hazardous nature of a compound.

SPOT QUIZ III

Diagram the structure of these compounds with the dash method:

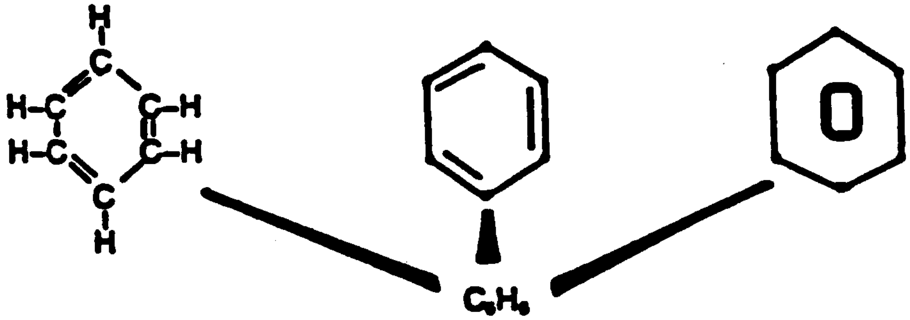
H_2O
CO_2
CH_3OH

SINGLE & MULTIPLE BONDS

In general, compounds with multiple bonds between atoms are more unstable than those with single bonds (C = C as opposed to C-C) that is, THEY ARE MORE REACTIVE.

Compounds with multiple bonds can react with Oxygen in the air or Oxidizers without **ANY** outside heat. Some examples are acetylene and carbon disulfide. Acetylene, stored for extended periods of time, can react explosively with oxygen in the air. Carbon disulfide is so reactive with oxygen that it can be ignited by the heat from a steam pipe. Turpentine can undergo spontaneous combustion at room temperature! **Oxygen is a VERY electronegative substance and will react with ANY loosely held electrons** (hence its affinity for multiple-bond compounds).

There is one exception to this multiple bond principal: the **RESONANT BONDS** found in the **AROMATIC** compounds. The **CYCLIC** structure of Benzene, Toluene, Xylene, Styrene, etc. is quite stable. The structure is usually represented in three ways:



NOTE: frequently, Hydrogen atoms are not represented in the structure diagram of a molecule. There may be so many of them the structure that, to save time, it is assumed that you know they are there, attached to those dashes on the Carbon atoms.

SHAPE

Different molecules with the same formula but different shapes are called **ISOMERS**. Molecules come in three basic shapes:

1) Straight chains
2) Branched chains
3) Cyclic or rings

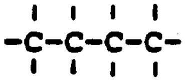
a) Cyclic (ring) structures are the most stable

b) Branched chains are the next most stable

c) Straight chains are the least stable and comparatively rare

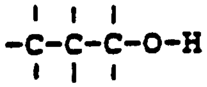
STRAIGHT CHAINS:

are a continuous chain of atoms (excluding Hydrogen atoms):



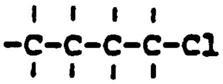
$$-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-$$

Butane
C_4H_{10}



$$-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-O-H$$

Propyl
C_3H_7OH

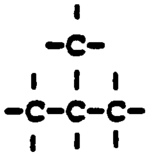


$$-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-Cl$$

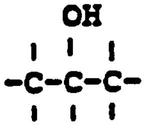
Butyl Chloride
C_4H_9Cl

BRANCHED CHAINS:

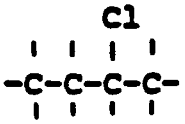
are a continuous chain of atoms with one or more branches of one or more atoms (excluding Hydrogen):



Iso Butane
C_4H_{10}



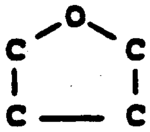
Iso Propyl Alcohol
C_3H_7OH



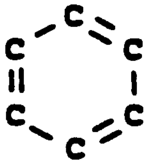
Sec. Butyl Chloride
C_4H_9Cl

CYCLIC:

Rings of five or six atoms are most common:



Tetra Hydro Furan (THF)
$C_4H_{10}O$



Benzene
C_6H_6

WHAT DOES THE SHAPE OF A MOLECULE TELL US?

Branched isomers are more common and have a greater fire potential (and make better fuels) than straight-chain molecules. For example:

n-Octane has a flash point of 56°F (13.3°C)

iso-Octane has a flash point of –10°F (–12.2°C)

RULE-OF-THUMB: Unless it's an AROMATIC, the molecule is probably BRANCHED.

The name of a compound can help you determine its molecule's shape.

The molecule is BRANCHED if the name has a prefix like iso-, sec.-, tert.-, neo-, etc.

The molecule is STRAIGHT if there is no prefix.

The molecule is cyclic if the name implies that the compound is an AROMATIC.

SUMMARY

1) If a formula is only nonmetals, the compound is a nonsalt.
2) Generally, nonsalts are:
    - a) mostly gases and liquids
    - b) moderately to very toxic
    - c) insoluble in water
    - d) flammable
3) Diagram the structure of a molecule to determine the types of bonds.
4) Isomers of a compound may behave very differently.
5) A molecule's shape can be:
    - a) Straight
    - b) Branched
    - c) Cyclic

When reading chemical names, prefixes can indicate the number of Carbon atoms in the radical:

PREFIX:	NUMBER OF CARBONS:
METH-	one
ETH-	two
PROP-	three
BUT-	four
PENT-	five
HEX-	six
HEPT-	seven
OCT-	eight
NON-	nine
DEC-	ten

A molecule with 1-4 Carbon atoms in a chain is a gas at normal temperature and pressure, 5-17 is a liquid, and 18 or more is a solid.

FAMILIES OF ORGANIC CHEMICALS:

Just as there were "families" of chemicals among the salts, there are "families" among the nonsalts. First, we'll look at the Families of hydrocarbons.

Hydrocarbons contain only Carbon and a few other nonmetals (and mainly Hydrogen). They are the largest class of covalently bonded molecules and can be broken down into a few families with similar formulae, names, and hazardous behaviors.

1) **SATURATED HYDROCARBONS:**

ALKANES can form straight or branched chain isomers
General Formula: C_nH_{2n+2} eg. C_5H_{12}

The Alkanes occur naturally in petroleum oil. The names of alkanes end with **-ane**; meth**ane**, prop**ane**, oct**ane** (beware of "trade" names like "kerosene," "gasoline," etc. They are called "saturated" because they have the greatest possible number of hydrogen atoms for a given number of carbons. The carbons all have **single bonds** to the other atoms.

The smaller alkanes (methane-pentane) have relatively low toxicity. The larger alkanes (hexane and larger) tend to be very toxic.

2) **UNSATURATED HYDROCARBONS:** ALKENES & ALKYNES

These compounds are "unsaturated" because they have less than the maximum number of hydrogens for a given number of carbons. Molecules of these compounds will have multiple bonds.

ALKENES Straight or branched chain isomers.
General Formula: C_nH_{2n} eg. C_5H_{10}

Structurally: These molecules have a double (C=C) bond. Molecules with multiple bonds are quite reactive. The names of alkene compounds end in **-ene**.

ALKYNES Straight or branched chain isomers.
General Formula: C_nH_{2n-2} eg. C_2H_2; C_4H_6

Structurally: These molecules have a triple (C=C) bond. Molecules with multiple bonds are quite reactive. Properly, the names of alkynes end in **-yne** but the one that you will most frequently encounter is **ACETYLENE** (C_2H_2) (go figure).

3) **AROMATICS HYDROCARBONS:** Cyclic structure ("benzene ring")

The "coal tar" family: General Formula: C_nH_{2n-6} eg. C_6H_6

These chemicals occur naturally, many in petroleum oil. There is no uniform naming system for the aromatics but there are relatively few of them. The three aromatics you are most likely to encounter are **BENZENE, TOLUENE, OR XYLENE**. The aromatics have a six carbon ring with resonant bonding and are very stable. Aromatic vapors may have a pleasant odor but can be **VERY TOXIC**. Remember, many insecticides are derived from aromatic compounds. Avoid skin contact, ingestion, or inhalation.

COMPARISON OF ALKANES, ALKENES AND ALKYNES:

ALKANES:
ETHANE (C_2H_6): B.P.-89°C; LEL = 3% UEL = 12.5% (range = 9.5%)
PROPANE ($CH_3CH_2CH_3$): B.P.-42°C; LEL = 2.1% UEL = 9.5% (range = 7.4%)

ALKENES:
ETHENE (ETHYLENE) (C_2H_4): B.P.-104°C; LEL = 2.7% UEL = 36% (range = 33.3%)
PROPYLENE (CH_2CHCH_3): B.P.-47°C; LEL = 2% UEL = 11% (range = 9%)

ALKYNES:
ETHYNE (ACETYLENE) (C_2H_2): F.P.18°C; LEL = 2.5% UEL = 100% (range = 97.5%)

SPOT QUIZ IV

1) Using the dash (Kekule) model, show the structure of these compounds:

   a) NI_3
   b) C_2Cl_3H
   c) C_2H_2
   d) C_3H_6
   e) C_6H_6 (cyclic)
   f) C_4H_{10}

2) Identify the following compounds as saturated, unsaturated, or aromatic:

   a) C_3H_8
   b) C_8H_{16}
   c) C_8H_8
   d) $C_{10}H_{18}$

3) Identify the following compounds as alkanes, alkenes, alkynes, or aromatics:

   a) C_4H_{10}
   b) Toluene
   c) C_2H_2
   d) Tridekane
   e) C_6H_6
   f) Octylene

4) What are the three aromatic hydrocarbons you are most likely to encounter?

5) What is the name and formula of the alkyne you are most likely to encounter in the field?

Now, we'll cover the **HYDROCARBON DERIVATIVES**.

Hydrocarbon derivatives are, logically, derived from petroleum hydrocarbons.

Petroleum hydrocarbons **(H-C)** are used as the raw material for 225 billion pounds (2.25 x 10") of synthetic organic chemicals annually. That works out to 1200 pounds (1.2 x 10_3) of H-C derivatives produced for each man, woman, and child in the U.S.

Most H-C derivates are made from eight petroleum H-Cs:

SATURATED	Methane - CH_4	
	Ethane - C_2H_6	
	Propane - C_3H_8	
	Butane - C_4H_{10}	
UNSATURATED	Ethylene - C_2H_4	
AROMATIC	Benzene - C_6H_6	"BTX" Group
	Toluene - C_7H_8	
	Xylene - C_8H_{10}	

A Hydrocarbon derivative is a compound with a H-C backbone (called a **RADICAL**) which is attached to other elements (like N, O, etc.) called the **functional group**. The functional group determines the family and behavior of a compound.

As an example:

From the following compounds remove a hydrogen:

SATURATED	C_4H_{10}
UNSATURATED	C_2H_4
AROMATIC	C_6H_6

This yields three radicals or H-C fragments:

SAT.RADICAL	C_4H_9-
UNSAT.RADICAL	C_2H_3-
AROM.RADICAL	C_6H_5-

Now, attach a functional group (we'll call it "Y") to each radical:

SAT.DERIVATIVE	C_4H_9 - Y
UNSAT.DERIVATIVE	C_2H_3 - Y
AROM.DERIVATIVE	C_6H_5 - Y

Each compound has a different backbone (radical) but the same functional group and it is the functional group that determines the derivative's family and behavior.

The families and functional groups of H-C derivatives are:

Alkyl Halides	X (any Halogen)
Alcohols	OH
Ethers	O
Amines	N
Ketones	CO
Esters	CO_2
Aldehydes	CHO

The structures are usually not on product labels but you can still use label formulas to identify the family of a product. Remember: the **functional group** is the key to identification.

FORMULA:	FAMILY:	NAME:
$C_2H_2\mathbf{X}$	Alkyl Halides	Ethyl Halide (Flouride, Bromide, Chloride, Iodide)
t-$C_4H_9\mathbf{OH}$	Alcohols	Tertiary Butyl Alcohol
$(C_2H_5)2\mathbf{O}$ or $C_2H_5\mathbf{O}C_2H_5$	Ethers	D-Ethyl Ether
$CH_3\mathbf{N}H_2$	Amines	Methyl Amine
$(CH_3)_2\mathbf{N}H$	Amines	D-Methyl Amine
$(CH_3)_3\mathbf{N}$	Amines	Tri-Methyl Amine

NAMING THE MEMBERS OF A FAMILY:

On the left of the chart is the H-C raw material, on the right is the derived radical.

COMPOUND:	NAME:	RADICAL:	NAME:
CH_4	Methane	CH_3	Methyl-
C_2H_6	Ethane	C_2H_5	Ethyl-
C_3H_8	Propane	C_2H_7	Propyl-
		C_3H_7	IsoPropyl-
C_4H_{10}	Butane	C_4H_9	Butyl-(normal)
		C_4H_9	IsoButyl-
		C_4H_9	Sec.Butyl-
		C_4H_9	Tert.Butyl-
C_2H_4	Ethylene	C_2H_3	Vinyl-
C_6H_6	Benzene	C_6H_5	Phenyl-

Start with the formula of a H-C derivative: n-$C_4H_9OC_2H_5$

1) It's one of the ETHER family (Functional Group "-O-")
2) Next, name the radicals:
   n-C_4H_9- (normal) Butyl-
   -C_2H_5 Ethyl
3) Put them all together, you've got: n-Butyl Ethyl Ether

SPOT QUIZ V

Cover the right-hand column and name these formulas:

t-C_4H_9OH	Tertiary Butyl Alcohol
$C_2H_3COC_2H_3$	Di-Vinyl Ketone
(i-$C_3H_2)_2O$	Di-IsoPropyl Ether
i-$C_4H_9NH_2$	IsoButyl Amine
C_2H_5OH	Ethyl Alcohol

HYDROCARBON DERIVATIVE FAMILIES:

(And some of their more common members)

I **ALKYL HALIDES** (R-X) (“R” is the radical {backbone})

Methyl Halides	Methyl Chloride	CH_3Cl
	Methyl Bromide	CH_3Br
Ethyl Halides	Chloroform	$CHCl_3$
	Carbon Tetrachloride	CCl_4
	Ethyl Bromide	C_2H_5Br
Vinyl Halides	Vinyl Chloride*	C_2H_3Cl*
	Tetra Chloro Ethylene	C_2Cl_4
Amyl Halides#	Phenyl Chloride	C_6H_5Cl

Chronic exposure: may cause nerve damage, and kidney or liver damage. Acute exposure: may cause dizziness, intoxication, and narcotic-like effects.

*Vinyl Chloride may polymerize. **POLYMERIZATION** is the combination of small (usually) unsaturated molecules to form giant “chain” molecules. The process usually liberates large quantities of heat.

#“Amyl” refers to an aromatic or cyclic backbone.

II **AMINES** R-N-

Methyl Amine	CH_3NH_2
Ethyl Amine	$C_2H_5NH_2$
Di-Ethyl Amine	$(C_2H_5)_2NH$
Tri-Ethyl Amine	$(C_2H_5)_3N$
Phenyl Amine (Aniline)	$C_6H_5NH_2$

Chronic exposure: possible kidney and liver damage and anemia. Aniline impurities can cause cancer.

Acute exposure: these materials are caustic and burn tissues. Prolonged exposure can cause skin ulcers.

NOTE: Amines are usually VERY TOXIC—don’t use your nose to search for them. As a warning characteristic, amines have a foul odor; like rotting flesh or really hideous farts.

III **ETHERS** R-O-R

	shelf life:	
Methyl Ethyl Ether	1 year	$CH_3OC_2H_5$
D-Ethyl Ether	1 year	$(C_2H_5)_2O$
Di-IsoPropyl Ether	3 months	$(i\text{-}C_3H_7)_2O$
Di-Vinyl Ether	1 year	$(C_2H_3)_2O$
Tetra-Hydro-Furan (cyclic)	1 year	C_4H_8O

Chronic exposure: moderately toxic except for the cyclic ethers.

Acute exposure: has an anesthetic effect.

In prolonged storage, ethers can slowly oxidize to form EXPLOSIVE organic peroxides. Mild heat or vibration can cause these products to DETONATE. The structure of organic peroxides is R-O-O-R.

IV **ALCOHOLS** R-OH

Methyl Alcohol	CH_3OH	(poison)
Ethyl Alcohol	C_2H_5OH	
Iso Propyl Alcohol	$i\text{-}C_3H_7OH$	

Chronic exposure: moderate to low toxicity (except for those labelled “poison”). Excessive ingestion causes liver damage.

Acute exposure: avoid inhalation or skin contact. Avoid ingestion of alcohols labelled “poison”.

V **KETONES** R-CO-R

Acetone	CH_3COCH_3	
Methyl Ethyl Ketone (MEK)	$CH_3COC_2H_5$	Narcotic
Mesityl Oxide	$C_4H_7COCH_3$	May polymerize

Chronic exposure: can lead to liver and kidney damage. Avoid inhalation, skin contact, and ingestion.

Acute exposure: loss of balance and drunken behavior as some of the alcohols are neurotoxins.

VI **ESTERS** R-CO-2-R

Ethyl Acetate	$CH_3CO_2C_2H_5$	
Vinyl Acetate	$CH_3CO_2C_2H_3$	May polymerize
Methyl Acrylate	$C_2H_3CO_2CH_3$	May polymerize

Chronic exposure: moderately toxic except for the unsaturated esters. Exposure can cause liver and kidney damage.

Acute exposure: don’t inhale, allow skin contact, or ingest vinyl or acrylic esters.

NOTE: don’t confuse the Esters and OxySalts even though they have the same “-ate” ending on their names.

VII **ALDEHYDES** (CHO is the **“Carbonyl”** group)

Formaldehyde	$HCHO$	
Acetaldehyde	CH_3CHO	
Butyraldehyde	C_3H_7CHO	
Crotonaldehyde	C_3H_5CHO	May polymerize

Chronic exposure: avoid inhalation, skin contact, and ingestion—esp. formaldehyde and unsaturated carbonyl groups. Potential liver and kidney damage.

Acute exposure: as for chronic exposure.

Aldehydes can oxidize in storage form organic peroxides (EXPLOSIVE).

SPOT QUIZ VI

1) Match the formula to its family:

- a) CH_3CHO
- b) t-C_4H_9OH
- c) C_2H_5OH
- d) C_6H_{12} (not cyclic)
- e) C_3H_6
- f) C_8H_{10}
- g) CH_3NH_2
- h) $(C_2H_5)_3N$
- i) C_4H_8O
- j) $CH_3CO_2C_2H_5$
- k) $C_2H_5COCH_3$

- 1) Alkanes
- 2) Alkenes
- 3) Alcohol
- 4) Ether
- 5) Amine
- 6) Ester
- 7) Aldehyde
- 8) Ketone
- 9) Alkyl Halides
- 10) Aromatic H-C

2) Match the name to its family:

- a) Ethyl Acrylate
- b) Aniline
- c) Phenol
- d) Xylok
- e) Styrene
- f) Cyclopentane
- g) Toluol
- h) Vinyl Acetate
- i) Di Ethyl Amine
- j) Di Ethyl Ether
- k) Hexa Dekane

- 1) Alkane
- 2) Alkene
- 3) Alcohol
- 4) Amine
- 5) Ether
- 6) Ester
- 7) Aldehyde
- 8) Ketone
- 9) Aromatic H-C
- 10) Alkyl Halide

ANSWERS:
SPOT QUIZ I

1) They are in the same chemical family
2) Non Metals: C, O, F, As
3) Non Salts: a, c, f Salts: b, d, e

SPOT QUIZ II

1) Atoms seek a stable state with eight bonding electrons in their outer shell.

2) a) NaF b) SnF_2, SnF_4 c) Cu_2S, CuS d) CaO e) Na_2SO_2 f) Mg_3N_2
   a) Sodium fluoride
   b) Tin II fluoride
      Tin IV fluoride
   c) Copper I sulfide
      Copper II sulfide
   d) Calcium oxide
   e) Sodium hyposulfide
   f) Magnesium nitride

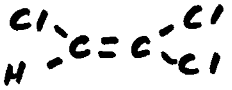
3) a) oxide
   b) hydroxide
   c) oxysalt
   d) peroxide
   e) hydroxide
   f) oxysalt
   g) oxysalt
   h) binary

4) It prevents sunlight from acting as an energy activator.

SPOT QUIZ IV

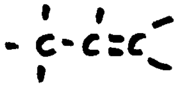
1) a)

b)



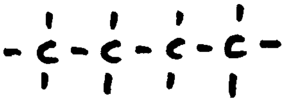
c)

d)



e)

f)



2) Saturated: a, h
   Unsaturated: b, c
   Aromatic: c, e

3) a) alkane
   b) aromatic
   c) alkyne
   d) alkane
   e) aromatic
   f) alkene

4) Benzene, toluene, xylene

5) Acetylene: C_2H_2

SPOT QUIZ VI

1) a-7
b-3
c-3
d-2
e-2
f-10
g-5
h-5
i-4
j-6
k-8

2) a-6
b-4
c-3
d-9
e-9
f-1
g-9
h-6
i-4
j-5
k-1

QUICK REFERENCE TO CHEMICAL FAMILIES:

FAMILY:	FORMULA:	COMMENTS:	USES:
SATURATED H-C (Alkanes)	C_nH_{2n+2}	cpds.>5 carbons	fuels/solvents raw materials
AROMATIC H-C (coal Tar H-C)	C_nH_{2n-6}	Very Toxic	fuel/solvents raw materials
UNSATURATED H-C (Alkenes & Alkynes)	C_nH_{2n} C_nH_{2n-2}	potential oxidizer	cooking oils/ solvents in paints and varnish
AMINE	$R\text{-}NH_2$ $R_2\text{-}NH$ $R_3\text{-}N$	very toxic	oil refining polymer form. insecticides
ETHER	R-O-R	anesthetic	anesthetics solvents
ALCOHOL	R-OH	some are poisons	beverage solvent fuel
ALDEHYDE	R-CHO	potential oxidizer	preservative perfume disinfectants
KETONE	R-CO-R	narcotic	solvents
ESTER	$R\text{-}Co_2\text{-}R$	moderately toxic	solvents/paper coating/paints

MATERIALS WITH:	WILL:
UNSATURATED BACKBONE	1) react spontaneously with air or oxidizers 2) probably be very toxic 3) possibly polymerize
AROMATIC OR CYCLIC BACKBONE	probably be VERY toxic (most insecticides are in this category)

TABLE OF ELEMENTS

(Arranged by atomic number)

ELEMENT	SYMBOL	AT. NO.	AT. WT.	VALENCE
Hydrogen	H	1	1.008	+/-1
Helium	**He**	**2**	**4.0026**	**0**
Lithium	Li	3	6.941	+1
Berylium	Be	4	9.01	+2
Boron	B	5	10.81	+3
Carbon	C	6	12.01	+2+/-4
Nitrogen	N	7	14.007	+/-1+/-2+/-3+4+5
Oxygen	O	8	15.999	-2
Fluorine	F	9	18.998	-1
Neon	**Ne**	**10**	**20.179**	**0**
Sodium	Na	11	22.99	+1
Magnesium	Mg	12	24.305	+2
Aluminum	Al	13	26.98	+3
Silicon	Si	14	28.086	+2
Phosphorus	P	15	30.974	+/-3+5
Sulfur	S	16	32.06	+4+6-2
Chlorine	Cl	17	35.453	+/-1+5+7
Argon	**Ar**	**18**	**39.95**	**0**
Potassium	K	19	39.102	+1
Calcium	Ca	20	40.08	+2
Scandium	Sc	21	44.956	+3
Titanium	Ti	22	47.9	+2+3+4
Vanadium	V	23	50.941	+2+3+4+5
Chromium	Cr	24	51.996	+2+3+6
Manganese	Mn	25	54.938	+2+3+4+7
Iron	Fe	26	55.847	+2+3
Cobalt	Co	27	58.933	+2+3
Nickel	Ni	28	58.71	+2+3
Copper	Cu	29	63.546	+1+2
Zinc	Zn	30	65.37	+2
Gallium	Ga	31	69.72	+3
Germanium	Ge	32	72.59	+2+4
Arsenic	As	33	74.92	+/-3+5
Selenium	Se	34	78.96	+4+6-2
Bromine	Br	35	79.904	+/-1+5
Krypton	**Kr**	**36**	**83.80**	**0**
Rubidium	Rb	37	85.468	+1
Strontium	Sr	38	87.62	+2
Yttrium	Y	39	88.906	+3
Zirconium	Zr	40	91.22	+4
Niobium	Nb	41	92.906	+3+5
Molybdenum	Mo	42	95.94	+6
Technetium	Tc	43	98.906	+4+6+7
Ruthenium	Ru	44	101.07	+3
Rhodium	Rh	45	102.91	+3
Palladium	Pd	46	106.4	+2+4
Silver	Ag	47	107.87	+1
Cadmium	Cd	48	112.40	+2

ELEMENT	SYMBOL	AT. NO.	AT. WT.	VALENCE
Indium	In	49	114.82	+3
Tin	Sn	50	118.69	+2+4
Antimony	Sb	51	121.75	+/-3+5
Tellurium	Te	52	127.6	+4+6-2
Iodine	I	53	126.90	+/-1+5+7
Xenon	**Xe**	**54**	**131.3**	**0**
Cesium	Cs	55	132.91	+1
Barium	Ba	56	137.34	+2
Lanthanum	La	57	138.91	+3
Cerium	Ce	58	140.12	+3
Praseodymium	Pr	59	140.91	+3
Neodymium	Nd	60	144.24	+3
Promethium	Pm	61	(147)	+3
Samarium	Sm	62	150.4	+2+3
Europium	Eu	63	151.96	+2+3
Gadolinium	Gd	64	157.25	+3
Terbium	Tb	65	158.93	+3
Dysprosium	Dy	66	162.50	+3
Holmium	Ho	67	164.93	+3
Erbium	Er	68	167.26	+3
Thulium	Tm	69	168.93	+3
Ytterbium	Yb	70	173.04	+2+3
Lutetium	Lu	71	174.97	+3
Hafnium	Hf	72	178.49	+4
Tantalum	Ta	73	180.95	+5
Tungsten	W	74	183.85	+6
Rhenium	Re	75	186.2	+4+6+7
Osmium	Os	76	190.2	+3+4
Iridium	Ir	77	192.22	+3+4
Platinum	Pt	78	195.09	+2+4
Gold	Au	79	196.97	+1+3
Mercury	Hg	80	200.59	+1+2
Thallium	Tl	81	204.37	+1+3
Lead	Pb	82	207.2	+2+4
Bismuth	Bi	83	208.98	+3+5
Polonium	Po	84	(210)	+2+4
Astatine	At	85	(210)	+/-1+5+7
Radon	**Rn**	**86**	**(222)**	**0**
Francium	Fr	87	(223)	+1
Radium	Ra	88	226.03	+2
Actinium	Ac	89	(227)	+3
Thorium	Th	90	232.04	+4
Protactinium	Pa	91	231.04	+4+5
Uranium	U	92	238.03	+3+4+5+6
Neptunium	Np	93	237.05	+3+4+5+6
Plutonium	Pu	94	239.05	+3+4+5+6
Americium	Am	95	(243)	+3+4+5+6
Curium	Cm	96	(247)	+3
Berklium	Bk	97	(245)	+3+4
Californium	Cf	98	(248)	+3
Einsteinium	Es	99	(254)	+3
Fermium	Fm	100	(253)	+3

ELEMENT	SYMBOL	AT. NO.	AT. WT.	VALENCE
Mendelevium	Md	101	(256)	+2+3
Nobelium	No	102	(254)	+2+3
Lawrencium	Lw	103	(257)	+3
Unnilquadium	Unq	104	(261)	+4
Unnilpentium	Unp	105	(262)	/
Unnilhexium	Unh	106	(263)	/
Unnilseptium	Uns	107	(262)	/
Rutherfordium	Rf	104	(261)	1
Dubnium	Db	105	(262)	1
Seaborgium	Sg	106	(266)	1
Bohrium	Bh	107	(264)	1
Hassium	Hs	108	(277)	1
Meitnerium	Mt	109	(268)	1

MODULE 3
SPECIALIZED PROTECTIVE CLOTHING

OBJECTIVES

The student should be able to:

1. List and describe the 4 levels of Chemical Protective Clothing, CPC.
2. Define basic terms as they relate to the selection of chemical protective clothing or equipment.
3. Examine chemical resistance charts and tables and interpret the information, so as to select the appropriate level of protective clothing.
4. Select the appropriate level of protective clothing that should be used by the emergency response personnel when given a simulated incident involving hazardous materials.
5. Explain and perform the procedure to check, test, clean, and inspect personal protective clothing.
6. Explain how protective clothing can place additional burdens on the human body.
7. Explain the need for rehabilitation & medical monitoring.
8. Demonstrate the donning and doffing of a fully encapsulating Level A and non-encapsulating Level B Suit.

OUTLINE

HAZARDOUS MATERIALS TECHNICIAN

SPECIALIZED PROTECTIVE CLOTHING

INTRODUCTION

- REASON FOR PROTECTIVE CLOTHING
- EFFECTS OF HAZARDOUS MATERIALS
- ROUTES OF ENTRY
- LEVELS OF PROTECTIVE CLOTHING

CHEMICAL PROTECTIVE CLOTHING

- CHEMICAL RESISTANCE
- REVIEW OF CHARTS AND TABLES
- TYPES OF MATERIALS AVAILABLE
- SELECTION OF PROTECTIVE CLOTHING

INSPECTION STORAGE and CLEANING

LIMITATIONS

- PHYSICAL
- EQUIPMENT
    - Medical Considerations for Utilizing
        Chemical Protective Clothing (CPC)
    - Overview of Medical Protocols and Rehabilitation

RESPIRATORY PROTECTION and SCBA USAGE

DONNING & DOFFING LEVEL A & B TYPE SUITS

(PRACTICAL HANDS ON EXERCISES)

LAWS AND REGULATIONS

Current regulations as adopted by U.S. OSHA and EPA clearly stated that individuals who are to enter or work in environments that contain significant levels of materials that when an unintentional release into the environment occurs, that proper selection and utilization of protective clothing or equipment is required to be available and strictly enforced.
(29 CFR 1910.120 and 40 CFR)

Because many materials possess inherent characteristics that when we become exposed to them directly or indirectly, may cause injury or death in humans. Proper use and understanding of Protective clothing, may allow the exposure to these materials occur within acceptable limits.

The ability of protective garments to resist passage or breakdown by a material is of extreme importance especially in dealing with peoples lives and well being, as well as resolving the situation at hand.

Hazardous material response is likened to going to the zoo. When you went to the zoo you felt fairly confident in your safety, as long as the wild animal was behind the steel bars.

We know that the animals are wild, unpredictable, and very dangerous. Yet we feel safe. **How safe would we feel if the wild animals escaped from their cages or containers?**

Much the same can be said about Hazardous Materials. We know about the nature of material. We know what the material has the capability to do.

As an emergency responder we are typically called when the material has escaped from its container or is threatening to do so, with sometimes serious consequences.

Typically we are asked and often required to place our very person in between the hazard and the public. In doing so we are placed in harms way. Our job is simple, we must corral the wild animal. To accomplish this mission that the public has given to us, we as emergency responders must perform our job which places us in the chemical atmosphere with these inherently dangerous materials. To assist in our mission, chemical protection clothing must be worn. These protective enclosures are only as good as we make them and maintain. Bare in mind that not all materials can properly protect the wearer. Selecting the right garment to wear is slightly more complex than picking the right tie to wear to dinner.

The concept of going after the wild animal is a long, well understood practice as far as the fire service is concerned. Firefighters everyday place themselves in harms way and through aggressive offensive action, extinguish the fire in short order. Hazardous Material response does require rapid response and a thorough assessment. The practice of quick, immediate aggressive action, can have very serious consequences on both the public, which we are there to protect, and ourselves, as the emergency responders summoned to correct the situation.

After years of training, practical exercises and real experiences, a long spoken, but often forgotten idea has resurfaced. This concept usually is forgotten due to the need to deliver fast service, quick action and cost associated with its enactment. Haz. Mat. Teams are more closely examining the concept of looking much more carefully in the jump-in and get-it concept. Today, H. M. Teams are asking, CAN I MAKE A DIFFERENCE? IF I CAN'T—WHY SHOULD I GO IN THERE?

INTRODUCTION

REASON FOR PROTECTIVE CLOTHING

The effects of chemical exposure to the human body are many fold. The predominant physical & chemical or toxic properties of hazardous materials will dictate the type and degree of chemical protection that is required.

Once a specific hazard has been identified, the appropriate level of protective clothing should then be selected that will provide the wearer with the maximum level of protection.

EFFECTS OF HAZARDOUS MATERIALS/ROUTES OF ENTRY

The level of protection assigned must match the type and degree of hazard confronted. All too often, personnel become lured into a false sense of security, primarily because there is no detectable odor or taste of a hazard. The effects on the body that has been exposed to a particular material is affected by the route in which it enters the body.

EXAMPLE #1
You arrive at an incident in which a 55 gallon container has been breached. The product has been identified as sulfuric acid. The spill area is contained to the immediate area.

The primary hazard encountered would be that of direct skin contact. To protect our people, we would select the appropriate level of protection to prevent or minimize exposure via skin contact.

EXAMPLE #2
Prior to entering into a confined space that has a known level of carbon monoxide, a survey with a detector is performed. The detector reveals that the level of carbon monoxide is sufficient to warrant respiratory protection. However, a check with an oxygen meter shows that there is sufficient oxygen levels present.

The primary hazard is through inhalation of carbon monoxide. The selection of the appropriate respiratory protection to protect against this type of exposure would be mandatory.

The effects of exposure to the human body are not as apparent as a physical injury, which is readily seen and often felt by the injured party.

The effects of carbon monoxide are cumulative. One exposure for a short duration may have no effect. However, two or three more exposures for the same short period, may have serious effects and may even cause death.

To fully understand the importance of protective clothing, let’s review the basics with regard to the routes of entry that these materials may take.

The form of hazardous materials or substances influences how it can gain entry into the body, and what damage it can cause. This form may change during the manufacturing or production process.

ROUTES OF ENTRY:

There are four ways in which toxic substances can enter the body:

- **INHALATION**
- **INJECTION**
- **INGESTION**
- **ABSORPTION**

Often a substance can enter the body by more than one route.

INHALATION:

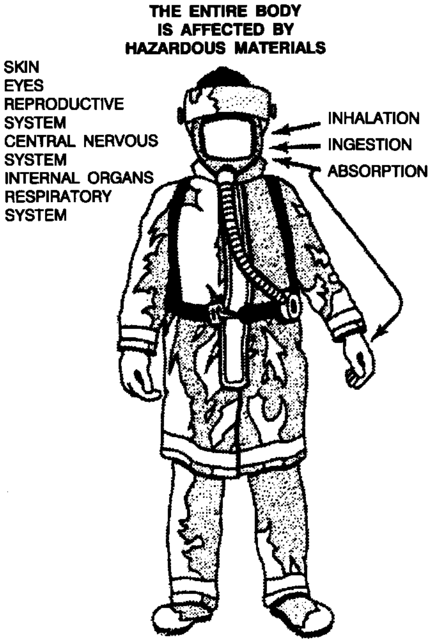
This is by far the most common route of entry in which poisons are absorbed into the body. Dusts, fumes, mists, vapors & gases can all be inhaled. In the respiratory tract they may either irritate the lungs and tract and/or be absorbed directly into the blood stream. Once in the blood they are carried to other organs. While a fair amount are actually exhaled almost immediately, some parts which do not dissolve in the blood may remain to cause problems. (I.E. ASBESTOS.) Because breathing is so important as a route of contamination, having respiratory protection plays a vital role in providing a level of protection.

INGESTION:

This route is less common and often overlooked. Ingestion rarely takes place by deliberate swallowing of a toxic material. Rather, dusts, fumes and mists can collect on tables, chairs, food, drink and cigarettes and be contaminated. Then as we eat, drink and smoke we ingest these contaminants into our bodies. Dust on hands, face and clothing can get into the mouth just by wiping ones face. Some materials have different effects depending on how they enter the body.

As an example, trichlorethylene, a common solvent has more immediate and serious effects when swallowed than when its vapors are inhaled.

Solids cannot be inhaled, but liquids and their vapors could enter the body by all three routes.



ABSORPTION:

Some materials and substances attack the skin such as acids. These are often referred to as corrosive materials. Some irritate the skin. They may cause skin allergies, dermatitis or even result in forms of cancer after prolonged exposure. Other materials such as phenol or nitrobenzene easily penetrate the skin and enter the body and the blood stream. A check of airborne contamination would be recommended in dealing with materials that may act like these. You would also have to examine skin contact and provide protective measures to prevent this contact.

INJECTION:

This route of entry may be confused or associated with drug use. Injection is the entry of a material into the body by the act or process where the bodies exterior skin is broken and allows contaminates to enter. Examples may be jagged edges of metal that you trip or fall on which have the materials covering them.

Once inside the body, the effects take different steps.

ACUTE EFFECTS:

An acute reaction is one that occurs in the body as an immediate response to an exposure. Effects are sometimes visible and can often be traced to a source. Acute reactions normally are short lived. They may be followed by recovery or permanent damage.

CHRONIC EFFECTS:

May not be easily detected or obvious. Symptoms may be gradual, may go unnoticed for a considerable time period after the exposure. They may result in permanent damage, which by the time the source is detected or identified, the exposure has been allowed to continue and the damage sustained. (I.E.—ingestion of an alpha particle which is radioactive.)

As a simple example—the difference between acute and chronic effects. The acute reaction to alcohol consumption is drunkenness. Heavy or large amounts of alcohol consumption may produce vomiting and unconsciousness. After the body has processed the alcohol through its system the result is a headache or hang-over which disappears in a relatively short time. In addition there is no real permanent damage done.

The chronic reaction to heavy consistent exposure to alcohol is addiction (alcoholism) with possible liver damage (cirrhosis).

Typically we think of it only in terms of a single exposure to a single substance or material. But in reality we may be exposed to not just one material or substance, but rather to dozens of different substances.

Such exposures to two and three or even four various chemicals can result in:

1. An additive effect.
2. A greater than additive or syngergistic effect.

If the chemicals independently attack different parts of the body, their combined effects will probably be additive—the sum of the separate effects. However, when the same organs are attacked by the different chemicals the effects are often synergistic, or much greater than the simple sum of the parts. (I.E.—an individual who smokes cigarettes, has been exposed to high asbestos levels and is also a heavy drinker.)

LEVELS OF PROTECTION:

Personnel who respond to emergencies involving hazardous materials and substances must wear protective clothing when there is a known or suspected atmospheric contamination, or when vapors, gases or particulates may be generated and when direct contact with skin affecting substances may occur. Full face respiratory protection provides a level of protection to the lungs, eyes and gastrointestinal tract against airborne toxins.

Chemical protective clothing provides a protective level from direct skin contact, skin-destructive and skin absorbable materials and substances.

LEVEL A

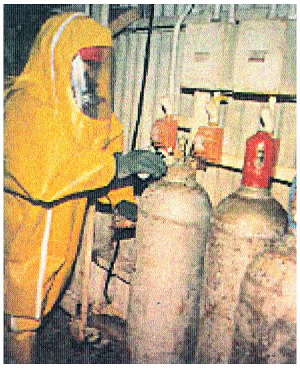
LEVEL B

LEVEL C

LEVEL D

Protective equipment has been divided into four (4) categories according to the degree of protection afforded to protect the body against contact with known or anticipated toxic materials or substances.

● LEVEL A



Should be worn when the highest level of respiratory, skin, and eye protection is required or needed.

- Positive Pressure Breathing Apparatus (NIOSH & MSHA) Approved
- Chemical Resistant protective suit (NFPA compliant)
- Gloves Inner, Chemical Resistant
- Gloves Outer, Chemical Resistant
- Boots Chemical Resistant, Steel toe, and shank ANSI Approved
- Hard Hat (under suit)*
- Coveralls (Under Suit)*
- Two way Radio (Intrinsically Safe)
- Cooling Vest (Ice Vest)*

*Optional

OSHA states in the HAZWOPER standard, that Level A protection is required when the possibility of skin absorption of a material may occur or is exposed to an IDLH atmosphere.

LEVEL B

Should be worn when the highest level of respiratory protection is needed but a lesser level of skin protection is required.

- Positive Pressure Breathing Apparatus (NIOSH & MSHA) Approved
- Chemical Resistant protective suit (NFPA compliant)
- Gloves Inner, Chemical Resistant
- Gloves Outer, Chemical Resistant
- Boots Chemical Resistant, Steel toe, and shank ANSI Approved
- Hard Hat (under suit)*
- Coveralls (Under Suit)*
- Two way Radio (Intrinsically Safe)

*Optional

Typically used for the bulk of hazardous materials responses.

LEVEL C

Is used when a lesser degree of skin protection and respiratory protection is needed. Should be worn when the criteria for using respiratory protection is met. Air Purifying Respirator (APR) is designed for on site use only when the product is known, there is sufficient oxygen in the air, and the APR can filter the respiratory hazard.

- Full Face Respirator (NIOSH & MSHA) Approved
- Chemical Resistant protective suit
- Gloves Inner, Chemical Resistant
- Gloves Outer, Chemical Resistant
- Boots Chemical Resistant, Steel toe, and shank ANSI Approved
- Hard Hat (under suit)*
- Coveralls (Under Suit)*
- Two way Radio (Intrinsically Safe)

*Optional

• LEVEL D

Work utility uniform. Provides a barrier to dust, mist and power type hazards. Is considered as a work uniform and not on any site with respiratory or skin hazard. A cotton or fire retardant (FR) coverall; with escape pak may also be used in place of structural firefighter equipment.

- Full Face Respirator (NIOSH & MSHA) Approved
- Coveralls
- Hearing Protection
- SAR or Escape Pak
- Gloves
- Head Protection (Approved Hard Hat)
- Boost (ANSI Approved)

CHEMICAL PROTECTIVE CLOTHING

INTRODUCTION:

Chemical protective clothing are those materials manufactured which by their physical chemical make-up are able to resist the physical and chemical hazards that are inherent in various hazardous materials and substances. These products have excellent to fair resistance to selected chemicals. **NO MATERIAL HAS TOTAL RESISTANCE TO ALL CHEMICAL EXPOSURES.** Very often chemical resistance is extremely limited. The degree in which they protect the wearer from the specific hazard is measured by several different methods.

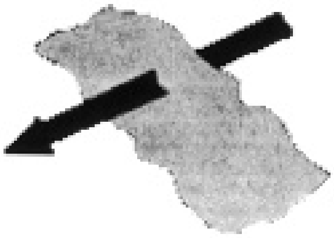
CHEMICAL RESISTANCE:

The ability of a material to physically resist degradation, permeation and penetration by a contaminant.

The degree of resistance is measured by the testing of a particular material or substance against a specific product or chemical. To assist users and potential users of specialized protective clothing, manufacturers of materials submit their product or fabric sample to a research testing laboratory or testing agency to perform tests on their materials and determine how resistive these materials are, and to what products they are resistant against and how long these materials are resistive. If permeation does occur, at what rate, and does the material degrade etc. To fully understand the importance of chemical resistance, let's review some common terms which relate to chemical resistance.

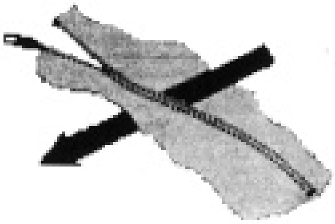
DEGRADATION:

Degradation is the loss in physical properties caused by an exposure to a chemical(s). Damage to the material may be so slight that it may not be visible to the naked eye to detect deterioration of the material.



PERMEATION:

Is the process by which a chemical moves through a material on a molecular level or diffusion. Permeation is typically measured by the time it takes to pass from the other side of a material (once exposed) and be measured on the inside. This is referred to as permeation time. Permeation rate is the rate or amount at which the chemical passes through. It is important to note that not all substances permeate all materials.



PENETRATION:

Is the flow of a substance or material through openings such as zippers, seam, stitches, holes or tears in the garment.

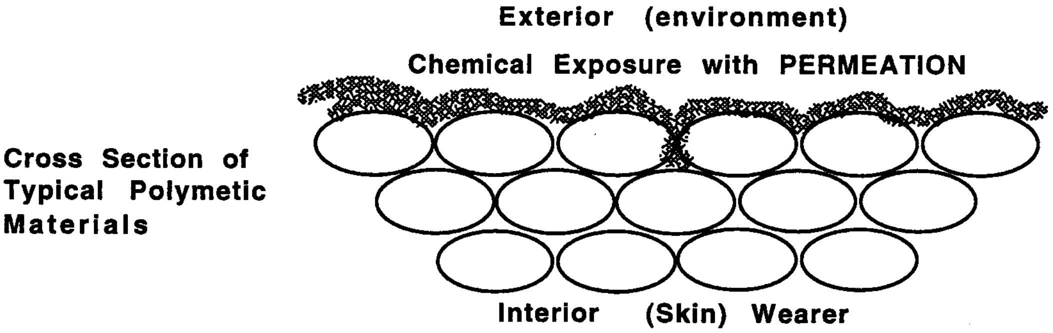
CHEMICAL RESISTANCE

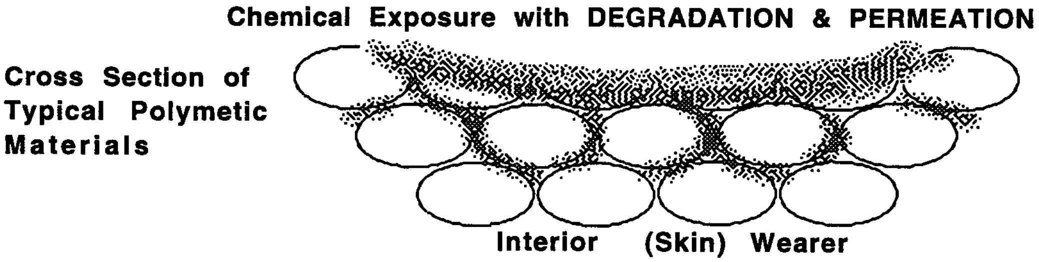
Chemical resistance is represented by charts and tables distributed by the manufacturers of the protective clothing or their testing agencies which have performed these tests. They typically show their resistance or relative effectiveness against generic classes of chemicals. The majority of these tables or charts show the ability of a material to resist by **degradation**. The test performed simply tests if the material once exposed degrades. If the material does not degrade then it may be listed as excellent resistance capability to a specific chemical.

The remainder of the charts or tables show resistance ratings on data collected by **permeation**. If permeation does occur, the time it takes after exposure and the rate it occurs is usually listed on this type of chart.

It is important to note that presently not all protective clothing materials are being tested for each specific chemical. In addition, tests are subject to variation due to the test method performed. Since these tests are performed under controlled environments, exposure in the field may differ from those in the laboratory tests. Results may actually be longer or shorter. Some other factors that may influence the outcome may be the time the chemical is in contact with the material, the concentration of the chemical, and what level or how strong the chemical is. Temperature and humidity are all factors that are not calculated with regard to field activities.

To understand the importance of permeation and how it can compromise the safety of the haz. mat. responder, see the diagram below.





Chemical resistive charts and tables provide only a guide to use in the selection of the appropriate level of chemical protection based on the hazards present.

CHEMICAL PROTECTION OF CLOTHING MATERIALS BY GENERIC CLASS

Genric Class	Butyl Rubber	Polyvinyl Chloride	Neoprene	Natural Rubber
ALCOHOL	E	E	E	E
ALDEHYDES	E-G	G-F	E-G	E-F
AMINES	E-F	G-F	E-G	G-F
ESTERS	G-F	P	G	F-G
ETHERS	G-F	G	E-G	G-F
FUELS	F-P	G-P	E-G	F-P
HALOGENATED HYDROCARBONS	G-P	G-P	G-F	F-P
HYDROCARBONS	F-P	F	G-F	F-G
INORGANIC ACIDS	G-F	E	E-G	F-P
INORGANIC BASES	E	E	E	E
KETONES	E	P	G-F	E-F
NATURAL FATS & OILS	G-F	G	E-G	G-F
ORGANIC ACIDS	E	E	E	E

KEY: E = EXCELLENT G = GOOD Source US DOT/USCG September 1974
F = FAIR P = POOR

PERMEATION RATE FOR TYVEK FABRICS 1994

		Tyvek QC		Tyvek Sarenex 23-P		Tychem 7500		Barricade		Tychem 9400	
		Normal Break Thur Time	Perm Rate	Normal Break Thur Time	Perm Rate	Normal Break Thur Time	Perm Rate	Normal Break Thur Time	Perm Rate	Normal Break Thur Time	Perm Rate
Chemical Name	**Physical Phase**	**minutes**	**ug/cm2 /min**	**minutes**	**ug/cm2 /min**	**minutes**	**ug/cm2 /min**	**minutes**	**ug/cm2 /min**	**minutes**	**ug/cm2 /min**
Acetone	L	immed.	10	24	1.6	338	0.16	>480	ND	>480	ND
Acetonirile	L	immed.	16	13	2.8	14	180	<480	ND	>480	ND
Ammonia (anhydrous)	G	immed.	3.1	32	0.15	125	0.5	47	0.4	47	0.4
1,3Butadiene	G	8	12	>480	ND	>480	ND	>480	ND	>480	ND
Carbon Disulfide	L	immed.	high	8	>50	>480	ND	>480	ND	>480	ND
Chlorine Gas	G	immed.	>50	>480	ND	>480	ND	>480	ND	>480	ND
Dichloromethane	L	immed.	>50	>480	ND	>480	ND	>480	ND	>480	ND
Diethylamine	L	immed.	64	12	>50	>480	ND	>480	ND	>480	ND
Hydrogen chloride	L	immed.	9.3	>480	ND	180	0.54	>480	ND	>480	ND
Sulfurin Acid concen.	L	>480	ND	>480	ND	>480	ND	>480	ND	>480	ND

Copied from the Dupont Chemical And Fibers Div.
Permeation Guide for DuPont Tychem Fabrics 1994.

CHEMICAL RESISTANCE AND PERMEATION CHART
Playtex Industrial Gloves—Styles #834, #835, #4153

Permeability—	Expressed as the amount of vapor diffusing through the rubber film per unit time (mg/cm2 hrs.)
Chemical—Resistance	Expressed as the deterioration of the film to the resistance solvent/chemical.

Chemical	Permeation Rating	Chemical Resistance Rating	Chemical	Permeation Rating	Chemical Resistance Rating
Acetone	S	S	Isobutyl Alcohol	E	E
Acetonitrile	VG	E	Isopropyl Alcohol	VG	E
Acetic Acid, Glacial	VG	VG	Kerosene	VG	VG
Ammonium Fluoride (4%)	E	VG	Methyl Alcohol	VG	E
Ammonium Hydroxide Concentrated	VG	E	Methyl Ethyl Ketone	S	S
Amyl Acetate	VG	VG	Methyl Isobutyl Ketone	S	S
Aniline	VG	E	Methylene Chloride	P	P
Benzene	P	P	Mineral Spirits	S	VG
Carbon Tetrachloride	P	P	Muriatic Acids	E	VG
Castor Oil	E	E	Naphtha	P	S
Cellosolve	VG	E	Nitric Acid (25%)	VG	E
Chromatic Acid (5.9%)	S	VG	Nitric Acid (69%)	P	S
Cleaning Solution	S	S	Nitrobenzene	P	P
Chlorobenzene	P	P	Nitroethane	VG	E
Cyclohexanone	S	S	Octane	S	VG
Diethanolamine	VG	E	Oleic Acid	E	VG
Diethyl Ether	P	P	Perchloroethylene	P	P
Dimethylacetamide	VG	S	Phenol	VG	E
Diethylformamide (DMF)	VG	S	Pine Oil	S	S
Doctyl Phthalate	VG	E	Phosphoric Acid	VG	VG
Ethyl Acetate	S	VG	Potassium Hydroxide (50%)	E	E
Ethyl Alcohol	VG	E	Sodium Hydroxide (25%)	E	E
Ethylene Glycol	VG	E	Sulfuric Acid (5%)	E	E
Formamide	VG	VG	Sulfuric Acid (25%)	E	VG
Formaldehyde (30%)	VG	S	Tetrahydrofuran (THF)	P	S
Formic Acid	VG	VG	Toluene	P	S
Hydrochloric Acid (10%)	E	E	Trichloroethane	P	P
Hydrochloric Acid (Concentrated)	E	E	Trichloroethylene	P	P
Hydroflouric Aicd (50%)	VG	VG	Triethylamine	VG	E
Hydrogen Peroxide	VG	E	Xylene	P	S

Key to Chart: **E** = no permeation/no chemical attack
VG = trace permeation/mild chemical attack
S some permeation/moderate chemical attack
P significant permeation/significant chemical attack

This is a partial list of chemicals in which Playtex gloves have been tested. Method of testing is available upon request. If recommendations are required for specific concentrations, or operating conditions on chemical listed above, or on chemicals not listed, please contact:

Industrial Glove Division, International Playtex Inc.
700 Fairfield Avenue
Stamford, CT 06902

TYPES

Some of the most common materials used in the manufacture of protective clothing:

- Poly Vinyl Chloride (PVC)
- Poly Vinyl Alcohol (PVA)
- Butyl Rubber
- Viton—(fluroelastomer)
- Chlorinated polyethylene (CPE)
- Neoprene
- Nitrile
- Natural Rubber (Latex)
- Tyvek (Spun Bonded Olefin)
- Teflon or combination of other materials with teflon.

SELECTION BY LEVELS OF PROTECTION

The level of protection selected should be based on:

- The type and measured concentration of the chemical substances in the ambient atmosphere and its toxicity.
- Potential for exposure to substances in air, splashes of liquids, or other direct or indirect contact with materials or substances due to work being performed.

In dealing with unknown concentrations or levels of exposure, the maximum level of protection should be selected.

SELECTION OF CHEMICAL PROTECTIVE CLOTHING:

Personnel who work in or respond to emergency situations involving hazardous materials or substances must wear protective clothing if they are going to survive.

The selection of the appropriate level of protective clothing depends on the specific hazard known or suspected.

A full face respirator will provide protection for the lungs, eyes, gastrointestinal tract from airborne toxicants. Chemical resistant clothing will provide protection to the skin from contact with skin-destructive and skin-absorbable chemicals.

Together with good personal hygiene, one can limit and reduce the level of ingestion of materials into the human body.

Protective clothing is designed to provide protection to the body from physical contact with a suspected or known chemical. The degree of protection is broken down into **four (4) categories**.

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 is necessary.
LEVEL C	should be worn when the criteria for using air purifying respirators are met.
LEVEL D	should be worn only as a work uniform, not on or in any situation where there is a respiratory or skin hazard. This does not afford the wearer any measurable level of protection.

Levels of protective ensembles are measured by the type and concentration levels of the chemical substances that are or may be encountered, and their toxicity to the human body.

They are also measured by their potential for exposure to a substance in air, splashes of liquids, etc. In incidents or situations where the type of chemical or chemicals and their concentration levels are not known or not readily determinable, the selection would be based on providing the maximum level of protection available. Personal protective clothing and its proper wearing will reduce the potential for contact with toxic materials and substances.

Ensuring the health and safety of emergency responders requires safe work practices, proper decontamination and site entry protocols. Altogether, these provide an integrated approach for reducing the harm to the responders.

Other types of protection that must be considered, but are not specifically listed as chemical protective equipment, and are incorporated into the levels of protection that are standard issue to all those working in the field include the following:

- Head protection (hard hat, helmets, etc.)
- Foot protection (boots & shoes)
- Hand protection (gloves)
- Ear protection (ear plugs or muffs to protect against damage to the ear).

Some other factors to be considered dealing with chemical protective clothing and its use in hazardous material response are:

STRENGTH:	The materials ability to resist tears, punctures, and abrasions as well as tensile strength.
FLEXIBILITY:	The ability of a material to remain soft and pliable, easy to move about and work. Stretchability.
THERMAL LIMITS:	The ability of a material to maintain its protective capability in temperature extremes. Thermal limits would include cold weather and hot weather. Examples would be that of how lower temperatures effect mobility and how during high temperatures the ability of the material to insulate the wearer.
LIFE EXPECTANCY:	The ability to resist aging due to exposure to sunlight, general use, repeated washing using cleaning agents and its ability to be decontaminated.

Additionally, specialized equipment that may be utilized for specific applications are, but not limited to:

- Approach Suit
- Flash Suit
- Proximity Suit
- Entry Suit

These specific types of protective clothing may be used to provide the wearer with additional protection depending on the specific hazard presented.

An example may be that an entry team may wish to use an aluminized suit or approach type suit in dealing with a hazard that has a high potential to ignite or is flammable in nature (i.e.—Propane). While this equipment is not specifically chemically resistant, it provides an added level of protection to the wearer.

As each response organization evaluates the hazard confronting them, many are now and have been requiring the use of **FLASH SUIT** protection. While little to no protection is afforded with respect to chemical resistance, its use can go a long way to improving survivability in the field where volatile materials are present.

APPROACH SUIT

These specific types of protective clothing may be used to provide the wearer with additional protection depending on the specific hazard presented.

An example may be that an entry team may wish to use an aluminized suit or approach type suit in dealing with a hazard that has a high potential to ignite or is flammable in nature (i.e.—Propane). While this equipment is not specifically chemically resistant, it provides an added level of protection to the wearer.

FIRE ENTRY

LIMITED USE GARMENTS (DISPOSALS)

Similarly, tyvek garments which have specific protective properties in as far as chemical resistance, have been used over top of standard chemical protective clothing and firefighting turnout gear to provide the wearer with chemical protection when dealing with materials that are flammable and/or possess a high potential for ignition.

Variations of protective clothing ensembles are encouraged; however, it should be noted that variations should only be used after careful consideration of the potential hazard involved. Part of the risk assessment phase is to determine the risk, assess the hazard and potential, and develop your tactical plan. While variations of protective clothing may be classified as EPA Level B protection, users should always check with the manufacturer of the material or garment and be guided by their recommendation prior to the actual use in the field.

FLASH SUIT PROTECTION

Basically a coverall type design that completely covers the wearer and his Level A protective garment. Typical materials used are aluminized outer covering with either Nomex III™ substrate material or PBI® Kevlar™ fabric.

The basic design is to provide the wearer exposure to up to 2000 degrees Fahrenheit for not longer than 5 seconds. (momentary flash)

Intended and designed for those entries that have or have had the potential for the materials to volatilize and ignite.

USE OF FIREFIGHTING (TURN-OUT) EQUIPMENT IN HAZ. MAT. RESPONSES

We have now examined several aspects of chemical protective clothing and its proper selection. We have identified that there are several parameters that *must* **be** examined or evaluated to choose the proper level of protective clothing. They are:

[ ] Chemical Resistance
[ ] Flexibility
[ ] Resistance to Aging
[ ] Strength
[ ] Temperature Characteristics
[ ] Ability to be Decontaminated

We know that there is no *"Protect-all"* garments or clothing materials available. The Chemical compatibility must be evaluated as well during the hazard and risk assessment phase.

The use of Structural firefighting equipment has long been used by emergency responders as initial entry protection and continued through the final clean-up or incident stabilization.

It cannot be overemphasized that **STRUCTURAL FIREFIGHTING CLOTHING IS NOT DESIGNED TO OFFER ANY CHEMICAL PROTECTION**. Its use may prove advantageous from the aspect of mobility and readily accessible for use. It is only capable of providing protection to the limit of what it was intended or designed for.

Structural firefighting equipment can provide sufficient protection to the wearer who is fully aware of the hazards to be encountered and the limitations of the garment. Their use may be considered when:

- **Unlikely contact with splashes of extremely hazardous materials.**
- **Total atmospheric concentrations do not contain high levels of chemicals toxic to the skin.**
- **There are no adverse effects from chemical exposure to small areas of unprotected skin.**

The use of structural firefighting clothing in dealing with hazardous materials may be closely associated with the use of vinyl or PVC coated (DUCT TAPE). The placement of this type of tape is used as a stop gap measure to provide additional restriction or a barrier to reduce the passage of materials by way of the natural opening in the firefighting gear. These areas include:

- The bottom of the protective pants
- The front of the coat along the closure
- The coat collar area
- The cuff (where the coat sleeves meet the glove)
- Around the waist (over the turn-out coat)
- Around the entire facepiece of the SCBA

STRUCTURAL FIREFIGHTING CLOTHING IS NOT DESIGNED TO OFFER ANY CHEMICAL PROTECTION

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Variations of protective clothing ensembles are encouraged. It should be noted that variations should only be used after careful consideration of the potential hazard involved. Part of the risk assessment phase is to determine the risk, assess the hazard and potential, and develop your tactical plan.

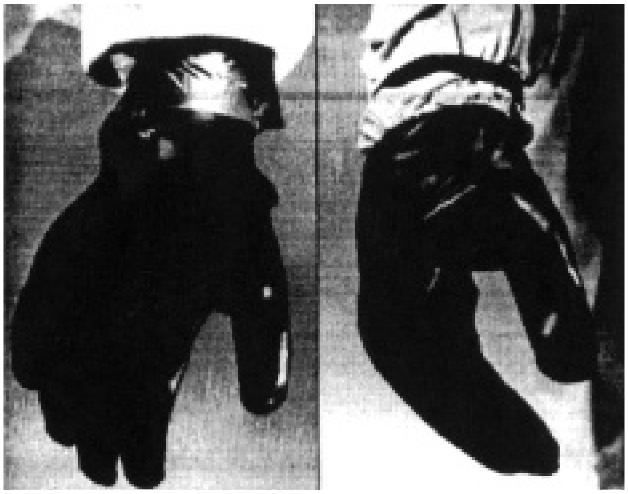
While variations of protective clothing may be classified as EPA Level B protection, users should always check with the manufacturer of the material or garment and be guided by their recommendation prior to the actual use in the field.

DUCT TAPE

The use of duct tape has been in use for many years. While there has not been any definitive testing of the flammability, combustibility, chemical resistance or chemical compatibility of duct tape, there has been a quiet controversy between Haz. Mat. Teams and response specialists on its use.

Haz. Mat. Team personnel and trainers have for many years utilized duct tape to provide a barrier/seal between the protective garment and the glove/boot interface or other opening. This use, while not exactly perfect, provided a very cost effective answer to a common condition during CPC usage.

As depicted here, there are alternative methods that can be used or developed in place of the duct tape.



Some of the controversy can be attributed in part only to the level of use. The primary use in some areas has been only during Level B use. Some others have been using this type of tape for Level A entries.

A careful examination of each and every entry should be made to determine as much as possible that any device, whether duct tape or rubber band will help or hinder.

INSPECTION, TESTING, MAINTENANCE & STORAGE:

Like any other piece of equipment, chemical protective clothing requires a certain level of care. Given proper care a chemical suit may last many years. However, one exposure to a contaminate without the proper care may render the protective value of this equipment void. The improper storage may also contribute to the deterioration or the premature demise of protective clothing.

Most manufacturers provide general cleaning and care instructions in every suit or product they produce. This care may include the proper steps to be taken in the repair of these garments. Additionally, there are several agencies which provide such services and may be contracted to provide care, cleaning, repair and testing of protective ensembles.

Prior to use of chemical protective clothing or equipment the wearer should examine the clothing to ensure that:

- The equipment is not damaged from previous exposure.
- It is not damaged from improper storage.
- That all the component parts are present and are in working order.

The inspection should include a check of the following:

- Seams
- Surface abrasions
- Rips & tears
- Stitches and binding
- Zippers and suit closures
- Valves & connectors

Basically any item or deficiency that may either by itself or jointly with other deficiencies may cause a breach or compromise of the integrity of the protection that the equipment is designed to provide. It would be indicative that the suit or ensemble be removed from service and/or repaired.

STORAGE:

While the majority of the manufacturers of protective clothing spell out how the equipment is to be used, what the material is resistant against, and where to obtain assistance, they do not clearly address the storage practices other than:

- do not store the suit when wet; allow to fully dry.
- do not store the suit in direct sunlight.

The majority of failures can be traced back to how the suit was stored. It is important and proper to follow manufacturer's instructions.

CLEANING:

Cleaning protective equipment is another important function. The manufacturer's instructions should be consulted for the recommended practices in cleaning materials that may be used. Typically, warm water and a mild soap or liquid detergent is often recommended.

LIMITATIONS:

There are basically two (2) types of limitations that one may encounter with regard to protective clothing:

● Physical limitations	Those restrictions placed upon the human body to reduce its movements or deprive its senses. Also includes those conditions brought on by use of the chemical garment and in combination with environmental conditions/weather.
● Equipment limitations	Those restrictions placed or inherent by design of the protective clothing. The higher the level of protection, the greater the limitations encountered.

● PHYSICAL LIMITATIONS

Wearing protective clothing creates some problems. The main problem being that the human body is shielded from the normal circulation of air. Perspiration does not evaporate, thus eliminating the body's main mechanism for cooling. With that gone, the body is prone to heat stress, including heat stroke, which can be fatal. Heat related problems are very common when temperatures rise above 75°F.

Work schedules for persons wearing protective clothing **must be closely and conservatively monitored** or regulated lest heat stress becomes more of a threat than the chemical hazard itself.

The best way to combat heat stress is to allow the body to cool normally. The most efficient body-cooling process is by evaporation. Someone wearing protective clothing that has no ventilation perspires profusely.

If the perspiration remains in contact with the skin, it has a better chance of evaporating and cooling the body surface. If the perspiration is allowed to run off the body quickly, less evaporation occurs.

This happens when shorts are worn under a fully encapsulating suit. Also, the suit material can become very hot and cause severe burns if it contacts the wearers bare skin. Long cotton underwear is the best choice. It clings to the body when soaked with perspiration, thus allowing the greatest amount of cooling by evaporation and also protects the body from burns caused by the suit itself.

During extended periods of work in protective chemical clothing, some sort of "cooling" should be considered or provided to the wearer. The best method is to provide frequent rest periods. Additionally, drinking of water is highly recommended and has proved to work effectively in reducing heat stress conditions, and actually enhances work performance.

While cooling vests, Ice Vest or Packs do provide a cooling effect to the wearer, they also add considerable weight.

HEAT STRESS

Prevention is the key to dealing with heat stress. Be aware of weather conditions, the limitations presented by personal protective equipment you are using, and the need to provide rest periods for long term operations.

There are three (3) types of emergencies related to heat stress.

The signs and symptoms of heat cramps are severe muscle cramps in the legs and abdomen, exhaustion, dizziness or faintness. Victims seldom lose consciousness.

The signs and symptoms of heat exhaustion are rapid shallow breathing, heavy perspiration, total body weakness, and dizziness leading to unconsciousness.

Heatstroke is the most serious of heat stress. (Heatstroke is also called "Sunstroke." You do not have to be in the sun to have heatstroke.) The symptoms include dry, hot skin, dilated pupils, loss of consciousness (possible coma), and convulsions. **Heatstroke is A TRUE EMERGENCY!**

The signs and symptoms of heat stress were taken from **EMERGENCY CARE**, 3rd Edition, Grant, Murray and Bergeron.

REST & REHABILITATION

In addition to heat stress, hazardous material responders face other types of physical and emotional stress related to their work at emergency operations. It is in the best interest of safety for personnel to provide for rest and rehabilitation periods.

The location for the area used for R&R must be on the clean side (SAFETY ZONE) of the incident. The location should be upwind and uphill since the people using the area will be without protective equipment and will have assumed a lower awareness towards danger by having been disengaged from the incident.

Personnel coming to the R&R area must have been thoroughly decontaminated in the WARM ZONE before leaving the WARM ZONE. The R&R area should be away from the incident, out of the weather, and provide a real opportunity to rest and regain physical and emotional strength before resuming operations.

Sanitary facilities may need to be provided as well as liquids and food if they will not cause an ingestion hazard. This area should be a place of refuge from the incident, not a location to launch the next operation.

Rest and Rehabilitation are the purposes of this area and that should be the only function assigned to this site area.

EQUIPMENT LIMITATIONS:

As we attempt to better equip and protect our personnel, we have developed out of necessity, equipment that provides the wearer with certain levels of protection. However, it also has brought about other problems.

- The inability to communicate effectively.
- The reduction of the field of vision.
- The loss of senses—smell, taste and touch.
- Heightened emotions. (Anxiety)
- The inability to provide a total (all encompassing) chemical resistant suit.

The majority of these items listed may be reduced or eliminated by technology or additional equipment and proper and recurring training. They can either separately or in any combination present some unique situations.

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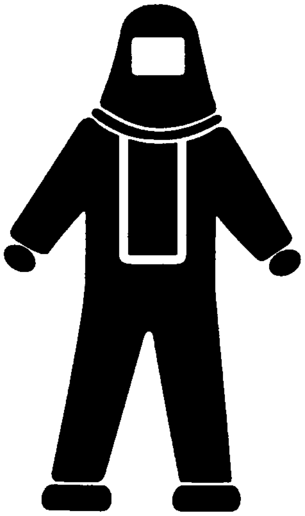
Medical Considerations for Wearing CPC



The most common cause of injury to workers involved in hazardous materials mitigation is heat stress—induced by the wearing of chemical protective clothing. With the availability of higher capacity SCBAs, the restricting factor on work periods has become the health, and wisdom, of the individual. We must adequately assess the health threats to all workers in CPC and properly implement the necessary safeguards to ensure well-being. Stress management techniques and medical monitoring of emergency response personnel are the principal points in accomplishing that goal.

Both physiological and psychological stress can severely affect response personnel. Under certain conditions, stress can contribute significantly to accidents or harm workers in other ways. This chapter will provide information about the physiologic and psychological stress encountered by site workers and discuss the important aspects of a medical monitoring program.

Stress Programs

Any complete program that attempts to reduce the potential for abnormal physical stress or mental anxiety should incorporate pre-incident, on-site and post-incident components:

- Workers must be periodically examined by medical authorities to determine if they are physically, and if possible, psychologically fit to perform their duties.
- Continual practice and training must be provided in using PPE, especially Self-Contained Breathing Apparatus and Chemical Protective Clothing.
- An effective safety program must be implemented, and concerted efforts made, to protect the worker. These actions help to ensure personnel that their health and safety will be protected now, and in the future.

Stresses of Encapsulating Garments

Many hazardous materials responders and team managers tend to underestimate the risks to personnel working in chemical protective clothing because they focus on the environment and the chemicals, and fail to adequately recognize the health risks associated with wearing CPC.

Technological advances in chemical protective clothing, SCBA and umbilical air systems make it possible to work in hazardous environments for much longer periods than was ever permitted before. This presents a significant increase in the health risk to personnel as they become limited more by their own physical conditions than by the limitations of their protective equipment. Yet, this very same protective equipment can become a *"hostile interior environment"* as personnel are subjected to 100% relative humidity and elevated temperatures within 7 minutes of donning the suit.

Response personnel must also recognize situations where there is a potential for protective clothing to become breached or otherwise damaged. Protective ensembles, by their very design and function, are intended to prevent a hostile exterior environment from entering the suit and reaching the individual. This infers that the suit will also keep hostile substances *inside* the suit, next to the individual, once they have entered. It can create a situation where the substance concentration is higher in the *interior* of the suit than on the exterior.

Incident Stressors

Personnel operating in chemical protective clothing are typically subjected to four types of stressors: environmental, mechanical, psychological and physiological.

- Environmental stresses include temperature and humidity both outside and inside the suit, wind conditions, terrain, confined spaces, etc. These factors can affect both the physical and mental state of personnel wearing CPC. These factors must be taken into account during work mission planning activities.
- Mechanical stresses are caused by faults or defects in the protective equipment; limitations inherent in the CPC (mobility, dexterity, visibility, etc.); or objects that come into contact with the garments creating punctures, tears, rips or abrasions. Close inspection of the suits, careful planning at the incident, and attention to detail in the task, are the best preventative techniques for mechanical stress.
- Physiologic stresses are created by the physical characteristics of the individual: age, fitness, health and personal habits. We will discuss these shortly.
- Psychological stresses are manifested by anxiety and/or claustrophobic reactions to operating in adverse environments, with dangerous materials, or under unfamiliar conditions. These may be due to the incident, the individual, or the chemical protective equipment itself. Often these psychological stresses have lingering effects that must be dealt with during Incident Stress Debriefings and/or individual counseling conducted by trained professionals.

Physiological Factors

Just wearing an encapsulating garment puts personnel at considerable risk for injuries ranging from heat-related illnesses to various physical traumas, chemical toxicity, or psychological harm. Conditions related to the incident (the environment, the CPC itself, difficulty and duration of the work performed, etc.) are part of the problem. Individual physical and emotional characteristics of the personnel themselves are also significant contributing factors. Some of the factors that predispose individuals to injuries include lack of physical fitness, lack of familiarity, anxiety, age, dehydration, obesity, personal habits, illness, sunburn, diarrhea and disease. Each are discussed below:

- **Lack of physical fitness** is an avoidable condition that should not be tolerated by employers or employees. Agencies should develop doctrines that encourage only the most fit to use chemical protective clothing and be members of a hazardous materials team. Personnel who have low work capacities are more susceptible to heat-related injuries.
- **Lack of familiarity** is another inexcusable factor in injuries. Team members should practice and drill with various CPC until they are as comfortable with them as they are with any other tool.
- While **anxiety** may be overcome with time and training, **claustrophobia** is too serious of a condition to risk an employee’s health on. No one with this condition should be allowed to work in chemical protective clothing, particularly the encapsulating kinds.
- **Age** affects personnel in numerous ways: general health, reaction time, stamina, and dexterity are but a few. Younger individuals are often preferred for assignments that require working in CPC. However, older individuals who are physically fit and experienced in dealing with hazardous materials are a valuable resource, and should not be overlooked merely because of age.
- **Dehydration** caused by sweating, diarrhea or other conditions is one of the principal causes of heat-related injuries. Therefore, anyone who exhibits symptoms of dehydration (unusual thirst, etc.), or signs of other maladies for that matter, should not be assigned to duties that require the use of CPC.
- **Obesity** causes excessive stress on the body, especially to the cardiovascular system, under normal conditions. Wearing CPC will put additional stress on the body. Obese individuals should not be chosen for tasks requiring the use of CPC.

- **Personal habits** can greatly affect an individual's health. Alcohol, smoking and drug use can result in diminished lung capacity and mental alertness. Even an individual who is experiencing the effects of a "rough night on the town" should be barred from wearing CPC. Over the counter medications, especially decongestants and antihistamines, may increase the risk of heat stress.
- **Infections or other illnesses** preclude personnel from operating at "peak efficiency." Strenuous physical activity will further deplete their already overtaxed energy and immune systems. In addition, these individuals should not come into contact with others to whom they may spread their illness or infection.
- A **sunburn** can cause extreme discomfort when it's irritated. The body is already coping with one injury. Aggravating that injury may cause further harm to the individual.
- **Diarrhea** depletes large amounts of body fluids. Expecting an already dehydrated individual to operate in an environment where fluid loss is the greatest hazard is tantamount to gross negligence. Diarrhea may also cause other problems for personnel confined in an encapsulating suit.
- **Chronic diseases,** such as emphysema and bronchitis, can severely limit the physical capabilities of personnel. Emergency response personnel who manifest signs of chronic illnesses should be prohibited from joining hazardous materials teams.

Work Tolerance

Chemical protective clothing directly influences work tolerance. Heavy, bulky suits are much more difficult to work in than lighter suits. Level A suits have been known to reduce work tolerance by as much as 50%. The slight margin of comfort created by multi-piece suits helps to explain their popularity over the encapsulating type.

Heat stress and work tolerance are interrelated. As the work duration increases, heat tolerance decreases. Chemical protective clothing adds weight, bulk and heat to the wearer. It also severely reduces the effectiveness of normal heat exchange mechanisms such as evaporation of sweat, convection from cooling currents and radiation of body heat. The interior of the suit begins to behave much as a sauna does with temperatures rising to well over 100 degrees F. The temperature inside the suit can be more than 25% higher than the external ambient temperature. At the same time, interior suit humidity rises until it is near 100%. This not only severely represses the body's cooling mechanisms, it acts to reflect heat back towards the body, elevating core temperatures even further. The result can quickly become catastrophic if the metabolic processes are not managed properly.

As an example, FEMA studies have shown that personnel wearing Level A chemical protective clothing, working hard in a typical California summer climate, lost approximately 5% of their body weight within the duration of just one air bottle (about 45 minutes). This completely disrupts normal blood chemistry and is a very dangerous medical condition.

Effects of Cold Exposure

Personnel working in extreme cold, even for a short time, may experience severe injury to the surface of the body (frostbite) or profound generalized cooling (hypothermia). The result may include permanent injury or death. Personnel exhibiting signs of hypothermia should be immediately removed from the environment, placed in a warm location, covered with blankets and provided with warm liquids to drink.

Two factors influence the development of a cold injury: ambient air temperature and wind velocity. "Wind chill" is used to describe the chilling effect of moving air in combination with low temperatures. For instance, 10 degrees F with a wind of 15 miles per hour is equivalent in chilling effect to still air at –18 degrees F. As a general rule, the greatest incremental increase in wind chill occurs when a wind of 5 mph increases to 10 mph. This simple doubling in wind speed can quadruple the wind chill factor. The effects are far worse when the skin is wet. Water conducts heat 240 times faster than air. Thus, the body cools suddenly when chemical protective equipment is removed and the clothing beneath is soaked with perspiration. Local injury resulting from cold is included in the generic term *"frostbite."* Areas of the body which have high surface-to-volume ratios, such as fingers, toes and ears, are the most susceptible to frostbite. Frostbite of the extremities can fall into three categories:

- Frost Nip or Incipient Frostbite: Characterized by sudden blanching or whitening of the skin.
- Superficial Frostbite: Characterized by skin with a waxy or white appearance that is firm to the touch, but the tissue beneath is resilient.
- Deep Frostbite: Characterized by cold, pale skin that is solid to the touch. This is an extremely serious injury.

Systemic *hypothermia* is caused by exposure to freezing or rapidly dropping temperature. Its symptoms are usually exhibited in five stages:

- Shivering: the body's automatic mechanism to generate heat through muscle contractions.
- Apathy, listlessness, sleepiness, and sometimes rapid cooling of the body to less than 95 degrees F.
- Unconsciousness, glassy stare, slow pulse and respiratory rates.
- Freezing of the extremities.
- Death.

Always consult available standard reference books any time signs and symptoms of hypothermia become visible.

Work Mission Duration

Work mission duration is an important factor in safeguarding the health and well-being of response personnel. Work mission duration is dependent upon a number of factors including travel and decontamination times, environmental conditions, work load, CPC, and the limitations of the personnel themselves. It must also include a safety factor to protect against problems that may arise during the operation.

A "Work Mission Duration" form, such as the sample on the following page, can be used to provide a relatively subjective analysis of safe operating times. The form provides recommended work times based on environmental conditions. Actual operating times can be adjusted based on available air supplies. However, there are two important points to remember when adjusting work times. First, the person with the lowest remaining air supply dictates the time remaining for all team members. Second, return travel time, decontamination time and the safety margin must all be deducted from the total time remaining in order to determine the safe operating work time.

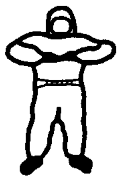
One other word of caution: umbilical air supplies are almost limitless. It's even more critical to follow the recommended work times when using umbilical air supplies to prevent over-exertion injuries to personnel.

Rest Periods

Providing adequate rest periods between work missions is just as important as limiting work mission duration. The Environmental Protection Agency has established guidelines for responder rehabilitation times based on research of endurance rates. This is one tool which is available to response teams. Drills and training exercises should be used as an avenue to measure and test rest period durations in given environments. However, regardless of how an agency determines adequate rest periods, the time frames must be predicated upon measurable factors such as the anticipated work levels, environmental conditions, type of protective garments, individual workers' characteristics and fitness, and medical monitoring results.

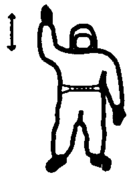
Work Mission Duration

Incident Name:________________________________ Date:_____________ Location:________________________

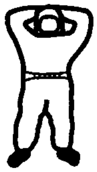


Out of Air

Need Help

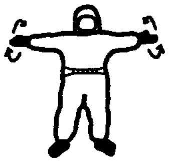


Evacuate



O.K.

Need Assistance with Repair



Situation Under Control

Air Supply	30 Minutes	45 Minutes	60 Minutes	Umbilical Air
Safety Factor				
Travel Time (times 2)				
Environmental Conditions (L-0, M-5, H-10)				
Work Load (L-0, M-5, H-10)				
Decontamination (maximum)				
Other				
Operating Work Time (To be amended during incident as dictated by actual air supply.)				

Recommended Work Time (Between Rest Periods) *

When wearing impermeable or semi-impermeable Chemical Protective Clothing

	Sunshine (Radiant Heat Exposure)		
Air Temperature (Maximum)	Full Sun Shadows 100% of time	Partly Sunny Shadows 50% of time	Full Shade No shadows from sun
70°F	60 min. of work	90 min. of work	120 min. of work
75°F	30 min. of work	60 min. of work	90 min. of work
80°F	20 min. of work	30 min. of work	60 min. of work
85°F	15 min. of work	20 min. of work	30 min. of work
90°F	15 min. light work	15 min. of work	20 min. of work
95°F	Extreme Danger	Danger	15 min. of work

* Reference: Occupational Safety & Health (OSHA) Guidance Manual for Hazwaste Site Activity (Table 8-10)

Work Mission Duration
Form Instructions

Each part of the Work Mission Duration Form which needs to be completed is explained below:

1. **Air Supply:** Across the top of the form are standard air supplies (30/45/60 minute air bottles and umbilical air). When completing the form, enter information into the column that corresponds to the air supply being used by the Haz Mat Team.
2. **Safety Factor:** A standard rule of thumb is that personnel should be able to perform the task, exit the zone, complete decontamination, and begin doffing before the low-air alarm bell sounds. On most SCBAs the bell will alarm with approximately a 5 minute reserve. Therefore, 5 minutes is an acceptable standard entry in this portion of the form.
3. **Travel Time:** This should be a close estimation of the travel time to and from the site.
4. **Environmental Conditions:** Environmental conditions impact emergency response personnel before they don PPE, while they are working, and after they doff the garments. Temperature and humidity are the primary factors to be concerned about. The recommended entries are as follows:

Entry	Environmental Condition
0	Cool and Dry
5	Warm and Moist
10	Hot and Wet

5. **Work Load:** The type of work is another measurable factor. The greater the work load, the greater the impact. The recommended entries are as follows:

Entry	Work Load
0	Light
5	Moderate
10	Heavy

6. **Decontamination:** Decon takes time to accomplish. The more people who need decontamination, the more time will be required. The number entered into this row should account for the time that it takes to decontaminate *all* team members.
7. **Other:** This row provides a place to account for other factors which impact air supply such as age, obesity or personal habits. Again, it is not recommended that these individuals participate in these types of activities, but sometimes there is no other choice.
8. **Operating Work Time:** The estimated operating work time is entered at the bottom of the form. To determine the operating work time, add the entries from all the previous rows, then subtract that number from the total air supply available.

Field Monitoring

Field monitoring must include conditions relating to the health and well-being of emergency response personnel. Temperature, relative humidity and wind speed are the minimum components necessary to define the environmental parameters for personnel at the site.

Ambient air temperature and relative humidity are combined to determine the "heat index." This index is a measure of the body's ability to cool itself. As already mentioned, the most important cooling process of the body is evaporation. The amount of moisture that air can hold is a function of the ambient air temperature. The higher the temperature, the more moisture that it can hold. When the air is already high in moisture content, less moisture can be removed from our bodies. In other words, humidity decreases the effectiveness of evaporation and general cooling.

The lungs are an important source of evaporation in the human body. While the following is an oversimplification of the physiology involved, it is important for responders to understand the impact of humidity. As the moisture content in the air increases, the exhaled air in the lungs begins to approximate the same moisture level and no evaporation occurs. When the moisture content in the lungs is high, the amount of oxygen in the lungs is diminished. Additionally, the lungs serve to expel wastes dissolved in water, much as urine does. When the moisture in the lungs cannot evaporate, these wastes begin to build up. This is one reason why people tend to feel such discomfort in high humidity.

As already indicated, the wind speed (or "wind chill factor") is another important condition. It can be beneficial in warm climates, and dangerous in cold ones. Wind chill charts should be a standard reference for emergency response teams as they monitor the well-being of personnel at the scene.

Heat Related Illnesses

Heat related illnesses are the most common stress situation encountered by site workers. However, the potential for these life-threatening injuries is not limited to emergency situations. Records exist to document that personnel are just as susceptible to these stresses during drills and training sessions.

Most of the systematic studies that apply to heat stress and protective clothing are adaptations of military tests conducted from the 1940's to the 1960's. However, in 1990 the Biotherm Company conducted stress testing for FEMA. 20 firefighters were tested for psychological responses to each of 3 suits. The climactic conditions used during this study were:

Climactic Conditions	Degrees Celsius	Degrees Fahrenheit
Hot/dry	38.9-42.2	102-108
Hot/wet	30.0-33.8	86-93
Comfortable	21.1-27.2	70-81
Cold	5.7-7.2	42-45

Each firefighter wore one suit per day. The individuals' rectal temperature, heart rate, blood pressure, recovery rate and body weight were recorded. The inside garment temperature was determined and environmental parameters were measured. The test lasted 55 total minutes, with 45 minutes of exercise time—equivalent to 5.5-6.5 METs. Results showed that increases in all parameters were greatest during the hot/dry and hot/wet phases. Rectal temperatures exceeded NIOSH regulations in all cases (100.5 degrees F). Some heart rates exceeded maximum treadmill test values.

In determining workers who may be at risk for heat stress, it was found that those workers with low work capacities were more likely to develop high body temperatures than workers with high work capacities. This was determined by measuring maximum oxygen consumption (VO_2 maximum) which is a measure of aerobic fitness. Some results of the aerobic fitness and heat stress studies were:

- Among workers with VO_2 maximums ≤ 2.5 L/min., 63% are heat intolerant.
- Workers with VO_2 maximums < 2.5 L/min. had a 5% risk of heat stroke compared to only a 0.05% chance if their VO_2 maximum was > 2.5 L/min.

Human beings are homiotherms. This means that they self-regulate their internal temperatures. This "body core" temperature—not the temperature at the skin surface—is what we have come to recognize as 98.6 degrees F (37 ± degrees C). This is an average temperature and very few individuals actually register 98.6 degrees F on a regular basis.

Body core temperature is maintained by a portion of the brain known as the hypothalamus, through what is known as the "set point." When core temperatures deviate too many degrees on either side of the set point the brain sets into motion certain physical reactions to counter the temperature change:

- Shunting blood to the core, along with muscle contractions (shivering) to raise internal temperatures, or,
- Shunting blood to the surface, along with sweating (evaporation) to lower internal temperatures.

These physical reactions are based upon standard thermodynamic laws: conduction, convection and radiation.

This heat balance equation is expressed as:

$$DT = \text{Met Heat} \pm \text{convection} \pm \text{radiation} \pm \text{conduction} - \text{evaporation}$$

(where DT = Deep Temperature and Met Heat = Metabolic Heat)

Metabolism

The human body produces metabolic heat through the process of converting food into cellular energy by oxidation. The energy of breaking down sugars, such as fructose and sucrose, results in the production of heat and light. This is the same by-product of any chemical change that you learned in weeks 1A and 1B. The metabolism of food is an inefficient process. Only twenty percent of the energy converted in the metabolic process is usable by the body's cells. The other eighty percent ends up wasted as heat radiated from the body. This process is continuous, occurring even when the individual is at rest. The metabolic rate varies dependent upon food intake and physical activity. However, the base metabolism is fairly constant at 60-70 kilo-calories per hour (60-70 kcal/hr.). This basal metabolic rate is known as 1MET.

Measuring metabolic heat produced by the body is a difficult process because the device would have to account for all heat escaping from every point of the body, as well as any heat absorbed by body tissues. Using oxygen consumption as the base, a metabolic equivalent can be expressed as the use of 1 milliliter of oxygen per kilogram of body weight per minute of time:

$$1 \text{ MET} = 1 \text{ ml } O_2/\text{Kg}/\text{Min.}$$

This technique is used because of the ease of measuring oxygen consumption. In lay terms, it can be expressed through some common examples:

Activity	Kcal/hour	METs
Walking 2.5 mph with a 58 lb. load	415	6
Standing and performing arm work	240	4
Standing still	35	0.5

Heat Exchange

Heat exchange is a subject that you are probably familiar with. The terms conduction, convection, radiation and evaporation are common to the fire service. The metabolic process utilizes these same processes of exchange in the conversion of food energy. A quick review of the heat exchange modes is in order.

Conduction is the transfer of heat between two solids, or a solid and a liquid, that are in contact with one another. The dissipation of heat through conduction is minimal for emergency response personnel. This would typically only occur where the responder's body came into direct contact with the PPE suit material.

Radiation is the transfer of heat between two bodies that are not in direct contact with each other. This transfer occurs as electromagnetic waves that carry energy from an emitter (radiator), outward in all directions, to a receiver. An example of this is the heat radiated from asphalt on a hot day. Objects that emit electromagnetic energy greater than 39 degrees C (95 degrees F) are heat radiators to the human body. Color is another heat variable. Lighter colored objects or materials tend to reflect the majority of the electromagnetic energy that strikes them, while dark objects tend to absorb most of that energy.

This means that while light colored PPE suits will absorb some radiated heat, they will absorb far less than the darker suits will.

Convection is the transfer of heat that does not involve a phase change. Simply stated, convection utilizes liquid or gaseous mediums, or masses, to transport heat energy to other objects. These liquid or gaseous masses pick up the heat and carry them on rising columns to other objects where they can be absorbed. An example of this would be cool air blowing against dry skin. This form of heat exchange is also of little use to responders wearing PPE because of the insulating properties of the suit. As responders exhale air into the suit, the suit expands, creating an air void that limits the transfer of heat (or cooling).

Evaporation is the transfer of heat using a phase change. This phase change utilizes heat carried by a liquid such as sweat. As air travels over this liquid, heat energy is absorbed by the air, through evaporation, and carried away from the body. Evaporation is the major process, set off by the brain "set point," for body cooling. PPE is utilized by responders because it is impermeable to the transfer of vapors. This same quality renders the garments totally ineffective to the transfer of heat away from the body by evaporation.

Physical Heat Responses

The combination of physical exertion and lack of cooling begins to raise the body's core temperature. As the internal temperature rises, the body starts various control functions to moderate this heat. Increasing amounts of blood are shunted from the core to the cutaneous layers of skin. Greater amounts of sweat are produced for evaporative cooling. The heart begins to pump faster and harder to move more volumes of heat to the surface.

The body begins to lose ground when the heat cannot be dissipated quickly enough. The internal heating process continues, building more heat that still cannot be dissipated by normal body mechanisms. Eventually, the thermal regulatory system is overwhelmed. The brain now exacerbates the cooling problem by greatly increasing the "set point," which severely diminishes any further amounts of sweat production. This condition marks total failure of thermoregulation by the body.

The circulatory system functions to delivery oxygen and fuel to the individual cells. Blood, carrying these essential nutrients, is delivered through a regional system of arteries, arterioles, capillaries and capillary beds. This network can be regulated by the brain to carry only the amount of nutrients needed by each area of the body. However, this system can also be overcome. When that happens it leads to a condition known as anaerobic metabolism. This is a condition where oxygen is no longer supplied in sufficient quantity to continue the metabolic process that converts food to energy and nutrients (amino acids, carbohydrates, etc.). Oxygen insufficiency cannot be continued indefinitely.

One example of this insufficiency is the build-up of lactic acid in the muscle tissues. Lactic acid is a by-product of muscular activity which can only be removed through oxidation. However, the metabolic processes of muscle activity preferentially use available oxygen to assist the muscles in work. Since there is insufficient oxygen during activity to oxidize both the acid and the muscle tissues, the acid begins to accumulate. The results are muscle cramps and physical pain, and can lead to blood acidosis—a potentially fatal condition.

Additionally, all humans are exercise-limited by the cardiovascular system. When energy is no longer available from the ready nutrient sources, blood sugars and stored fats, the body will begin to go after other sources—muscles, then nerves, and then other tissues. The brain is in even worse shape since it cannot store oxygen or nutrients, and must have immediately available supplies of both.

The body's initial response to exercise is to increase the heart stroke volume (SV). This is the amount of blood produced by one beat of the heart. The second body response to exercise is to increase the heart rate (HR)—the number of beats. The identified safe maximum number of beats-per-minute for an individual is computed by the equation:

$$\text{Max. HR} = 220 - \text{age}$$

The increased stroke volume and heart rate can result in a cardiac output of 20-25 liters per minute:

$$\text{SV} \times \text{HR} = 20\text{-}25 \text{ L/min}$$

Typically, the average adult blood volume is about 3.2 liters. This blood is primarily composed of plasma and red blood cells. Blood also provides the fluid used in the production of sweat. Therefore, sweating begins to deplete the available blood volume as some of the fluid is converted for the sweating process.

Physical exertion provides another impact. Exercise begins a process in the body that leads to the dilation of the blood vessels. As the walls of the vessels begin to expand, the normal blood capacity can no longer fill the intervening space. The normal plasma volume is insufficient to circulate oxygen and nutrients to the various body areas that are in need. A simple rapid increase of only 5 or 10% dilation in the vascular system is sufficient to produce relative hypovolemia. When massive vasodilation occurs, such as often accompanies shock, blood volume resuscitation may require 15-25 liters, or more.

Heat Related Injuries

If the body's physiological processes fail to maintain a normal body temperature, and excessive heat is allowed to build up, a number of physical reactions can occur. These may range from mild (fatigue, irritability, anxiety, decreased concentration and dexterity) to fatal. Standard reference books should be consulted for specific treatment in these instances. Heat related injuries are the result of certain thermal disorders:

Heat Rash: Caused by continuous exposure to heat and humid air, and aggravated by chafing clothes. Heat rash decreases the ability to tolerate heat, as well as being a general nuisance.

Heat Cramps: Caused by profuse perspiration with inadequate fluid intake and chemical replacement (especially salts). Signs of heat cramps include muscle spasms, and pain in the extremities and abdomen.

Heat Stress: The first manifestation of the body's thermoregulatory failure is heat stress. Typical signs and symptoms include fatigue, irritation, altered mental state or level of consciousness, and dehydration. The body temperature is between 37-38 degrees C (98.6-100.4 degrees F).

Heat Exhaustion: The second manifestation of heat stress is heat exhaustion. It is caused by increased stress on various organs to meet increased demands to cool the body. While the body is still capable of producing sweat, a condition known as cardiovascular insufficiency is developing. This condition exists when the total available blood volume is no longer capable of fulfilling the vascular system's needs. Typical signs and symptoms include shallow breathing; flushed, cool, moist skin; profuse sweating; dizziness and lassitude. The body temperature is between 37.5-38.5 degrees C (99.5-101.3 degrees F).

Heat Stroke (Sunstroke): The final manifestation is heatstroke—commonly called "sunstroke." This is the catastrophic failure of the body's thermoregulatory system and is a true medical emergency that can rapidly result in the patient's death. The body must be cooled immediately to prevent severe injury and/or death. Signs and symptoms include red, hot, dry skin; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; hypotension; coma. The body temperature is over 40.8 degrees C (104.9 degrees F).

Treatment of Heat Illness

Anyone who exhibits the signs or symptoms of a heat related illness requires immediate medical attention. These individuals should be removed to a shaded area and cooled by evaporative or active cooling methods. Intravenous therapy should be considered anytime that cardiovascular insufficiency is a factor in the patient's condition. For all heat related injuries, the following protocols should be adhered to:

- Maintain vital signs.
- Monitor patients.

Transport patients to the nearest medical facility, if appropriate.

Medical Monitoring

The need for medical monitoring guidelines is heightened by the pressures placed on emergency responders by their supervisors, peers, and their own individual motivations, to continue working even when it is no longer safe for them to do so. Fortunately, OSHA requirements specify medical monitoring as a component of the Site Safety Plan. This reduces the chances that individuals may exceed their physical limitations due to inappropriate motivations. However, we must also recognize that medical monitoring has certain implications. It may shorten the work time for each individual, which requires that additional trained responders be available to mitigate the same incident. Medical monitoring may also increase the time between entries, and increase the times needed for rehydration, rest periods and temperature recovery—again increasing the number of trained responders required. These two factors illustrate the need to better prioritize the objectives for personnel working in the various zones.

Pre-Entry and Post-Entry Assessments

Medical support and assessment is an important element of an effective Hazardous Materials response. Medical monitoring should be initiated both before entry into the Exclusion Zone, and after exiting. The Level II Responder is responsible for the execution of, or the supervision of, medical support for hazardous materials responders.

More important than the legal requirements for medical monitoring is the personal impact of monitoring on the individual. We already know that heat related illnesses (heat stress, heat exhaustion and heat stroke) are the number one health risk to emergency responders at hazardous materials incidents. Heat related illnesses are most prevalent during warm or hot weather. Monitoring vital signs provides the best method to prevent or identify these conditions. Obviously, the backbone of this program rests with assigning critical values that identify these symptoms before they become serious.

Monitoring procedures are not limited to field locations. 29 CFR 1910.120 designates two types of programs: baseline medical exams and field monitoring programs. Medical monitoring is a multi-faceted program that is predicated on the status of the individual:

- Employees who have hazardous materials incident response functions as a regular, expected function of their employment.
- Employees who *do not* have hazardous materials incident response functions as a regular, expected function of their employment.

Employees in the first category fall into the group of those who must have baseline medical examinations, as well as pre-entry and post-entry monitoring. Employees in the second group require pre-entry and post-entry monitoring only.

Baseline medical evaluations are conducted under the guidance of a physician and are done biennially, annually, or prior to response. Pre-entry physicals are routinely conducted by field EMS personnel who should be assigned exclusively to this duty at the scene and answer directly to the site safety officer only. Post-entry screening applies the monitoring guidelines, as suggested in this chapter, to assess physical status at the scene (see Medical Monitoring Position Description).

Emergency response personnel must establish a medical monitoring station at each hazardous materials incident. The medical monitoring site should be located near the “dress out” area for the Entry and Decontamination Team personnel. If possible, this should be in a cool, shaded location away from noise and other distractions.

All pre-entry and post-entry vitals that are taken must be documented. Therefore, agencies should establish some sort of record keeping system to document these vitals.

Elements of an Effective Medical Monitoring Program

Advances in medical science have altered our understanding of what constitutes heat illnesses and what their more accurate indicators are. Previously, we held the belief that the best indicators for measuring heat distress were accomplished by assessing the patient’s temperature, heart rate and blood pressure. We now accept that a more accurate assessment is gained by measuring the patient’s body core temperature, heart rate and water weight loss. Therefore, an effective medical monitoring program should include assessments of these essential factors.

Body weight: It is possible for individuals to have a sweat rate as high as 3.5 liters per hour when they are wearing chemical protective clothing. Fluid loss is an element of heat stress management that cannot be made up quickly. Fluid metabolism is a slow process that must occur throughout the day to be truly effective. A good rule of thumb for fluid replacement is to administer the equivalent amount of fluid weight as was lost through the incident activity. When considering the administration of fluids, do not rely on the patient’s thirst level alone. This is a deceptive indicator. A more accurate indicator is deeply yellow colored urine. However, false indicators from certain vitamins and various foods can also create this condition. Don’t guess. Rely on measurable indices: body weight loss using a scale accurate to within 1/4 of a pound.

Suggested water weight loss parameters are:

- Body weight loss should not be allowed to exceed 1.5% of total body weight.
- A 3% loss of body weight should require that the individual be immediately removed from all duties pending a thorough assessment by a qualified medical authority.
- A 5% loss of body weight should require that the individual be immediately transported to the nearest medical facility for a thorough assessment.

Be cautious when taking the post-entry body weights. Post-entry assessment is intended to weigh the amount of fluid remaining in the body tissues. Weighing individuals who have rehydrated or are still in sweat soaked garments defeats the purpose of the measurement. Pools of liquid in the stomach or hanging on the body serve no immediate value and may mask a serious condition. Make sure the post-entry weight is a “dry” one.

Body temperature: The most common of body temperature assessment is the oral thermometer, but oral temperatures are not accurate enough to rely on for determining patient well-being. The second option is hardly practical in the field. Even though rectal temperatures are the most representative deep core temperature indicator, few responders would consider them to be practical at a hazardous materials site. The third option provides the best solution. Tympanic temperature readings (taken through the ear drum) are a good indicator of body core temperatures and are relatively easy to acquire.

The best method of accurately determining an individual’s temperature rise is by establishing a baseline prior to the event. This is accomplished by measuring the temperature every day over a two week period. However, this is not always an easy task to accomplish. Again, some guidelines can be utilized:

- A maximum rise in temperature should not exceed 1.5 degrees Fahrenheit upon post-entry examination.

- No personnel should be permitted to continue working until their temperatures return to within 0.5 degrees of normal.
- To be valid, the temperature must be acquired as quickly as possible after the individual has exited the work zones.

Pulse or heart rate: The pulse is the best indicator of the overall stress being applied to the body. It is a direct measurement of how fast the body is attempting to cool itself, and it indicates the aerobic exercise recently generated by the individual. The most widely accepted pulse measurement is known as the *"Age Adjusted Maximum Heart Rate."* This figure represents the limit to which an individual can maintain aerobic exercise for extended periods without damaging the heart muscles. However, this number should never be exceeded by personnel. To figure the Age Adjusted Heart Rate, subtract the individual's age from the number 220.

220 – age = Adjusted Heart Rate

Blood pressure: This is a health component that is not believed to be affected by heat stress, and does not require constant monitoring. However, it is a measurement of the "quality" of rest by the heart muscle between each stroke and is worth tracking.

General health: Is an overall indicator of the responders' fitness for stressful working environments. This includes general physical appearance and identification of personnel who haven't been feeling well lately.

Neurological status: Can be an early indicator of stress and/or exposure.

Electrocardiograph strip: These devices are rarely available in the field, but they are a good, qualitative baseline when they are.

Fluid Replacement, Rest and Recuperation Guidelines

The Medical Monitoring plan must address every factor pertinent to the full recovery and return-to-work of all personnel. These factors include: fluid replacement, rest, and heart recovery.

Water is the best fluid replacement. Sweetened drinks tend to inhibit the metabolic process that restores water to the cells, as does carbonation. However, personnel should be allowed to drink something that they like. Fruit juices and electrolyte solutions should be diluted with water prior to consumption. This will improve the body's ability to assimilate these liquids. Alcohol and caffeinated drinks should never be permitted because they actually promote dehydration, as do salt tablets. Additionally, drinks that are cooled to between 50-60 degrees better facilitate the absorption of water by the body.

The medical monitoring plan may use a variety of methods to determine rest and recuperation periods. As an example, aerobically fit personnel, working under normal conditions for twenty minutes should rest as per the following:

Ambient Air Temperature	Rest Period
<70 degrees F	30 minutes
70-85 degrees F	45 minutes
>85 degrees F	60 minutes

Recommended work durations, between rest periods, for personnel wearing CPC is covered by the Occupational Safety and Health Guidance manual for Hazardous Waste Site activity in Table 8-10. (Refer to the Work Duration Form on page 2.6.) However, minimum recovery guidelines must be utilized to determine when personnel have returned to a condition where they may wear CPC and return to a work zone again. The minimum suggested health guidelines are:

Vital Sign	Minimum Guideline
Temperature	A return to within .5 degrees of normal
Body Weight	A return to within 1.5% of normal
Pulse	A return to within 5%, and <90 beats per minute
Blood Pressure	<150/90

These guidelines may be amended, deleted, or added to based upon the guidance of your Team physician.

Guidelines for Removing Workers

A responder manifesting any one of the following signs should be removed from work. Responders removed from work due to these medical signs are not allowed to return to work until cleared by a qualified medical authority.

Vital Sign	Point at Which Responders Should Be Removed from Work
Body Temperature	>38 degrees C (100.4 degrees F)—This is an OSHA requirement
Pulse	>85% of the maximum heart rate (Maximum 220-age) >110 beats per minute while the individual is at rest
Heart rate recovery	<10 beats per minute*
Body weight loss	>3%
Other	Other signs and symptoms of heat related illness such as skin temperature and cardiac rhythms

* Heart rate recovery is measured by taking the first and third minute pulse rates immediately upon exiting the work zone and then determining the difference. It is stated as:

(Heart rate recovery = 1 minute rate – 3 minute rate)

Personal Exposure Records

29 CFR 1910.120 requires personal exposure records for all personnel working at a hazardous waste site. By definition, a hazardous materials incident is a hazardous waste site. This requirement covers all employees who were exposed to, or were potentially exposed to, hazardous materials. This regulation requires the employer to document exposures in the employee's records and maintain those files for thirty years beyond the last day of the individual's employment. However, records do get lost or accidentally destroyed. Therefore, it is essential that the employees maintain their own copies of the file. Otherwise, it may be very difficult to prove occupational exposures in the future.

NJSP

Emergency Management Section

DP/HMERP Unit Medical Monitoring Form				Page____of_____			Critical Values						
							Heart Rate				Body Weight		
Name / Age	Date	Time	B/P	Pulse	Temp	Weight	Age	MHR	85%	60%	Wgt	3%	5%
							20	200	170	120	150	146	143
							21	199	169	119	155	150	147
							22	198	168	119	160	155	152
							23	197	167	118	165	160	157
							24	196	167	118	170	165	162
							25	195	166	117	175	170	166
							26	194	165	116	180	175	171
							27	193	164	116	185	179	176
							28	192	163	115	190	184	181
							29	191	162	115	195	189	185
							30	190	162	114	200	194	190
							31	189	161	113	205	199	195
							32	188	160	113	210	204	200
							33	187	159	112	215	209	204
							34	186	158	112	220	213	209
							35	185	157	111	225	218	214
							36	184	156	110	230	223	219
							37	183	156	110	235	228	223
							38	182	155	109	240	233	228
							39	181	154	109	245	238	233
							40	180	153	108	250	243	238
							41	179	152	107	255	247	242
							42	178	151	107	260	252	247
							43	177	150	106	265	257	252
							44	176	150	106	270	262	257
							45	175	149	105	275	267	261
							46	174	148	104	280	272	266

Summary

The encapsulating suit may be the most dangerous environment encountered at a hazardous materials incident. Monitoring of emergency response personnel needs to be improved as air times and entry times increase. Some parameters can be modified to improve personnel safety. Remember that the risk of heat stress is proportional to the aerobic fitness of the worker. Consider improving the Fit(ness) of the responder, rather than improving the fit of the suit to the responder. Account for those conditions that cannot be modified and always provide for safety first.

Heat related illnesses are the number one cause of injuries to hazardous materials emergency responders. Limiting the occurrence of these injuries is dependent upon controlling the physical processes that lead to them. Prevention begins with awareness and ends with preparation. Preparation must be an on-going process for each responder before the incident occurs, while awareness of these hazards will help the responder to travel safely through the incident.

Medical monitoring of responders is important, not just because it is required. Establish an SOP for medical monitoring for your agency. Ask for guidance from your team physician. And, if you do commit errors, make them on the side of safety. Don't forget to provide EMS personnel with information on the signs and symptoms of exposure to the site chemicals as soon as they become available.

Study Questions

- Describe the four types of stresses encountered when wearing CPC.
- What factors make personnel susceptible to heat related illnesses or other injuries?
- How does wearing CPC impact work tolerance?
- How may cold exposure affect emergency response personnel?
- How is a Work Mission Duration form used to protect response personnel?
- What two factors should be considered when modifying work duration?
- Describe the ways in which the body responds to changes in core temperature.
- Describe the four types of heat related illness, and the signs and symptoms associated with each.
- What is the appropriate treatment for heat related illnesses?
- What are the components of a medical monitoring plan?
- What is the best indicator of overall stress on the body?
- Why shouldn't substances containing salt, alcohol or caffeine be given to personnel?
- What are the guidelines for removing personnel from work?
- How long must employers maintain personal exposure records?

INFORMATION SHEET #2.1
Medical Monitoring Leader—Position Description

CHAPTER 1—CHECKLIST

1.1 **CHECKLIST USE:** The checklist presented below should be considered as a minimum requirement for this position. Users of this manual should feel free to augment this list as necessary.

1.2 **MEDICAL MONITORING LEADER CHECKLIST**

- Check in and obtain briefing from the Assisting Safety Officer—Hazardous Materials.
- Obtain briefing from HazMat Group Supervisor.
- Obtain needed equipment from the HazMat Unit.
- Obtain chemical and medical information from the Technical Specialist—Hazardous Materials Reference.
- Obtain baseline medical information from team members.
- Brief on-site EMS crews.
- Assist Decontamination Unit Leader in transfer of patients to the Medical Group/Unit.
- Maintain communication and coordinate operations with the Entry Leader.
- Maintain communication and coordinate operations with the Assistant Safety Officer—Hazardous Materials.
- Maintain Unit Log (ICS Form ______)

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CHAPTER 2—ORGANIZATION, PERSONNEL, RESPONSIBILITIES AND PROCEDURES

2.1 **ORGANIZATION:** The Medical Monitoring Leader reports to the Assistant Safety Officer—Hazardous Materials. The Medical Monitoring Leader is responsible for implementing medical monitoring for all personnel operating in the Exclusion Zone and the Contamination Reduction Zone. The Medical Monitoring Leader may assist the Medical Unit Leader in providing medical care to Entry Team members and Decontamination Team members who have been exposed to hazardous materials or who are suffering from heat related illnesses. The Medical Monitoring Leader, using objective criteria, will determine the fitness of the Entry Team or Decontamination Team members to conduct operations.

2.2 **PERSONNEL:** The Medical Monitoring Leader is part of the organizational structure designed to provide the Assistant Safety Officer—Hazardous Materials with the expertise to evaluate and monitor the medical condition of all emergency response personnel who may be required to use Personal Protective Equipment (PPE). Personnel in this position must be able to perform team member physical assessments, according to the guidelines presented in this policy. The Medical Monitoring Leader shall follow the established pre-entry Medical policy for determining whether team members are authorized for entry operations. The Medical Monitoring Leader must be able to recognize the signs and symptoms of heat disorders, hazardous materials exposures, and other medical emergencies. These responsibilities require that the personnel assigned to this position be **minimally** certified to the Emergency Medical Technician—1 level.

2.3 **RESPONSIBILITIES:** The purpose of the On-Site Medical Monitoring Program is to ensure the safety of emergency response personnel. Emergency response personnel are exposed to high levels of physiological and psychological stress. Personnel may develop heat stress while wearing Personal Protective Equipment (PPE) or while working during temperature extremes. Team members may also be exposed to hazardous substances. The On-Site Medical Monitoring Program uses objective criteria to monitor the physical health of all members of the Entry Team, Back Up Team, Decontamination Team, and other assigned support personnel.

A Medical Monitoring Leader shall be appointed if **any** personnel will be using PPE. The person assigned to this position shall be trained in the On-Site Medical Monitoring Program. Depending on the number of personnel donning PPE it may be necessary to assign additional personnel to the Medical Monitoring Team.

The Medical Monitoring Leader shall acquire the following equipment:

- Stethoscope(s)
- Blood Pressure Cuff(s)
- Oral or Tympanic, Basal Thermometer
- Weigh Scale
- Medical Monitoring Leader Checklist
- Medical Monitoring Forms

2.4 STANDARD OPERATING PROCEDURES—ON-SITE MEDICAL MONITORING

Pre-Entry

Pre-entry vital signs and weights shall be taken prior to performing any strenuous activity or donning any chemical protective equipment. Baseline vital signs should include:

- Blood Pressure
- Pulse
- Respirations
- Weight
- Temperature

The Medical Monitor shall calculate the following values for each Team member:

- Maximum Heart Rate (220 – Age)
- 85% of Maximum Heart Rate
- 60% of Maximum Heart Rate
- 5% Body Weight
- 3% Body Weight

All information shall be entered on the medical monitoring forms.

Any team member with any of the following conditions shall not be allowed to don PPE:

Temperature	>99.8 degrees F,
Blood Pressure	>150/90,
Heart Rate	>60% of Maximum Heart Rate, or
Respirations	>25

The Medical Monitoring Leader shall obtain Hazard and Toxicity information from the Technical Specialist—Hazardous Materials Reference. Also, signs and symptoms of chemical exposure shall be ascertained if the chemical is known. The Medical Monitoring Leader shall reference the Cal-EMSA treatment guidelines for pre-hospital treatments for known environments and potential exposure complications.

The Medical Monitoring Leader shall brief on-site EMS crews. The following information, if known, shall be conveyed:

- Chemical Name
- Hazard Class and Name
- Hazard and Toxicity Information
- Potential for Secondary Contamination
- Pre-hospital Management after Initial Decontamination
- Procedure for Transfer of Patients to EMS
- Pre-hospital Management of Medical Emergencies

Post-Entry

After team members doff PPE they shall immediately proceed to the medical monitoring station. The medical monitors will obtain the following:

- Pulse—first minute
- Pulse—3 minutes after first pulse (recovery rate)
- Temperature
- Weight
- Blood Pressure
- Respirations

Determinations will then be made for capabilities to perform further entry operations.

If any one of the following criteria are met the team members shall not be allowed to perform duties requiring the use of PPE for 24 Hours:

Pulse	>85% of Maximum Heart Rate
Temperature	>100.4 degrees F
Recovery Heart Rate	<10 BPM (initial pulse – 3 Min. pulse)
Blood Pressure	>160/100
Weight Loss	≥3%

The Medical Monitoring Leader shall immediately report the name of any team members meeting the above criteria to the Assistant Safety Officer—Hazardous Materials and the Entry or Decontamination Leader as appropriate.

No team member shall be allowed to re-don PPE if they cannot meet the pre-entry requirements previously described.

Any team member exhibiting signs or symptoms of heat exhaustion, or heat stroke, or who has had a weight loss ≥5% shall be transported by Advanced Life Support Ambulance to the hospital for evaluation. Intravenous fluid resuscitation may be required for these personnel.

Any team member who is exposed to hazardous materials shall be assessed by Advanced Life Support personnel for signs and symptoms of exposure at toxic levels. Any person exhibiting signs and symptoms of exposure shall be transported to a hospital emergency department by ALS ambulance according to local medical guidelines. If the individual is not exhibiting any signs and symptoms of a hazardous material exposure, the individual may still be required to be evaluated at a hospital emergency department if, in the opinion of the Asst. Safety Officer—Hazardous Materials and/or the Environmental Health Specialist, such evaluation is necessary based on the properties of the hazardous material. The Medical Monitoring Leader shall immediately notify the Hazardous Materials Group Supervisor and the Assistant Safety Officer—Hazardous Materials of any team member who needs transport to the hospital. Transportation shall be arranged through the Medical Unit Leader, or appropriate supervisor. Unless the team members condition is emergent, the on-site ambulance should not be used as this would require shutting down any further operations in the Exclusion Zone.

While at the medical monitoring station, Team members should drink at least 16 fluid ounces of water or other suitable substance for rehydration (Gatorade, Powerbust). Team members should be encouraged to drink more than this if they still feel thirsty. Soda, or other liquids containing caffeine, carbonation, or alcohol will not be allowed. Remember, thirst is not an adequate indicator of heat exposure. Consult fluid resuscitation charts when appropriate.

After all operations are terminated, the Medical Monitoring Leader shall collect all Medical Monitoring Forms and give them to the Documentation Unit Leader or Hazardous Material Group Supervisor. This shall include documentation for all cost recoverable items. All recoverable equipment used by the Medical Monitoring Team should be cleaned and returned to the Haz Mat Unit(s). All waste materials shall be disposed of by the appropriate method(s).

RESPIRATORY PROTECTION NEED

One of the most common routes of entry of chemical exposure is by inhalation. Entry of a chemical by inhalation is also one of the easiest to control. While the respiratory tract or system has some very good protection, most often during chemical exposures, this protection is not sufficient to handle the chemical exposure. Health and Safety professionals must consider one of the three (3) means of controlling respiratory hazards from these chemical exposures.

- Engineering Controls
- Administrative Controls
- Personal Protective Equipment

NOTE: Personal Protective Equipment is last on the list.

The OSHA HAZWOPER standard (29 CFR 1910.120) does not permit the use of administrative controls as a means of reducing worker exposure to chemical hazards. If engineering controls are not utilized, the effects of chemical exposure on the human body may be:

- Asphyxiation
- Allergic reaction
- Anesthetic effect
- Irritations
- Systemic poisoning
- Cancer causing

If engineering controls are inadequate or not practical, personal protective equipment (respiratory) will need to be used.

The OSHA respiratory protection standard, 29 CFR 1910.134 requires employers to supply suitable respiratory protection for all employees and personnel who may be exposed to unknown levels of toxins, IDLH atmospheres and/or above permissible exposure levels (PEL) OSHA and PEOSHA address a written respiratory program.

Respiratory protection program shall include:

1. Standard Operating Procedures/Guidelines (SOP/SOG) for the selection and use.
2. Proper selection of respirators based on the hazard.
3. Training of personnel in the use, care and maintenance of respiratory equipment.
4. Regular cleaning and maintenance.
5. Routine inspections before & after use with appropriate documentation.
6. Constant monitoring of work area for changing conditions and worker stress.

7. Continual evaluation of respiratory compliance program.
8. Determination of medical fitness of users.
9. Use of approved equipment (typically NIOSH and MSHA).
10. Proper fit testing.

Also included in the program is the use of the buddy system, emergency alerting, evacuation and accountability.

TYPES OF RESPIRATORY PROTECTION

There are two major classifications for respiratory protection:

1. Air Purifying Respirators (APR)
2. Atmosphere Supplying Respirators (SAR, SCBA)

1. Air purifying respirators allow the wearer to use atmospheric air by filtering out, absorbing or neutralizing the airborne contaminants.

Use of air purifying respirators are limited and only appropriate when:

1. Atmospheric oxygen levels are above 19.5%
2. Chemical substance is known
3. Chemical substance can be filtered, absorbed or neutralized
4. Chemical substance has a detectable odor below IDLH
5. Airborne concentration of chemical substance is known
6. Airborne concentration of chemical substance does exceed .1% or 1000 ppm
7. Airborne concentration of chemical substance does not exceed established IDLH

The caisters or cartridges used in an air purifying respirator are selected according to the chemical in the air and the physical state of the chemical. These cartridges are color coded:

Atmospheric Contaminants to be Protected Against	Colors Assigned
Acid Gas	White
Hydrocyanic Acid Gas	White with 1/2 inch green stripe completely around the canister near the bottom
Chlorine Gas	White with 1/2 inch yellow stripe completely around the canister near the bottom
Organic Vapors	Black
Ammonia Gas	Green
Acid Gas & Ammonia Gas	Green with 1/2 inch White stripe completely around the canister near the bottom
Carbon Monoxide	Blue
Acid Gases, organic vapors & Ammonia gases	Brown
Radioactive materials, excepting tritium and noble gases	Purple (Magenta)
Particulates (dusts, fumes, mists, fogs, or smoke) in combination with any of the above gases or vapors	Canisters color for contaminants, as designated above, with 1/2 inch Gray stripe completely around the canister near the TOP
All of the above atmospheric contaminants	Red with 1/2 inch Gray stripe completely around the canister near the TOP

*Gray shall not be assigned as the main color for a canister designed to remove acids or vapors.

NOTE: Orange shall be used as a complete body, or stripe color represent gases not included in this table. The user will need to refer to the canister label to determine the degree of protection the canister will afford.

Air purifying respirators may be purchased as:

Tight Fitting Coverings

Quarter Mask

Half Mask

Full Facepiece

Mouthpiece/Nose Clamp (no fit test required)

Quarter-face APR

Half-face APR

Full-face-APR

Escape APR

2. Atmospheric Supplying Respirators

Atmospheric supplying respirators do not purify the contaminated air but supplies the wearer with “clean air” from some other source. The air may be either self contained or air supplied. Self contained (SCBA) respirators can be purchased as closed circuit or open circuit.

Closed circuit breathing apparatus recycles the wearers exhaled air. The carbon dioxide is chemically removed and fresh oxygen is introduced. This type of breathing apparatus is commonly referred to as a “rebreather.”

Open circuit SCBA exhaust exhaled air directly to the outside environment. Air is supplied to the wearer by either a single stage (conventional) or a two stage (NASA) regulator. Single stage regulators reduce the pressure from the air cylinder only once before reaching the wearer. This type of SCBA is usually characterized by a low pressure tube hanging from the facepiece. Two stage regulators have an initial reduction of cylinder air pressure immediately exiting the air cylinder. A second regulator is then placed at the face piece.

OPEN CIRCUIT SCBA

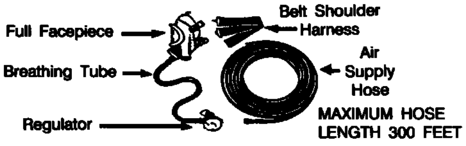
CLOSED CIRCUIT-4 HOUR SCBA

SCBA Donning Guideline

Each manufacturer has specific guidelines dealing with the donning, doffing, care, maintenance and repair of their apparatus. Check with them before any program is established.

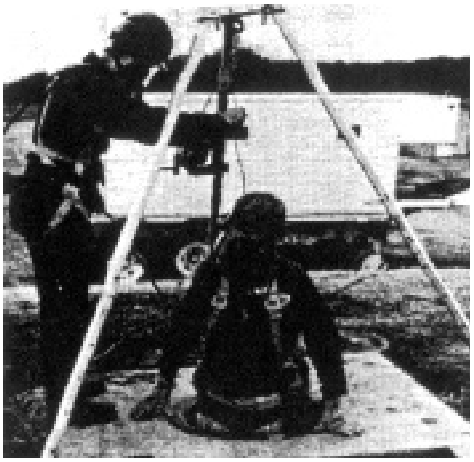
SUPPLIED AIR RESPIRATOR (SAR)

Commonly referred to as air line hook-up. The SAR is connected to larger air receiver as is used for entry that may require a small profile (such as Confined Space) or extended time periods. Typical equipment included is:

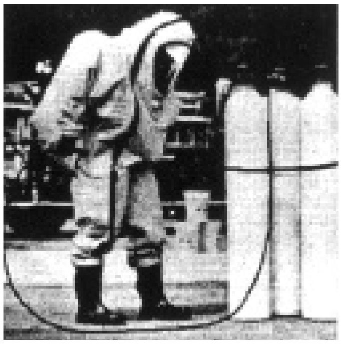


Supplied Air Respirator

1. Air hose (usually in 100 ft. length)
2. Air regulator
3. Air cylinders (2400 psi or greater)
4. Air mask with low pressure regulator
5. Escape bottle (10-15 minute supply)



CONFINED SPACE SAR



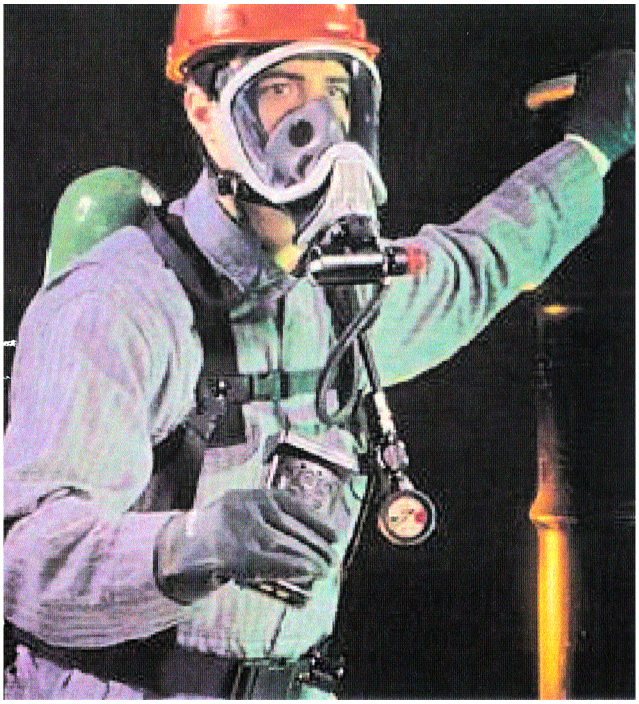
Level A w/airline

The SAR is very similar to the use of SCBA. Each of the devices must be NIOSH and MSHA approved.

While they provide extended stay time in an area, they do have some drawbacks.

- Limited to **300 ft.** Maximum distance
- A low pressure audible alarm and/or
- An attendant must be present
- Requires additional training
- Restricts mobility
- Can become entangled easily
- Difficulty in decontaminate after use
- Compatibility with exterior of air hose and chemical hazard.

SAR with Escape 'Bottle'



SCBA with airline connector

OSHA 2 IN 2 OUT RULE (Buddy System)

Any course or program dealing with the use of respirators would not be complete if we did not discuss the rules of the road. General OSHA standard under 29 CFR 1910.134 governs the use of respiratory protection. In addition, the fire service must also comply with the 1910.156 standard on Fire Brigades.

The HAZWOPER standard 1910.120 references the OSHA respiratory standards. All of the OSHA standards are available from the US DOL office in Washington D.C. or their local field offices. They are also available electronically via CD-ROM and the DOL subscription service, or via the Internet at http://www.OSHA.com..

1910.134(e)(3)(i)

(i) In areas where the wearer, with failure of the respirator, could be overcome by a toxic or oxygen-deficient atmosphere, at least one additional man shall be present. Communications (visual, voice, or signal line) shall be maintained between both or all individuals present. Planning shall be such that one individual will be unaffected by any likely incident and have the proper rescue equipment to be able to assist the other(s) in case of emergency.

(ii) When self-contained breathing apparatus or hose masks with blowers are used in atmospheres immediately dangerous to life or health, standby men must be present with suitable rescue equipment.

(iii) Persons using air line respirators in atmospheres immediately hazardous to life or health shall be equipped with safety harnesses and safety lines for lifting or removing persons from hazardous atmospheres or other and equivalent provisions for the rescue of persons from hazardous atmospheres shall be used. A standby man or men with suitable self-contained breathing apparatus shall be at the nearest fresh air base for emergency rescue.

Paragraph (q)(3)(v) of HAZWOPER requires that *"operations in hazardous areas (emphasis added) shall be performed using the buddy system in groups of two or more."* In addition, paragraph (q)(3)(vi) states that *"back up personnel shall stand by with equipment ready to provide assistance or rescue."* This section means that as a minimum, the buddy system must be used within the hazardous area (entry by at least two persons) and at least two additional personnel shall stand by outside the hazardous area.

Thus, there must be at least four individuals at the site. One of the two individuals outside the hazard area can be assigned to another task, provided that the second assignment does not interfere with the performance of the stand-by role.

Regarding the use of buddy systems, OSHA understands the HAZWOPER standard to mean the following: a buddy shall be assigned who is able to:

(1) provide the partner with assistance;

(2) observe the partner for signs of chemical, heat, or other hazardous exposure;

(3) periodically check the integrity of the partner's personal protective equipment/clothing; and

(4) if emergency help is needed, notify the appropriate individual (i.e., the Command Post Supervisor, the On-Scene Incident Commander).

The standard defines a "buddy system" and "IDLH" below as:

"Buddy system means a system of organizing employees into workgroups in such a manner that each employee of the work group is designated to be observed by at least one other employee in the work group. The purpose of the buddy system is to provide rapid assistance to employees in the event of an emergency."

"IDLH or Immediately dangerous to life or health means an atmospheric concentration of any toxic, corrosive or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere."

Source: OSHA SLC Interp. 1, May, 85

DONNING AND DOFFING LEVEL B TYPE SUITS

INTRODUCTION

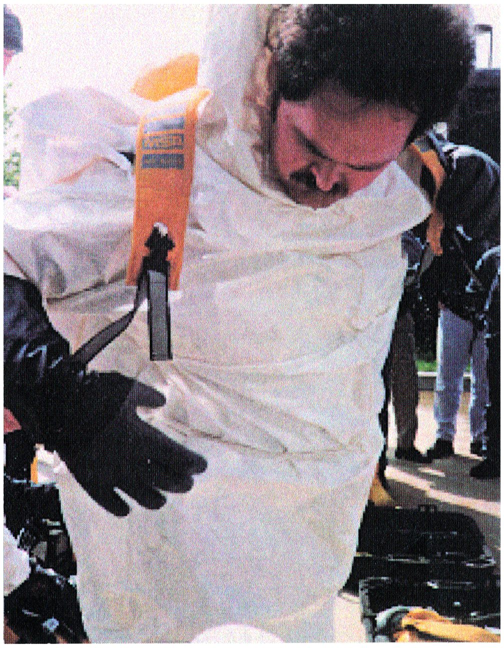
In responding to incidents involving hazardous materials or substances, it may be necessary for the emergency response personnel to wear protective clothing to include EPA LEVEL B TYPE suits. Donning and doffing is a relatively simple task. But a routine must be established and practiced frequently. Not only will correct procedures help install confidence in the wearer of the suit, but will also reduce the risk of exposure and the possibility of damage to the suit. It is especially important to establish a systematic method or procedure to remove this equipment to prevent or minimize the transfer of contaminants from the suit to the wearer.

Donning and doffing an EPA LEVEL B TYPE suit is more difficult if the wearer is doing it alone because of the physical effort required. The possibility increases of the wearer becoming exposed to contaminants or damaging the suit. Therefore, assistance from two or three others is needed to safely don/doff the protective suit.

The following procedure for donning/doffing a protective suit is only a general procedure. The manufacturer of the garment should be consulted for any specific details or recommendations. The wearer should be qualified and properly trained in the use of self contained breathing apparatus (SCBA) and physically fit to perform the strenuous tasks while wearing protective clothing. The old adage "learn by doing" should be encouraged, but not during actual emergencies.

GENERIC SUIT DONNING GUIDE

- Prior to donning the suit an inspection of the suit should be performed to detect any problems or deficiencies that may reduce the suit's effectiveness.
- While sitting (preferably), step into suit legs, place feet into boots if attached. (Consult manufacturer of suit for specific details.)
- Gather suit about the waist.
- Select the proper type & attach boots to suit (if not equipped). (The use of disposable booths or boot covers is recommended and desirable.)
- Put on inter-suit gloves. Secure to inter-suit.
- While standing, place arms into suit sleeves.
- Place outer gloves on outside of suit and secure. (The greatest level of hand protection should be placed on the outside of the suit.)
- Don SCBA. (May be different, depends on type protective suit selected.)
- Depending on the type of suit—slip head section over your head. This is where the assistance of safety personnel come into play.
- Don facepiece and adjust for fit. Do not yet hook-up to air supply.
- Tape and secure suit hood to face mask if provided.
- Tape and secure hard hat.
- Perform a final suit closure check. Adjust all straps, head pieces, other openings and fittings.
- Turn on SCBA bottle if not already on. Record pressure.
- Connect SCBA breathing hose to regulator. Check the person to see if they are breathing adequately and they are comfortable. Close all remaining openings. The taping around the face mask has been questioned for some time. Response groups feel that there is no value to this process. However, there are those that feel it can actually hinder the overall safety of the individual as it does not provide protection. Still others feel that it covers the unprotected area of skin. Clearly it should be evaluated at each use and site.



DOFFING:

Exact procedures must be established and followed to remove the protective clothing & SCBA. The adherence to these procedures is necessary to minimize or prevent contamination or possible contamination of the wearer through contacting the outside surface of the suit.

It is important to note that once the level of protection is established, the level of decontamination should also be established. This level of decontamination should be in full readiness prior to any personnel entering the hot zone to perform whatever functions are assigned to them.

A consideration that should be addressed is the fact that additional breathing time may be required to be on hand. A pre-arranged procedure should be developed if an individual begins to run out of air prior to completing decontamination. Several options may be selected to accomplish this task, either by suit design or an emergency strip down procedure. In any event, a procedure is a must. This is important to both parties involved, so that each knows exactly what they are to do.

Once the suit has been decontaminated, the assistance from the safety people is again required.

- Remove the hard hat.
- Remove the SCBA back frame (DO NOT Disconnect).
- Remove all outer tapes.
- Remove the outer boots if equipped.
- Remove the outer gloves if equipped.
- Remove inner booties if worn.
- Step out of suit, place on protective cover (suit to remain in decon Area).
- Remove the SCBA face mask.
- Remove inner gloves (Turn Inside-Out).
- Walk over to clean area for Medical Monitoring and Fluid Replacement.

Once again consult the manufacturer for their recommendations on the exact procedure to follow based on the specific type of suit that you are utilizing.

Finally—Practice, Practice and Practice.

PRACTICAL EXERCISE IN THE DONNING/DOFFING OF LEVEL B PROTECTIVE SUIT

This practical exercise is designed to acquaint the student with the aspects of wearing a level B protective suit. The student, through hands-on training and while working in groups of two (2) and three (3), will each be afforded the opportunity to wear a level B suit. The other members will provide assistance to the wearer in the entering (donning) and exiting (doffing) the suit and will act as a safety to that person in the suit.

STUDENT CHECKLIST

DONNING AND DOFFING LEVEL B PVC SUIT

- REMOVE ALL WATCHES AND JEWELRY, ETC. AND SECURE
- DON JUMPSUIT
- DON INNER GLOVES AND SECURE (TAPE TO OUTSIDE OF JUMPSUIT)
- DON OUTER SUIT (PVC)
- DON PROTECTIVE FOOTWEAR
- DON PROTECTIVE HOOD (NOMEX OR PBI) OPTIONAL
- DON SCBA
- DON SCBA FACE MASK AND ADJUST TO FIT
- PULL PVC HOOD OVER HEAD AND SECURE WITH TAPE TO FACE MASK
- DON OUTER GLOVES (TAPE OVER PVC SUIT)
- PLACE AND SECURE HARD HAT OVER TOP HOOD
- PERFORM FINAL CHECKS—TAKE AIR BOTTLE READING
- PLACEMENT OF TWO-WAY RADIO (OPTIONAL)
- HOOK BREATHING TUBE TO REGULATOR

STUDENT CHECKLIST

DONNING LEVEL B PROTECTIVE SUIT (TYVEK)

- REMOVE ALL WATCHES AND JEWELRY
- DON JUMPSUIT OR COVERALLS (USE WORK SHOES—SAFETY TYPE)
- DON INNER GLOVES, ATTACH TO OUTSIDE OF JUMPSUIT
- DON PROTECTIVE SUIT
- DON OUTER BOOT COVERS
- CLOSE ALL SUIT CLOSURES
- DON SCBA
- DON SCBA FACE MASK AND ADJUST FOR FIT
- DON OUTER GLOVES, TAPE TO OUTSIDE OF SUIT
- ATTACH HARD HAT
- FINAL CHECK, TAKE AIR CYLINDER READING, GO ON AIR

DECON OF LEVEL B PROTECTIVE SUIT

The following is a list of general procedures that may be followed. Variations may be encountered due to the type and/or style of suit utilized.

NO PERSON SHOULD BE APPROACHING THE DECON LINE WITH AN ACTIVATING LOW PRESSURE ALARM

- REMOVE HELMET OR HARD HAT (If Located on Outside of Suit)
- REMOVE SCBA—LEAVE MASK AND BREATHING ATTACHED TO FACE
- REMOVE ALL OUTER TAPES
- REMOVE OUTER BOOTS
- REMOVE OUTER GLOVES
- REMOVE OUTER SUIT
- REMOVE SCBA FACE MASK
- REMOVE INNER GLOVES (TURN INSIDE OUT)

PRE-USE CHECK OF PROTECTIVE CLOTHING

The following is a list of general procedures that may be followed. Variation may be encountered due to the type of and style of suit(s) utilized.

- CHECK OVERALL CONDITION OF SUIT OR GARMENT
- CHECK IF ALL COMPONENTS ARE PRESENT AND WORKING
- CHECK ALL SEAMS FOR BREAKS, WEAR SPOTS, ABRASIONS AND/OR AIR HOLES
- CHECK ALL STITCHES AND BINDINGS FOR RIPS, BREAKS AND WEAR
- CHECK EACH BOOTIE (IF ATTACHED) FOR RIPS, CUTS, TEARS OR ABRASIONS
- CHECK EACH GLOVE FOR ABRASIONS, WEAR SPOTS AND HOLES

MODULE 4

BASIC MONITORING EQUIPMENT

OUTLINE

- **Introduction**
- **Monitoring Device Selection Criteria**
- **Monitoring Devices**
- **Combustible Gas Indicators**
- **Oxygen Meters**
- **Colormetric Indicator Tubes**
- **Toxic Materials Meters**
- **pH Meter/Paper**
- **Other Devices**
- **General Considerations**

MODULE 4
MONITORING EQUIPMENT

OBJECTIVES

The student will be able to:

1. State the purpose for on-site environmental monitoring during a hazardous materials incident.
2. List two air borne contaminants that can be monitored using a combustible gas indicator.
3. Identify the range of accuracy for colormetric indicator tubes.
4. List three operating criteria for any monitoring device that must be considered in selection and use.
5. Demonstrate the purpose, operation (including interpretation of results and operational and calibration checks), and limitations for the following basic monitoring equipment:
   a. Combustible gas detector
   b. Oxygen meter
   c. Colormetric tubes
   d. PH paper and strips
   e. Toxic Materials Meters

INTRODUCTION

One of the tasks that fall to the initial entry team at a hazardous material incident is to determine the immediate or potential hazards at an incident that may affect response personnel, public health, and the environment. Without the ability to monitor Hazardous Materials from an accident, leak, or spill, the hazmat worker could become a victim of the situation. *The safety of workers and the public depends on proper monitoring.* Proper monitoring allows cleanup and containment to progress safely and provides immediate evidence of the effect of these efforts. Major concerns in this task are the possible dangers of fire, explosion, airborne contaminants, radiation, and oxygen deficiency. Initial entries and site investigations are performed to map or screen the sites for hazardous material concentrations. If there are unknown organic vapors/gases on site, an instrument like a **photoionizer** (HNU) or a gas **chromatograph** (OVA) may be used to get a total readout of vapor concentrations (but without positive identification). Identification of the contaminants allows you to calibrate your instruments for the specific material of interest. The **HNU** is of limited use with inorganic vapors and gases. **Colorimetric tubes** are more useful with inorganic materials but you need to have a good idea of what the material is before you can choose the correct tube. Most of the instruments use the same basic principles to operate, however new technology is constantly being introduced and applied to these devices. Microchip circuitry has increased the portability of equipment while also allowing for computerized data management and in some cases the responder can download data directly into a computer.

MONITORING DEVICE SELECTION

Carefully consider your choice of monitoring devices. All desirable features are usually not available in any one device. What works in a lab or industrial setting may not work at an emergency site.

Ease of operation is the first factor to consider in instrument selection. Complicated operating procedures and intricate adjustments add to an already tense situation. A monitoring device **must be reliable,** with a **fast response time** and **reproducible results.** The output of the device should be capable of quick and **easy reading** and interpretation. **Portability** is another item to consider. The device should be operational under a wide **range of environmental conditions** (i.e. cold and heat snowstorms, dust storms, salt air, rain, mud), and be able to **withstand travel** to and from the incident. Reinforced cases, padded shipping containers, and shock-mounted electronic packages are recommended. Lastly, the device must be **selective and sensitive**; that is, the instrument must be able to monitor the desired compounds with minimal interference from other materials, and be sensitive enough to detect those compounds at very low levels.

One item which must not be overlooked is the effect of the instrument on **user safety**. Electronic devices must be *"intrinsically safe,"* so that they do not serve as ignition sources in a combustible atmosphere. "Intrinsically safe" means that the analyzer is not able to release sufficient electrical energy, under normal or abnormal conditions, to cause ignition of an explosive or flammable atmosphere.1 Care should be taken to determine the "specific atmospheric mixture." A device rated as intrinsically safe for an atmosphere of gasoline vapors may not be intrinsically safe in an atmosphere of acetylene. By definition, "normal conditions" of operation include opens, shorts, and grounds in external wiring. "Abnormal conditions" include internal wiring problems or component failure.

"Explosion-proof" is another designation given to monitoring devices. This means that the ignition source in the instrument is encased in a solidly built container. When flammable gases or vapors enter the instrument, the resulting ignition is contained within the specially designed enclosure, and hot gases or flames are cooled prior to their exit into the surrounding atmosphere.

Underwriters Laboratory (UL), Factory Mutual Research Corporation (FM), the American National Standards Institute (ANSI), and the National Fire Protection Association (NFPA) have developed certification procedures for rating instruments as intrinsically safe or explosion-proof. Check for this approval. A certified device is not considered safe for use in atmospheres other than those indicated on the affixed plate. This plate carries the testing groups of materials for which it was certified. At a hazardous material incident the responder often asks the question, "Which air monitoring device should I choose." A complete assessment by emergency response personnel can help answer this question. Obtaining all of the information is important and critical. It will allow emergency response personnel select the right device(s) and gather as much information as possible. Some helpful clues include: placards, shipping papers, container size and shape, the type of material the container is made of, engineering of the container, interviews with facility manager or driver, interviews with affected people, vapor clouds, color of vapor clouds, evidence of contaminated soils/asphalt, or distressed vegetation to name a few. Experience and drilling will only make this assessment process more efficient.

These devices should have a routine maintenance and calibration record. Contingencies should be in place to have equivalent replacements when air monitoring equipment is damaged or out of service. All individuals responsible for operating and utilizing these devices should read the manufacturers instructions in order to understand the proper use, operation, maintenance, calibration, and skills needed to “trouble shoot” any problems with the device.

MONITORING DEVICES

There is a wide variety of monitoring and detection equipment which may be useful in a hazardous material response. They are capable of monitoring such items as the presence of explosive or flammable vapors, toxic materials, radioactive materials, or low oxygen concentrations. Monitoring equipment is useful for initial assessment and decision making. It is also necessary in checking for changes which might occur as clean-up and control activities proceed.

COMBUSTIBLE GAS INDICATORS

Probably the most widely used monitoring device is the combustible gas indicator or explosion meter. It is used to measure the percentage of the **lower explosive limit** (LEL) of flammable gases and vapors. The LEL is the minimum concentration of vapor or gas in air which can be ignited.

These instruments operate using a “hot wire” system. The atmosphere to be checked is brought into contact with a heated catalytic wire, typically platinum, which is part of a balanced resistor circuit called a Wheatstone Bridge. If the atmosphere contains a combustible gas or vapor, the material is oxidized on the wire (or filament) raising its temperature. As the temperature of the filament increases, so does its electrical resistance. As this resistance changes, the imbalance in the bridge circuit is measured as a percentage of the LEL.

If vapor concentrations are between the lower (LEL) and the upper explosive limits (UEL) the indicator signal on the combustible gas detector may remain above 100% indicating a readily ignitable atmosphere. At concentrations above the UEL, the volume of vapors is too great to allow ignition. **Under these conditions, the indicator needle or signal on some devices may rise above the 100% mark, then return to 0%.** Thus, it is important to understand fully the operation of a particular instrument in order that potentially dangerous misreadings may be avoided.

It is important to note that different combustible gases of the same concentration give considerably different percent LEL values. An instrument calibrated on a 50% LEL mixture of methane in air will not respond to exactly 50% with a similar mixture of pentane. Proper calibration done on a regular basis, in accordance with manufacturer’s specifications is a must.

There are two subclasses of combustible gas indicators: those with some type of pump to draw the sample into the instrument and those which rely on diffusion of the sample into the instrument.

The first type frequently is referred to as a “sniffer” and is useful for periodic monitoring, and is often used with a removable probe for sampling confined spaces. A battery-powered pump may be used instead of the more typical aspirator bulb. A low battery alarm is normally part of these instruments, and can be audible, visible, or both.

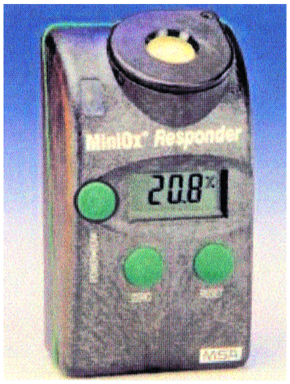
The diffusion type has a sensor located so that the air being sampled passes over it. The response time of these instruments is slightly slower because the air must pass through a semi-permeable membrane to be analyzed. This style of monitor is widely used when entering vessels and working in confined spaces, and is designed to operate continuously. It too is usually equipped with a low battery alarm.

As with all instruments, **there are some limitations**. These units are designed to operate properly only when there is a normal concentration of oxygen present; between 19.5% and 21%. Greater or lesser concentrations may lead to erroneous readings. Certain compounds, such as leaded gasoline, halogens (chlorine, bromine, etc.) and sulfur compounds can foul the filament and decrease both its sensitivity and reliability. Compounds which contain silicone will destroy the platinum filament. Refer to Figure 1.

The CGI is a "general survey instrument," it will not differentiate between, nor will it identify, the gases or vapors present. The Wheatstone Bridge reaction is temperature dependent therefore the accuracy of the reading will vary according to differences between temperature at the calibration and the ambient temperature when used in the field.

OXYGEN METERS

Oxygen levels can drop due to fires, displacement by other gases, or chemical reactions. In most cases, it is desirable to check the oxygen concentration before entering a confined space. Oxygen meters are also useful in combination with combustible gas indicators since low oxygen levels will cause inaccurate readings for the "hot wire" device. The normal ambient oxygen concentration is about 21% and oxygen meters are typically set to alarm at 19.5%. **OSHA defines atmospheres with less than 19.5% oxygen as oxygen deficient** and requires the use of supplied air respirators when working under this condition.



The oxygen meter consists of a semi-permeable Teflon membrane through which oxygen passes into an electrolytic solution. Reactions occur between the oxygen and a set of electrodes in the solution, producing an electric current proportional to the oxygen concentration. As the current passes through this electronic circuit, a needle indicator or other type signal is activated, indicating the percent of oxygen.

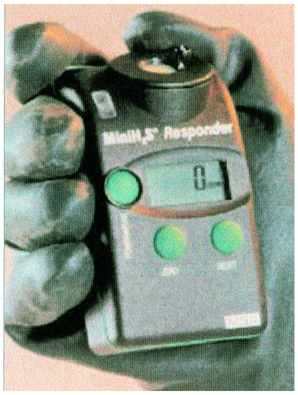
Elevation above sea level affects both efficiency and accuracy of these meters due to atmospheric pressure changes on the membrane. Less air pressure reduces both the rate and amount of diffusion, thus giving both slow and false readings. It is important to re-calibrate these instruments upon delivery.

Other factors that can cause problems with oxygen meters are 1) air borne particulates, mist, vapor, and 2) substances or compounds that can act as electrolytes. The first group can clog or contaminate the membrane, effecting air transport to the solution. The second group can change the current carrying capacity of the meters electrolyte, causing false readings.

The meter's electrolyte begins to degrade from the time when it is first energized, like the battery in your car. Most manufacturers recommend replacement of the meter cell every six months because of this degradation. Regular calibration and maintenance of these instruments is critical. Field replacement of the meter cell is a plus in design criteria.

TOXIC MATERIALS METERS

There are several other types of gas meters available that are designed to detect specific gases. Single purpose gas monitors can be found to detect carbon monoxide (CO), hydrogen sulfide (H_2S), or cyanide (HCN). These gas detection meters are based on electrochemical cells like the oxygen meter just discussed. These meters usually offer a direct readout gauge and a warning tone that can be set to warn the responder when a certain concentration of gas is reached. These monitoring functions can also be found in some multi-purpose monitors (like the MSA 360 we use in this course) which can monitor the concentration of combustible gases, oxygen, or carbon monoxide in the air at an incident.

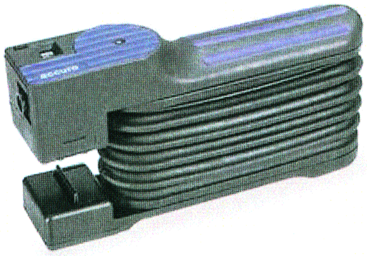


COLORMETRIC INDICATOR TUBES

One of the most widely used techniques for detecting specific chemicals is the colormetric indicator tube system. A glass tube filled with chemical reagents is opened on both ends and inserted into a hand-operated piston cylinder or bellows type pump. A specific volume of the suspect air is then drawn through the column of chemical reagents at a predetermined rate, reacting with the reagents. This produces a color change or stain, the length of which is proportional to the concentration. A scale is usually marked on the outside of the tube for easy quantification.

As stated, *colormetric tubes are specific for a particular chemical*. They are simple to use and allow easy changeover for the detection of different chemicals (simply use another type tube). The number of chemicals which can be tested is limited only by the number of different tubes produced by the manufacturer.

Two types of pumps are in general use: the piston pump and the bellows pump. In each case the calibrated pump draws a known volume of air through the detector tube with each stroke of the pump. An instruction sheet which accompanies each box of detector tubes specifies the number of pump strokes to take for the anticipated concentration of contaminant.



The accuracy of these detector tubes has been variously stated as having a **25% to 50% error factor**. Typical sources of errors are: wear, temperature variations, pressure differences, plugged orifices, stroke rate, and leaking valves. Variations that can affect the detector tubes are atmospheric conditions, tube diameter, packing, moisture, and age. **Tube performance can be improved by storing them in a refrigerator** to retard degradation and **leak testing with the pump** immediately prior to drawing a sample to verify the tube's integrity.

Another source of error is interference from the presence of other chemicals in the area being sampled. Interference may be additive, resulting in a higher reading, or subtractive, resulting in a lower reading, or masking, resulting in the prevention of color change.

pH METERS AND PAPER

The acidity or alkalinity of a liquid is measured as pH. A **pH of 7 is neutral**, a pH of less than 7 is *acidic*, and a pH of greater than 7 is *basic* (or alkaline). {Technically, pH is the logarithm of the reciprocal of the concentration of hydrogen ions in solution, that is, the number of H+ radicals as the negative log of 10 (10 to the negative power).}

A **pH meter** utilizes a glass electrode bulb introduced into the sample along with a reference element, containing a standard reference solution. A measurement of the ratio of hydrogen ions is read on a meter as pH. These meters are fairly simple to operate and maintain for field use. However, freezing and dry storage must be avoided for "wet" probes. Some meters can use "dry," gel, or metallic probes.

The use of **pH paper** is the most common field test for pH. A piece of litmus paper is exposed to the sample liquid. A color change occurs on the paper indicating the pH of the sample. This color change is visually compared against a reference chart for interpretation. This method is the simplest field test to undertake as long as safety is always considered, since the paper must come into contact with the actual chemical to be tested. *Proper protective clothing must be utilized*.

The use of pH paper generally requires a liquid sample but a corrosive solid may be checked by wetting the paper with distilled water and contacting a **sample** of the material. pH paper can also be wet and used to monitor the air for corrosive gases or vapors such as ammonia or hydrogen chloride.

Some limitations in the use of a pH meter are: frozen or "gelled" liquids, contamination of the probe electrolyte, improper immersion of the probe, and turbidity of the sample.

Limitations in the use of pH paper are: frozen or "gelled" samples, turbidity of the sample, color fading of the paper, and color or shade blindness of the user.

OTHER DEVICES

An array of other monitoring devices exist but they are primarily reserved for either follow-up monitoring activities or extended use. These other devices are also more expensive, more complicated, and more sophisticated. They will only be mentioned briefly for awareness at this level.

Generally, the first type is a photoionization detector, such as an HNU or Photodvac TIP.

The photoionization analyzer is a direct reading photoionization instrument. It is used to measure gross amounts of airborne substances capable of being readily ionized under ultra violet (UV) light. The instrument cannot differentiate between substances with any degree of accuracy, but can be modified to provide varying ranges for chemicals capable of being ionized. This requires changing of the UV lamp as well as the use of known calibration gases.

Operation of the meter is similar to others, in that the atmosphere is drawn into a test chamber and ionized with the light's electrovoltage potential.

When ionization occurs, it causes a change in electrical current measured by a voltage meter, which is translated into a parts per million (ppm) reading. The instrument must be properly calibrated to a pure sample of the gas of concern.

Operation of other ionization meters is similar to an explosimeter, in that the atmosphere is drawn into a test chamber and ionized with a UV light of known wavelength, as opposed to being "ionized" (i.e. burned) through combustion. The readings are changes in electron voltage potential across a voltage bridge, as opposed to a change in electrical resistance across a wheatstone bridge in an explosimeter.

Another class of meters operates in a manner similar to laboratory type gas chromatographs. A prime example of this is the Foxboro Organic Vapor Analyzer (OVA). Its principle of operation is based upon gas and thermal property laws. That is, gas particles will “flow” at certain rates (similar to liquids), and, if burned, will release specific heat capacities.

Gases are drawn into a changeable “packed” column and ignited upon exiting. The time needed to pass though the column, in concert with the heat produced upon burning, is “translated” to a dial or digital reading. Similar to a colormetric system, different columns, ignition temperatures, and charts are available to interpret the readings into a quantifiable term.

FIELD SAMPLING AND EVALUATION

There are numerous field tests which can be utilized to determine the basic characteristics of unknown materials or confirm the identity of a hazardous material. Some of the basic tests are flammability/combustibility, pH, and water solubility. There are commercially available kits and papers (similar to pH paper) that can be used to test for oxidizers, peroxides, sulfates/sulfides, and chlorinated compounds. These are simple tests that can be performed in the field with some basic knowledge of chemistry. There is also available a commercial test kit that uses basic field testing techniques in a “cookbook form” to identify characteristics of materials and chemical groups. This kit employs wet chemistry, physical tests, and other techniques. HazMat supplies and markets this kit but it does require training specific to this kit.

GENERAL CONSIDERATIONS

The user of any type, make, or style of field air sampling meter must be fully aware of:

1. inherent limitations of the device
2. localized pockets of gas concentrations
3. true meaning of the reading
4. practical application.

Not all meters will be able to “tell” the user the exact chemical or substance detected. They will not be able to “tell” the user the exact amount of contaminant, unless the meter was calibrated to that substance and is used in a “pure” contaminated atmosphere.

This overview is by no means complete, and is **not to be used as an endorsement of any specific monitoring device or product**. Since the cost of these instruments can range from as low as a few hundred dollars up to several thousand dollars, and their applications are limited, the response team or organizations should fully evaluate and explore their feasibilities within the organization and anticipated responses. Furthermore, the uses of the instruments must be trained in both the overall operations and limitations of the meters.

Lastly, the most often forgotten and **most critical aspect of any measuring device is its calibration and use**. Since the instruments will go unused for long periods of time, a routine schedule of calibration (both field and shop) and periodic “exercising” of the instrument must be conducted.

RADIOLOGICAL SURVEY INSTRUMENTS

1. INTRODUCTION

None of the ionizing radiations is detectable by any of man's five senses, therefore all indications of their presence and intensity must be obtained by instruments. Radiation detection devices, like other measuring instruments, operate because of some effect the phenomenon being measured has on matter. In the case of radiation, this effect is ionization. Survey meters are similar to other radiation detection instruments in their operational characteristics. 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 and energy of 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. All these conditions are not met in any one instrument, but they are approached in many. In any monitoring operation, one must select the proper instrument, use it intelligently, and then be able to interpret the results of the meter readings.

II. IONIZATION CHAMBERS

A. Theory

Ionization chambers are instruments in which the ionization initially produced within the chamber by radiation is measured without further gas-amplification. Primary ions formed in the chamber are attracted to the respective electrodes, and the current pulses are amplified externally to a measurable current. The gas-amplification factor is thus one.

B. Physical Description

Ionization chamber survey meters have three principal components: (1) the ionization chamber; (2) the electronic circuit; and (3) the dial or indicating meter.

(1) **Ionization Chambers** are usually about 30 to 50 cu. in. in volume and are filled with air at atmospheric pressure. The chamber wall design and type of material used in its construction determine the types of radiation to which it is sensitive. The larger the chamber the more sensitive the instrument and the greater the voltage required for proper operation. Practically all chambers have walls that conduct electricity and serve as the cathode, while wires mounted in the center of the chambers constitute the anode. Operating voltage is supplied by batteries and has a magnitude of about 100 volts. The current which flows is directly related to the type, energy, and quantity of radiation penetrating the chamber.

In general, ionization chamber survey meters are used to measure relatively high level intensities. Their low sensitivity enhances their capacity to measure radiation at higher dosages or exposure rates.

(2) **The electronic circuit** is actually a precision amplifier. Vacuum tube or transistor circuits are used to build up the feeble ionization current so that it may be measured directly by a microammeter. Most survey meters incorporate a system whereby the amplification characteristics of the circuit may be changed by factors of ten. This enables the operator to change the instruments' range and sensitivity.

Since there is a gas amplification factor of unity, circuit amplification becomes a problem which one does not necessarily have in a GM instrument. On the other hand, there is no problem of quenching the discharge or of losses due to coincidence.

(3) **The indicating meter** is usually a microammeter that registers the amplified current. The dial is generally calibrated in milliroentgens/hour or, in the case of contamination monitors such as the "Samson," in counts per minute.

C. Operation

Most ionization chamber survey instruments have a selector switch marked “off,” “check,” and x1, x10, x100. When the switch is off, the batteries are disconnected and the meter is short-circuited making the instrument inoperative. With the switch in the wait position, the batteries are connected, permitting the circuit to warm up and the instrument to be zeroed after a warmup period of from 1-5 minutes. The meter is connected while the ionization chamber is disconnected making it possible to adjust the meter accurately to zero even in the presence of radiation.

The ionization chamber does not wear out or suffer changes in characteristics as GM tubes do; however, the circuit of the ionization chamber survey meter has more elements that can get out of adjustment if not properly handled. Loose leads and weak batteries are a source of trouble which can be readily serviced. Other difficulties are usually caused by faulty circuits which cannot generally be fixed without the aid of a competent service man.

No audio indication is used in IC instruments and thus the operator must constantly watch the meter to ascertain the field intensity. There is a lag between the instant radiation enters the chamber and the time when the meter reaches its maximum reading; therefore, one must allow time for the meter to reach its maximum before taking a reading. This is on the order of a few seconds.

D. Calibration

Instruments are designed by manufacturers to read directly in radiation intensity units, generally mr/hr or r/hr; however, there is considerable error in a direct reading, since the characteristics of individual components causes variations in instrument response. Each instrument must be calibrated for accurate interpretation. Instrument response intended by the manufacturer is related to one type of radiation, usually of a definite energy range. If radiation of a different energy or type is measured, the results will be incorrect and the instrument must be recalibrated with radiation of the same type and energy that is to be measured.

For gamma ray calibration an ionization chamber instrument can be checked by placing it in a known field of radiation. Radium and Co^{60} are the most frequently used sources for gamma calibration.

E. Uses

The CDV-750 meter is used in high dose areas (R/H$_R$). This is not typical of most accidents that are encountered by the average emergency responder. They were made for nuclear bomb fallout area monitoring.

III. GEIGER-MUELLER INSTRUMENT

A. Theory

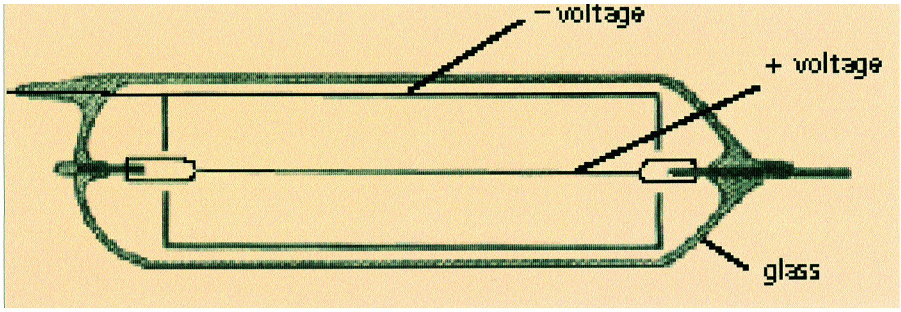
Essentially, the theory of ion collection in the GM type detector is the same as for the IC instrument except that there is the formation of secondary electrons; that is, primary ions, formed by the incident radiations, are accelerated (given energy) by the high voltage potential and this added energy enables them to produce secondary ion-pairs. The ratio of the total number of secondary ion-pairs produced to the primary ion-pair (Gas Amplification Factor) may be as high as 10^9. For control of the amplification, a quenching gas is introduced. This electrical avalanche, caused by radiation entering the Geiger-Mueller tube, sends a pulse to the indicating unit of the survey instrument. The quenching gas functions to stop the avalanche and makes the GM tube ready for another ionization event. The amplification, inherent in the detector tube, allows a single beta particle or gamma photon to be detected.

B. Physical Description

The principal elements of the portable Geiger counter are: (1) the GM tube with its housing; (2) the electronic circuit; and (3) the meter housing.

(1) **The GM Tube** is essentially a glass tube filled with an inert gas at less than atmospheric pressure. The filling gas, usually argon, yields ion pairs (when irradiated). Generally, the tube wall is the cathode and the wire traversing the axis of the tube is the anode. Some tubes have a thin window which admits alpha particles, but these are not used in survey meters to any extent.

Each GM tube has its own characteristic curve of counts/minute versus voltage, which will vary with usage of the tube. The operating voltage must be well up on the Geiger plateau for the proper operation, and it is generally in the range of 1 to 2 thousand volts.



Most Geiger tube walls are designed so that all but the weakest beta particles may enter. Allowing for the errors due to simultaneous entry, each and every beta particle entering the tube will be counted. Gamma ray counting is not nearly so efficient.

Since one measures each beta particle and each gamma ray that produces ionization within the sensitive tube volume, the instrument is extremely sensitive to radiation, and on the most sensitive scales background levels can be read.

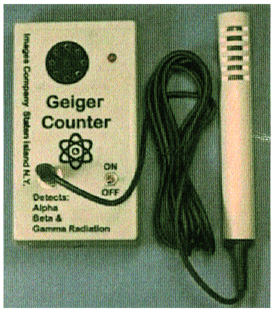
A discriminating shield is provided for the GM tube or probe when open admits both beta and gamma. With the shield closed only gamma is admitted.

The CDV-700 is a typical geiger meter. It should be noted however, that it is calibrated for gamma radiation and although it can detect beta radiation (with shield open) it **does not** measure it.

(2) **The Electronic Circuit** provides the desired voltage to the GM tube, assists in quenching the discharge and receives, amplifies and transforms pulses from the tube to the type of impulse that can be heard in an earphone and registered on a microammeter.

(3) **The Indicating Mechanism** on most Geiger counters is usually twofold; that is, earphones for audio indication and a meter for visual indication. The meters are in reality microammeters that indicate radiation intensity by a pointer on a scale. The pointer or needle will waiver slightly and an average reading should be used. In general, the dial is calibrated either in counts/minute or in milliroentgens/hour, or both. Also, the instrument has a switch for selecting different ranges of sensitivity. For the mr/hr scale, the sensitivities are usually indexed indicating full scale values at a particular switch position, whereas the counts/minute scale is usually marked by x1, x10, x100, or x1,000 of full scale as read on the face of the dial.

Equipment failure is generally due to batteries (some instruments have a battery check in the "on" position), loose connections or faulty GM tube. Never store batteries in the meter.



C. Operation

The operation of the GM Survey Instrument is essentially the same as that of the IC Survey Instrument. The warmup period is much less critical, and usually 5 to 10 seconds is ample. Care should be taken not to exceed the maximum capacity of the instrument; such excessive exposure will likely damage the GM detecting tube. The GM tube is in operation when in the "on" position and no zero adjustment is possible. It is important to remember that GM survey meters are sensitive instruments and in general do not read high levels of radiation intensity.

D. Calibration

The calibration of GM instruments is the same as for the IC type. The only change that might be noted is that a smaller source of radiation might be used for calibration, since the sensitivity of the GM is much greater than that of the IC instrument.

E. Uses

Survey Geiger-Mueller instruments are useful for low level beta, and gamma ray survey work; with proper modification, they may also be used to monitor for neutrons. Portable GM instruments are available in a variety of types and full scale ranges from .2 mr/hr to 50 mr/hr. Figures 4 and 5 show the typical G-M meters.

IV. PROPORTIONAL SURVEY INSTRUMENTS

A. Theory

This type instrument derives its name from the fact that it operates in the proportional region of the typical instrument response curve. The probe has an extremely thin window which admits alpha particles to the ionization chamber. The operating voltage is quite high, in the order of 1,500 to 4,000 volts. Gas amplification factors are in the order of 10^5 to 10^6. This instrument can be made to respond only to alpha particles, by choosing the proper operating point in the proportional region, and by circuit adjustment. Alpha particles, since they have the highest specific ionization, give greater pulses than do beta and gamma; thus, by properly adjusting the input sensitivity of the main instrument circuit, we can eliminate all indications from the detecting element except those produced by alpha particles.

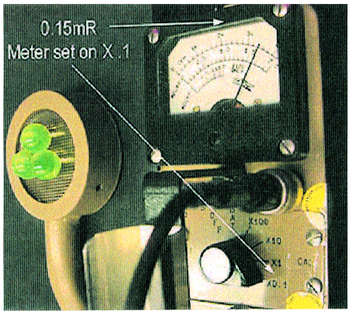
B. Physical Description

Proportional survey instruments have three principal components: (1) the ionization chamber; (2) the electronic circuit; (3) the meter.

(1) **The Ionization Chamber** has walls which serve as one electrode, and wires transversing the chamber which function as the opposite electrode. Such a chamber contains air or gas at normal pressure. A thin window of nylon, etc., allows alpha particles to enter, and the ionization they produce causes secondary ionization proportional to the production of primary ion pairs.

(2) **Electronic Circuit** is more complex than that used in other type instruments. It is necessary to control the chamber voltage within fairly narrow limits.

(3) **The Meter** is marked in counts/minute with several sensitivity scales. The dial is used in a manner already discussed.



C. Operation

The operation of the proportional radiation survey instrument is similar to other instruments. A warmup period of several minutes is usually required to allow the circuit to become properly energized.

D. Calibration

Calibration of proportional meters for alpha contaminatoin is accomplished by means of known quantities of the alpha emitter in question deposited on planchets.

E. Uses

Proportional survey instruments find their greatest application in alpha survey work. In making any alpha survey, the instrument probe must be extremely close to the surface being monitored. Figure 6 shows a typical gas proportional ALPHA survey meter.

V. SCINTILLATION SURVEY INSTRUMENTS

A. Theory

Scintillation counters depend upon the light produced when ionization radiation interacts with a phosphor or crystal of certain substances capable of producing this light. The scintillations produced in the phosphor or crystal are then permitted to fall on a photomultiplier tube which converts the light pulses to electrical impulses. These electrical impulses may then be amplified and caused to register on a microammeter.

B. Physical Description

Scintillation type survey instruments have four principal components: (1) the scintillating phosphor or crystal; (2) the photomultiplier tube; (3) the electronic circuit; and (4) the meter housing.

(1) **Scintillating Phosphors** may be liquid or crystalline, but for survey work, the crystalline type is, at present, preferable. If one is interested in detecting alpha radiation, a silver activated zinc sulfide screen (similar to the sensitive screen of a television picture tube) is generally used.

The Micro-R meter's probe is enclosed in a metal casing, thus it will only be responsive to small doses of gamma radiation.

(2) **The Photomultiplier Tuber** picks up light flashes from the phosphor which is in contact with it, and converts these light flashes to electrical impulses. It consists of a photosensitive screen, which emits electrons when light falls on it, and a series of dynodes at a positive potential with respect to the photocathode and with respect to each other. An electron liberated in the photocathode is accelerated to the first dynode, which is about 100 volts positive to the photocathode, where it knocks out additional electrons that are accelerated toward the second dynode. The second dynode is 90 to 100 volts positive to the first dynode and the electrons striking the second dynode produce still more electrons. This multiplication process proceeds through each successive dynode until the electrons reach the anode. From this process, the current amplificatoin is in the neighborhood of 10^9-10^{10}.

(3) **The Electronic Circuit** serves to maintain the voltage across the elements of the photomultiplier tube and to amplify the current impulses from the photomultiplier tube to a magnitude great enough to read on a meter.

C. Operation

Operation of scintillation survey instruments is similar to that of ion chambers and GM instruments. It should be pointed out that the photomultiplier tube of a scintillation instrument will be ruined if exposed to light without first removing the voltage applied to the tube.

D. Calibration

Scintillation instruments may be calibrated in the same manner as is used for a GM or an ion chamber instrument.

E. Uses

Scintillation devices may be used to detect either alpha, beta, gamma, or x-rays or neutrons simply by placing the proper phosphor in contact with the photomultiplier tube. Scintillation detectors are very sensitive, more sensitive and efficient than GM counters, particularly to gamma radiation. They may be used to detect extremely low levels of activity, as the noise background may be kept much lower than that encountered in the circuiting of a GM or ion chamber instrument. Losses due to dead time in a scintillator are very slight, as light flashes may be produced in many portions of the phosphor at the same time, and the decay time of these flashes is very short; consequently, scintillators are useful for measuring very high radiation intensities.

APPENDIX A

AREA CLASSIFICATION

The nature and degree of hazard existing in a particular location is denoted by specifying the location as being: Class I, II, or III; Group A, B, C, D, E, F, or G; and Division 1 or 2.

Class denotes the generic nature of flammable material.

Class I	locations where flammable gases or vapors may be present in the air in quantities sufficient to produce an explosive or ignitable mixture.
Class II	locations where combustible dusts may be present in sufficient quantity to cause hazard.
Class III	locations where the hazardous material consists of easily ignitable fibers or fixings that are not normally in suspension in the air in quantities sufficient to produce ignitable mixtures.

Group is more specific subclassification of the nature of the hazard. The materials in a group each present a hazard of the same general character.

The Class I groups recognized in Article 500 are shown in Table L-1.

Ethylene oxide and butadiene can be treated as Group C and D, respectively, if all conduits 1/2 inch size or larger are sealed.

Class II materials are grouped as follows:

Group E:	metal dust, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics. Sirconium, thorium, and uranium dusts, are not classified because they pose a special hazard because of ignition temperature as low as 20 degrees C, and very low minimum ignition energy when finely ground.
Group F:	carbon black, charcoal, coal or coke dusts which have more than 8% total volatile material, or which have been sensitized by other materials.
Group G:	flour, starch, or grain dust.

Division defines the probability of hazardous material being present in ignitable concentration.

Division 1	location where the probability of the atmosphere being hazardous is high by underwriting standards, i.e., where: (a) hazardous concentrations exist continuously, intermittently, or periodically into an open unconfined area under normal conditions.
Division 2	location where the generation and release are in closed systems or containers and only from ruptures, leaks, or other failures.

TABLE I CLASS I MATERIAL GROUPING

Group A Atmospheres

- acetylene

Group B Atmospheres

- acrolein (inhibited)
- butadiene
- ethylene oxide
- hydrogen
- manufactured gases containing more than 30% hydrogen (by volume)
- propylene oxide

Group C Atmospheres

- acetaldehyde
- allyl alcohol
- n-butyraldehyde
- carbon monoxide
- crotonaldehyde
- cyclopropane
- diethyl ether
- diethylamine
- epichlorohydrin
- ethylene
- ethylenimine
- hydrogen sulfide
- morpholine
- 2-nitropropane
- tetrahydrofuran
- unsymmetrical dinethyl hydrazine (UDMH 1, 1-dimethyl hydrazine)

Group D Atmospheres

- acetic acid (glacial)
- acetone
- acrylonitrile
- ammonia
- benzene
- butane
- 1-butanol (butyl alcohol)
- 2-butanol (secondary butyl alcohol)
- n-butyl acetate
- isobutyl acetate
- sec-butyl alcohol
- di-isobutylene
- ethane
- ethanol (ethyl alcohol)
- ethyl acetate
- ethyl acrylate (inhibited)
- ethylene diamine (anhydrous)
- ethylene dichloride
- gasoline
- heptanes
- hexanes
- isoprene
- isopropyl ether
- mesityl oxide
- methane (natural gas)
- methanol (methyl alcohol)
- 3-methyl-1-butanol (isoamyl alcohol)
- methyl ethyl ketone
- methyl isobutyl ketone
- 2-methyl-1-propanol (isobutyl alcohol)
- 2-methyl-2-propanol (tertiary butyl alcohol)
- petroleum naphtha
- pyridine
- octanes
- pentanes
- 1-pentanol (amyl alcohol)
- propane
- 1-propanol (propyl alcohol)
- 2-propanol (isopropyl alcohol)
- propylene
- styrene
- vinyl acetate
- toluene
- vinyl chloride
- xylenes

TABLE III SELECTED EXPOSURE LIMITS

Compound	TLV ppm	Odor ppm	IDLH ppm	REL ppm
acetaldehyde	100	0.21	10000	—
acetic anhydride	5C	81.2	1000	—
acetone	750	100	20000	—
acrylonitrile	(A2) 2 sk	21.4	4000	Ca
ammonia	25	46.8	500	50
arsine	0.05	<1	6	Ca
asbestos	(A1a)	none	—	Ca
benzene	10 (A2)	4.68	2000	Ca
benzidine	(A1b) sk	—	—	Ca
benzyl chloride	1	0.047	10	—
bromine	0.1	0.047	10	—
2-butanone (MEK)	200	10	3000	200
carbon dioxide	5000	none	50000	10000
carbon disulfide	10 sk	0.21	500	1
carbon monoxide	50	none	1500	35
chlorine	1	0.314	30	—
fluorine	1	<3	25	—
hydrogen cyanide	10 C sk	0.00027	50	—
isopropyl alcohol	400	<1	12000	400
LPG	1000	—	19000	—
methane	E	—	—	—
naphthalene	10	<0.3	500	—
phosgene	0.1	1	2	0.1
propane	E	1000-20000	20000	—
toluene	100	2.14	2000	100

NOTES:

A1a—human carcinogen with assigned TLV
A1b—human carcinogen without assigned TLV
A2 —suspected human carcinogen
C —ceiling TLV
Ca —carcinogen, no exposure recommended
E —simple asphyxiant
REL—Recommended Exposure Limit-NIOSH
Sk —skin notation
TLV —Threshold Limit Value-ACGIH

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MODULE 5
DECONTAMINATION

OUTLINE

- **Definition/purpose**
- **The Law**
- **Concerns of the Incident Commander**
- **Decontamination Location**
- **Decontamination Officer**
- **Decontamination Methods**
- **Decontamination Solutions**
- **In-house Decontamination**
- **Field Exercise**

MODULE 5

DECONTAMINATION

STUDENT MANUAL WORKBOOK

OBJECTIVES

The student will be able to:

1. Define the definition or purpose of decontamination.
2. List two reasons why it is important to decontaminate.
3. List five considerations associated with the placement, location, size, and establishment of the decon site.
4. Name three responsibilities of the decon officer.
5. Name the four types of decon.
6. List three factors that affect permeation.
7. List five methods of decon.
8. Establish a seven step decon site, and list the seven stations.

DECONTAMINATION

DECONTAMINATION DEFINED

It is important to address the steps necessary to prevent the unknowing spread of potential contaminants.

It is necessary to assure that all personnel, equipment, and vehicles used at the site are deconned to a point of safety, with respect to the off-site spread of contaminants. In other words, it would be the cleaning of vehicles, equipment, and personnel used or contaminated in an area or effort in order to sample, contain, or treat the contaminant, and to eliminate the spread of hazardous materials, chemicals, products, or substances to the environment.

For our purposes, the **definition or purpose of decon** is as follows:

1) Hot Zone Isolation/Exclusion

To help achieve this goal, make sure all personnel meet four criteria prior to entry into the hot zone. They are:

  A) Training

  B) Personal Protective Equipment

  C) Task to Perform

  D) Supervisor/Safety Officer/Incident Commander is Aware

2) Reduce the Spread of Contaminant

3) Removal

As the definition implies, decontamination is to prevent or mitigate the transport of residual materials, be it to people, property, or equipment, outside of the contaminated area. This transport may be to our families, adjacent property, or vehicles.

If the responding personnel become intimately involved with the runoff or other debris at the incident site, then in all probability they will have accumulated a certain amount of dust, dirt or liquid on their clothing. If hose lines, shovels, stokes, or other equipment was brought into the site, they too would have become "dirty." Should smoke or water pass or encompass a response vehicle, that also has become contaminated. The purpose of decontamination is to remove, as best as possible, those contaminants encountered.

Unfortunately, 100 percent removal may not be realistic. Therefore, what is conducted is the best practical approach to neutralize or remove the "dirt" from the impacted material or fabric.

DECON: IT'S THE LAW

Because the obvious reasons of why we perform Decon, we must remember that we are required to perform decontamination procedures according to regulations and standards. At the Operations level, the standard states that you will "know how to implement basic decontamination procedures."

Also addressed in OSHA 1910.120(q) is the Emergency Response Plan. The employer shall develop an emergency response plan for emergencies which shall address, as a minimum, decontamination. Finally, OSHA discusses decontamination in Appendix C—Compliance Guidelines and Appendix E—Training Guidelines, both found in the back of the standard.

Appendix C states that "decontamination should be tailored to the specific hazards of the site, and may vary in complexity and number of steps, depending on the level of hazard and the employee's exposure to the hazard. Decontamination procedures and PPE decontamination methods will vary depending upon the specific substance, since one procedure or method may not work for all substances. Evaluation of decontamination methods and procedures should be performed, as necessary, to assure that employees are not exposed to hazards by re-using PPE."

In addition to the OSHA standard, the National Fire Protection Association addresses decontamination in its 472 standard.

INCIDENT COMMANDER

Many knowledgeable people in the field of hazardous materials response consider decontamination to be the most critical step in the whole response process. You may think about this and disagree, thinking that other aspects of response such as choosing chemical protective clothing or air monitoring is more important. Granted that all areas of response must be properly addressed, just remember that you were "clean" prior to your arrival at the incident. You want to make sure you leave the scene just as clean.

One of the most important but often overlooked aspects in preparing to deal with hazardous materials incidents is planning to perform effective decontamination. **Decon must be part of the initial size up of the incident**. Included with the concerns of decon, initial size up would include:

A) **Proper assessment of site**
B) **Appropriate levels of protective clothing**
C) **Establishing control zones**
D) **Limiting access to the scene**

Decontamination will place an additional strain on equipment, manpower and resources, which may already be stretched to their limit. On the other hand, should decontamination be ignored, the prevention of spread of contaminants off-site, as well as the health and safety of the responders and their families, may be compromised.

DECON LOCATION

A primary means of maintaining site control in order to ensure safety and to prevent the spread of hazardous materials into uncontaminated areas is by establishing work zones. The work zones serve to limit site access (isolation), contain contamination (reduce spread), provide site security, and place real estate between the incident and the response community. There are several considerations one should keep in mind, such as the extent of contamination and the probability of airborne contamination, when establishing these work zones.

From prior hazardous materials training, we have become familiar with three work zones: commonly referred to as the hot zone, warm zone and the cold zone.

Common Terminology	**EPA Terminology**	**Slang Terminology**
hot zone	exclusionary zone	dirty zone
warm zone	contamination reduction corridor	
cold zone	support zone	clean zone

We know that the hot zone is an area that is considered to be contaminated, potentially contaminated, or which could become contaminated in the event of fire, explosion, or spill. This is an area that should be established when the first responder arrives at the scene, even if he or she was trained only to the Awareness level. If this person, based on information provided at the scene (remember the 6 clues), can determine what is "dirty," then believe it or not, a hot zone was established. And if you now have a hot zone, then you automatically have a cold zone (everything that is not hot). But what about the warm zone?

The warm zone lies upwind of the hot zone and is designed to prevent contamination from leaving the site. This is the area where the decontamination process will occur. It is established in an area presumed to be clean, but is considered potentially contaminated as soon as personnel or equipment are processed by whatever decon method necessary. Remember, decon is established in the cold zone.

How do we choose the specific location within the cold zone? Well, let us consider some of the factors needed to **pick a Decon site:**

1) Upwind/Uphill

2) In the Cold Zone

3) Proximity to Hot Zone

DECON OFFICER

The Decon officer is responsible for the overall operation and safety of the Decon process. This person must define the types of contamination the response personnel may encounter at the scene. Consideration must be given to the factors that may influence the extent of contamination, and the methods for preventing or reducing contamination.

Four Types of Decon

While planning the incident response, methods (SOPs) should be developed to prevent the contamination of personnel and equipment. For example, using remote sampling techniques, opening containers by non-manual means, bagging monitoring equipment, using drum grapplers, and avoiding areas of obvious contamination would reduce the probability of getting “dirty.”

Your team, prior to responding to any hazardous materials incident, should be familiar with a minimum decontamination set-up based on the number of personnel you would have on site, as well as, the type and amount of decon equipment you have available. Then, based on the specific conditions at the site, the decontamination process may be reduced, altered, expanded or eliminated based upon the best known information. Depending on severity, a simple brushing to a full maximum decontamination layout may prove necessary. Specific conditions at the site include:

A) **Type of contaminant**
B) **Amount of contamination**
C) **Type of protective clothing worn**
D) **Re-usable versus disposable equipment**

Since the number one goal of the Decon officer is to make sure that all personnel and equipment leaving the hot zone are cleaned, then it is the responsibility of this individual to choose the type of Decon needed for that specific incident. There are **four types of decontamination**. They are:

1) **Technical**—Removal of contamination from personnel and equipment through physical or chemical means. Used primarily by hazmat teams through a stage or step by step process.

2) **Emergency**—Immediate removal of contaminant usually from response personnel.

Examples: protective suit is damaged
responder or emergency worker is contaminated
firefighter is injured

3) **Gross**—The removal of surface contamination. Often used for mass decon (i.e., water deluge).

4) **Definitive**—Often used by emergency medical personnel or hospital employees for victim decon.

Remember, contaminants do not exhibit the same degree of hazard. At some incidents, a minor chlorine leak at the local swimming pool for instance, gross decon would be sufficient. Providing that there are provisions to catch run-off, a simple rinsing of protective clothing at the scene and a shower back at the station is all that's necessary to accomplish gross decon.

Exposure to some hazardous materials, such as poisons, warrants definitive decon system implementation. These are substances that can incur serious short term health effects if complete decontamination is not carried out quickly and efficiently. The definitive decon system, therefore, merits our serious attention. The more toxic a substance is, the more detailed or thorough decontamination must be.

FACTORS AFFECTING PERMEATION

We have learned in a previous module that there are three ways that chemicals can intrude your protective clothing. In case you forgot, let us quickly review each one:

A) **Degradation**—loss of or change in the fabric's chemical resistance or physical properties due to exposure.

B) **Penetration—**movement of material through physical imperfections, zippers, or stitched seams.

C) **Permeation—**material dissolves in and/or passes through on a molecular level.

Contaminants can be located either on the surface of personal protective equipment or permeated into the PPE material. Surface contaminants may be easy to detect and remove (gross decon); however, contaminants that have permeated a material are difficult or impossible to detect and remove. Permeated materials, if not removed, may continue to permeate to either surface of the material where they can cause an unexpected exposure.

The five major **factors that affect permeation** are:

1) Temperature
2) Physical Properties (state of matter)
3) Concentration
4) Contact Time
5) Contact Area

After you have considered the extent of permeation to the protective clothing, and have obtained the properties of the material from the Information Officer, you may now go ahead and select the decon method or technique best suited for the incident. Remember, although your team should be trained on a fixed minimum decon set-up, your process at the scene must be site specific.

DECONTAMINATION METHODS

We know by now that all personnel, clothing, equipment and samples leaving the hot zone must be decontaminated to remove any harmful chemicals or infectious organisms that may be adhered to them. Generally speaking, we can breakdown decon into three methods. The **three decon methods** are:

1) Physical
2) Chemical
3) Both

Many factors, such as cost, availability, and ease of implementation, influence the selection of the decontamination method. The contaminants will not always be known in a majority of cases and it will be necessary to use a decon solution that is effective for a variety of contaminants. The choice of a washing agent must be such that while it renders harmless the contaminant involved, it does not attack or degrade the host material or fabric.

The chemical and physical compatibility of the decontamination solutions or other decontamination materials must be determined before they are used. Any decontamination method that permeates, degrades, damages, or otherwise impairs the safe functioning of the PPE should not be used. Chlorine will disinfect and kill a variety of pathogens and bacteria, but it will also render nomex fire gear useless. Even though a base of caustic could be used to neutralize an acid, one would certainly not relish the idea of applying it to the skin in any great concentration. Consequently, the selection made must be best suited to both the host and the contaminant.

Furthermore, it should be stated that the decision to conduct decontamination may be less effective, economically and medically, than to dispose of the contaminated items or equipment. It is for this reason that all steps possible to be taken to protect and **isolate** equipment and workers from the hazardous materials and substances involved. Unfortunately, situations may arise which would, due to massive exposure or lack of knowledge and treatment, not allow for decontamination. Examples of this would include exposure to radiation, asbestos, and more recently the AIDS virus. In any of these cases, exposure will cause irreversible body damage despite efforts to arrest or remove the contaminant.

Therefore, the best that can be expected is to isolate, through protective clothing and shielding, and minimize, through limited exposure time and distance, worker contact with hazardous materials. Additionally, the establishment of the best practical decontamination program after exposure, or potential exposure, must be instituted at an emergency incident location prior to subjecting the responder to possible contamination.

DECONTAMINATION AREA PREPARATION

Any victim of a hazardous materials incident must be considered to be contaminated until demonstrated otherwise.

Security personnel should be stationed at the main entrance of the emergency department close to the decontamination area to prevent unauthorized entry, and to direct the vehicle transporting the patient to the appropriate area. A reception area should be set up just outside the emergency department entrance, where arriving contaminated patients can be screened for adequate decontamination.

A decontamination area should be large enough to facilitate decontamination of more than one patient and accommodate the many personnel involved in patient treatment and contamination reduction. The ventilation system should either be separate from the rest of the hospital or turned off in order to prevent spread of airborne contaminants throughout the facility. The best place (weather permitting) to evaluate and initially treat contaminated patients is outside where ambient ventilation will keep cross-exposure low. Some hospitals have radiation decontamination facilities that can be used with minor changes. An outside or portable decontamination system is a viable substitute and would aid in preventing contamination of the emergency department and other patients. A practical alternative for facilities with limited resources is to have a warm shower nozzle soap, a wading pool, and plastic garbage bags in a predesignated area outside the emergency department back door. The patient may be able to remove his or her own contaminated clothing, place it in a double bag, and do his or her own soap and water decontamination. A partial tent or curtain can provide privacy for the patients. In most circumstances, ordinary hospital gowns, plastic goggles, and plain latex gloves will adequately protect hospital staff in case they have to assist the patient in removing soaked clothing, wash exposed skin and hair, or perform eye irrigation. With large amounts of concentrated corrosives or very oily materials, such as pesticides, disposable CPC and unmilled nitrile gloves will offer additional protection. If it is anticipated that your facility is likely to receive heavy contaminated patients who have not received prior decontamination, then it may be appropriate to purchase appropriate protective gear and to fit and train emergency department staff in its use. However, no person should wear and use specialized PPE, especially respiratory protective gear, without prior training.

To prevent unnecessary contamination, all nonessential and nondisposable equipment should be removed from the decontamination area. A “clean” member of the staff should stand on the clean side of the decontamination area to hand in supplies and receive medical specimens.

DECONTAMINATION PROCEDURES

Hazardous materials incidents involve numerous on-site problems and operational concerns. Common to all these responses is the threat of contamination. Decontamination must be considered an essential part of hazardous materials response operations. This module will detail the purpose and steps taken in field decon operations.

Personnel may become contaminated in a number of ways including:

- contacting vapors, gases, mists or particles in the air
- being splashed by materials during rescue or containment operations
- walking through puddles of liquids or on contaminated soil
- treating contaminated patients
- using contaminated instruments or equipment

Decontamination is the process of making response personnel, victims and equipment free from contamination by eliminating or reducing harmful substances to a safe level. Response team personnel must undergo decon prior to removing their protective equipment. Victims need to be decontaminated before being turned over to EMS transport personnel. Equipment must be thoroughly cleaned so that its subsequent use will not lead to a spread of contamination.

Different chemical threats require varying levels of decon. In cases of extremely hazardous or unknown substances, the following minimum decon procedures should be complied with:

1. Establishment of an entry/exit point: This point will be used by all personnel to enter and exit the area of contamination. The use of one entrance will reduce the chance of contamination leaving the area. An emergency exit should also be established. This will allow for a secondary exit should conditions deteriorate and demand immediate evacuation.
2. Definitive Decontamination: This step may actually entail many intermediate steps. The personnel should undergo water rinsing and soap or solution washes to remove as much contaminant as possible. The number of washes will depend on the nature of the contaminant.
3. Removal and isolation of protective clothing: Outer protective clothing should be removed at this station. Outer gloves and overboots should be removed first. The protective clothing can then be removed with special care taken to reduce the risk of contaminating the worker. Inner gloves are the last piece of protective equipment to be removed.
4. Removal of personal clothing: With extreme hazardous substances, the removal and isolation of the worker’s personal clothing is necessary. All clothing should be isolated for future cleaning or disposal.
5. Personnel shower: In order to ensure complete decontamination, all personnel should shower. Liquid soaps work best. Special attention should be directed to the hair, fingernails and areas such as the underarms and groin. with known exposure, all run-off should be contained if possible.
6. Drying off and redressing: Disposable towels should be used for drying. Clean clothes can then be worn. Many teams use disposable coveralls or hospital scrubs.
7. Medical evaluation: All personnel with potential exposure must undergo a medical evaluation. Entry personnel should have received a pre-entry exam as a baseline. Vital signs, indications of exposure and signs of heat stress should all be evaluated. Personnel should be transported to a hospital for further evaluation if necessary.

The extent of this process will depend on the nature of the contaminant and the level of exposure. Steps 4 through 7 may not necessarily take place in this order. For example, the medical exam can follow primary decon and protective clothing removal. Or, if contaminants are not extremely hazardous, personnel may shower at an off-site location.

Water is an essential component of decon, and can be used to dilute many products. Water can be sprayed from garden hoses adapted for use or special deluge showers. Inexpensive showers can be made from PVC pipe with holes drilled to provide for water flow. Water massage shower heads are excellent because of their variable flow and spray patterns. Water sprays should be kept to a minimum to reduce overspray from the contaminant pools and to reduce the amount of contaminated water to be dealt with later.

PVC (plastic) pipe becomes brittle in cold temperatures and the glue used to hold the PVC together becomes much less adhesive. All PVC piping must be inspected and tested prior to use.

Decon usually requires the use of soaps or solutions. Usually a mild detergent and water may be sufficient. In special cases, a specific decon solution will be required. Depending on the contaminant, a special base, acid, solvent or bleach solution may be used. **These solutions are only used with equipment and should never be applied to skin.**

Water With Contaminant

Water from decon procedures needs to be contained and possibly disposed of as hazardous waste. Numerous devices are available to contain run-off water; children's wading pools, fire department drafting tanks, hose lines covered by visquene, containment areas fashioned from ladders and salvage covers, and commercially available portable decontamination tanks are all possible alternatives. The decision of which option to choose should be governed by how easy it is to assemble and use. Remember that there is a chance that the pool may need to be disposed of.

Personnel conducting decon operations must be properly protected. This should include the use of respiratory protection and chemical-resistant outer clothing.

Decon procedures must cover any equipment that has been inadvertently contaminated, such as protective equipment, SCBA, tools and possibly even vehicles. Equipment may need to be steam-cleaned or sandblasted to ensure that it is clean. Resources such as Chemtrec, computer data bases and the DEP can be contacted for assistance in determining extent of decon that is necessary.

Personnel should carry out a gross decon and isolation process on all equipment prior to completing procedures on themselves. Protective equipment and tools should be isolated for further cleaning and testing. Occasionally protective equipment cannot be totally decontaminated and must be disposed of. After the decon process is complete, the waste water and equipment (i.e., pools) may be disposed of as hazardous waste.

The personnel who are conducting the decon operations must also go through a cleaning process. Personnel should work their way through the deacon area, becoming cleaner as they progress. The object is to be absolutely clean when leaving the contamination reduction corridor. They should decon each other, with the last person finishing procedures on himself.

Two methods of measuring the effectiveness of decon procedures are swipe and permeation testing. Cloth or paper patches (swipes) are wiped over decontaminated surfaces and sent to a laboratory for analysis. Swipe tests can be done on protective clothing, equipment and skin. Permeation tests require that a piece of protective clothing be sent for analysis. However, both swipe and permeation testing provides after-the-fact confirmation. Along with visual observations, the test results can help evaluate the effectiveness of the completed decon procedures.

Decontamination Area Set Up

The decontamination area is set up by both security and members of the decon team.

Security:	Marks off restricted area with barrier cones and warning tape to designated restricted area depending on hospital. All personnel not associated with decontamination of the patients are to be restricted from the area by security. Security directs all ambulances, rescue units, other transportation vehicles with CONTAMINATED PATIENTS to the decon area.
Decon Team:	Assists in setting up the decon containment pool and shower setup. Prepares decontamination supplies, wash solutions, attaches hose to water supply. Tests water quantity and quality before the patient arrives. Determines if any additional supplies or materials are needed. Decon team suits up and waits for patients.

Once patients are in the area, only properly protected Decon members or medical staff, if in PPE, are permitted in the area.

Decon Termination Procedures

At the conclusion of the Decon process, it is important that the Decon area itself be decontaminated to prevent the spread of any contaminated material.

1. Clean up is usually done by **Decon Team** in **PPE**. However, local hazmat team should handle the clean up.
2. All solid waste that is contaminated is to be collected and placed in a “Contamination Bag.” (Double lined plastic garbage bags will work.)

   If it is determined to be a hazard, it will be disposed of by a hazardous waste company. For WMD events, be careful to protect and secure evidence.
3. Waste water is to be held as follows:
   a. if it is determined not to be hazardous, it can be disposed of in the sewer system.
   b. if hazardous, the waste water must be sealed in drums and arrangements made for pick up by a hazardous waste disposal company.
   c. the **Chemical Safety Officer** will make these determinations and arrangements.
4. The entire decon area is to be straightened up and cleaned down.
5. All supplies and decon equipment is to be properly put away. Inventory is to be taken as to what is to be needed.
6. Haz Mat supplies are to be relocated to storage area.

Common Sense Techniques

When performing decontamination, the goals, as well as the tasks needed to accomplish these goals, should be kept simple. There are "common sense" techniques that could be used to help protect the health and safety of all personnel involved and to prevent the spread of the hazardous material. Some of the "common sense" techniques to be considered are the following:

1. Check your own hands and feet (both should be protected upon arrival at the incident) for any signs of contamination.
2. Observe each other. Do a complete visual check of other personnel for signs of contamination. If a substance is noted, decontamination procedures must be employed.
3. If you are unsure that any piece of protective clothing or equipment has been completely decontaminated, carefully remove articles and leave them behind to be properly collected. YOUR SAFETY COMES FIRST, EQUIPMENT CAN BE REPLACED.
4. While decontaminating, avoid direct contact with the contaminated item.

Hazardous Materials/WMD Incident Decontamination Equipment and Supplies

Many of these items are available in the hospital. It would be advisable to set up an area where these supplies can be stored so that they are readily available when an incident occurs.

PERSONNEL PROTECTION EQUIPMENT

Face shield
Chemical goggles
Surgical gloves
Chemical protection suit with hood
Chemical resistant boots
Duct tape
ID badges

PATIENT DECONTAMINATION SUPPLIES

Sheets (Disposable)
Surgical Scrub brushes
Cotton tip applicators
Sterile water (for irrigation)
Wraps
Wash cloths (Disposable)
Spray container for soap
Soap
Scrub suits (Disposable)—For redress of ambulatory patient

DECON EQUIPMENT

The following supplies will be needed to set up the decontamination area:

Long handled scrub brushes (for decontamination of suits)
Warning tape
Warning signs
Cones
Containment pools
Decontamination table
Plastic floor covering
Hazardous Material labels for waste containers
Garden hose
Nozzle
Hazardous Materials Bags/Garbage bags
Markers
Scissors
Buckets
Waste containers

Recommended Decontamination Supplies

1. **Patient Decontamination System** that provides for the medical treatment and decontamination of a patient. This system should include a means of collecting waste water.
2. **Protective Floor Covering** constructed of a non-skid chemically resistant material.
3. **Waste Container** with a dolly, lid and liner. All contaminated articles such as the patient's clothes, dressing and medical supplies should be placed in this container for proper disposal.
4. **Sample Collection Kit** that contains all the instructions and necessary supplies for collecting samples. Should be done by qualified individuals.
5. **Decontamination Kit** that contains the necessary procedures, as well as fluids and materials, for patient decontamination.
6. **Antidotes** for use in specific cases.
7. **Contamination Control Measures** used to control access to contaminated area thereby minimizing the spread of the contamination.
    - warning rope
    - warning signs
    - boundary cones
    - step-off pad

Additional Supplies

- hose with splash reducing spray nozzle
- EMT scissors
- tincture of green soap
- waterproof drapes (i.e., Chucks)
- Irri-jet, all syringes, too many syringes
- adhesive tape
- towels
- soft scrub brushes
- XXXX buckets

PREVENTING HOME CONTAMINATION

Contamination of worker‘s homes with hazardous chemicals and substances transported from the workplace is a world wide problem. So says the National Institute for Occupational Safety and Health (NIOSH), which has released a report on this issue.

NIOSH found that workers can inadvertently carry hazardous materials home from work on:

- clothes
- hair
- in their vehicles
- skin
- tools

The incidents of home contamination have resulted in a wide range of diseases and, in some cases, death among worker’s families.

Here are some tips to prevent contamination at work and at home:

- Change clothes before going home and leave soiled clothing at work to be laundered by the employer
- Store street clothes in separate areas of the workplace to prevent their contamination
- Shower before leaving work
- Prohibit removal of toxic substances or contaminated items from the workplace
- Do not allow family members to visit the workplace
- Inform workers of the risk to family members and of preventive measures
- If contaminated clothing must be laundered at home, keep it separate from family laundry

WATCH OUT FOR YOURSELF AND EVERYONE ELSE!

Emergency Department ignition sources:

A. Most of the electrical/equipment switches.

B. Radios.

C. Electrical clocks.

D. Cigarettes, pipes, cigars, lighters, matches, etc.

E. Flashlights (including penlights) that are not intrinsically safe.

F. Portable radios that are not intrinsically safe.

G. Pagers that are not intrinsically safe.

H. Telemetry equipment that is not intrinsically safe.

I. Use of striking tools causing sparks.

J. Static electricity sparks *(nylon jackets act like batteries for static electricity).*

K. Battery operated hearing aids, watches, etc.

L. Defibrillators.

DECONTAMINATION PLAN

Besides the obvious reasons of why we perform decon, we must remember that we are required to perform decontamination procedures according to regulations and standards. At the Operations level, the standard states that you will "know how to implement basic decontamination procedures."

Also address in OSHA 1910.120(q) is the Emergency Response Plan. The employer shall develop an emergency response plan for emergencies which shall address, as a minimum, decontamination. Finally, OSHA discusses decontamination in Appendix C—Compliance Guidelines and Appendix E—Training Guidelines, both found in the back of the standard.

Appendix C states that "decontamination should be tailored to the specific hazards of the site, and may vary in complexity and number of steps, depending on the level of hazard and the employee's exposure to the hazard. Decontamination procedures and PPE decontamination methods will vary depending upon the specific substance, since one procedure or method may not work for all substances. Evaluation of decontamination methods and procedures should be performed, as necessary, to assure that employees are not exposed to hazards by re-using PPE."

In addition to the OSHA standard, the National Fire Protection Association addresses decontamination in its 472 standard.

DECONTAMINATION METHODS

METHODS	SPECIFIC TECHNIQUE EXAMPLES	CONTAMINANTS REMOVED
1) ***Physical***	• Water rinse (deluge shower)	Loose contaminants (soils or dusts)
	• Steam jets	Volatile liquids
	• Evaporation/vaporation	Adhering contaminants
	• Scrubbing/scraping	Adhering contaminants
	• Disposal of CPC	Deeply permeated materials
2) ***Chemical***	• Neutralization	Salts, acids and bases
	• Disinfection/sterilization	Infectious substances
	• Surfactants (e.g., detergents)	Adhering contaminants
	• Solidification	Certain liquid or gel contaminants
	• Dissolving contaminants (in solvents)	
	Water	Low chain hydrocarbons Inorganic Compounds Salts Some organic acids Some polar compounds
	Dilute acids	Basic (caustic) compounds Amines Hydrazines
	Dilute bases (i.e., detergent, soap)	Acidic compounds Phenols Thiols some nitro and sulfonic compounds
	Organic Solvents	Nonpolar compounds
	• Adsorption or absorption	Adhering contaminants
3) ***Both***	• Combination of above	Varies

HOW CAN YOU BE SURE DECON IS COMPLETE?

Decon methods vary in their effectiveness for removal of different substances. The effectiveness of any decontamination method should be assessed during the operation. If it is determined that contaminated materials are not removed or are penetrating protective clothing, the decontamination program must be revised.

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

There are, however, methods that are available to determine the effectiveness of decontamination. Remember, true testing for the presence of permeated chemical contaminants requires the pieces of the protective garments be sent to a laboratory for analysis. Besides that, here are **methods that may be available to you:**

1) *Visual check*
2) *Swipe tests*
3) *Analysis of cleaning solution*
4) *Analysis of containment (run-off) pools*

HEALTH AND SAFETY HAZARDS

We realize that decontamination is performed to protect our health and safety. One must be careful of the chemical and physical compatibility of the decon solutions or other materials before they are used. It would make sense that any decon solution or method that does more damage to protective clothing than that of the chemical on site should not be used. The contaminant must be identified before a decon solution is used, and reactions of such a solution with unidentified substances or mixtures could pose a problem. Remember these factors when preparing a decon solution and method at your next incident:

1) solutions may be incompatible with the hazardous substances being removed which could result in the production of an explosion, heat, or toxic products;
2) solutions may be incompatible with the clothing or equipment being decontaminated;
3) solutions or methods may pose a direct health hazard to workers such as the vapors emanating from the decon solution.

IN-HOUSE DECON

Out of doors decon is not very practical in cold weather. Imagine stripping down and showering in a portable shower, with only a sheet of plastic or salvage cover draped over the shower frame to protect you from subzero wind chills.

The alternate to outdoors decon in cold weather is an in-house system. The main priority of an in-house decon system is to decontaminate personnel in a quick, thorough, and efficient manner. Decon of equipment, clothing, and apparatus can be accomplished later in a less urgent manner.

An in-house decon system moves contaminated personnel from the incident scene to another location to perform decon. There still needs to be an on scene decon, consisting of a quick gross decon and removal of outer protective clothing, such as a chemical suit. The personnel are then transported to another location; one that would protect them from elements. The vehicle that transports these personnel will have to be checked for contaminants and decontaminated if necessary before being put back in service.

The first thing to consider is location. Did you respond to a fixed facility site that has safety showers or the equivalent to perform your decon operation? Is there a fire station or other facility in the area that can be taken out of service and be used for these purposes?

The area that is selected should have a large open area to store contaminated equipment and clothing, a shower area, and an environment control system (runoff collection).

CONSIDERATIONS FOR IN HOUSE DECONTAMINATION

1. Decon for inner PPE and body only—outer PPE done on site
2. All decon performed on apparatus floor—no other area of building
3. All equipment kept in the facility
4. Equipment and alterations
    A. Hot/cold water supply to front and rear walls with shut offs
    B. Station numbers marked on walls or floor
    C. Diagram on wall
    D. Storage boxes for equipment

CONSIDERATIONS FOR IN HOUSE DECONTAMINATION

STATIONS

1. SUIT WASH
2. SUIT RINSE
3. SUIT/BOOT REMOVAL
4. SCBA REMOVAL
5. INNER GLOVES/CLOTHING REMOVAL
6. BODY SHOWER
7. DRY/REDRESS
8. MEDICAL EVALUATION/TRANSPORTATION

EQUIPMENT

CONSIDERATIONS FOR DECONTAMINATION

4—Disposable pools
1—Roll plastic groundcover
4—Plastic garbage cans
2—Boxes of trash can liners
2—Rolls of barricade tape
2—Rolls of red marker tape
8—Stanchions
1—Body shower assembly
2—Garden hose assemblies with nozzles
2—Long handle scrub brushes
4—Short handle scrub brushes
2—Large sponges
1—Box powdered detergent
4—Small sponges
1—Box of disposable bath towels
1—Box of disposable towlettes
24—Tyvek suits with boots and hats

POSSIBLE CONSIDERATIONS FOR YOUR TEAM'S S.O.P.S

- NUMBER AND LAYOUT OF DECON STATIONS
- DECON EQUIPMENT NEEDED
- APPROPRIATE DECON METHODS
- METHODS OF AVOIDING CONTACT WITH POTENTIALLY HAZARDOUS SUBSTANCES
- PROCEDURES TO PREVENT CONTAMINATION OF CLEAN AREAS
- USE OF REMOTE SAMPLING AND SAFE HANDLING TECHNIQUES
- PROTECTION OF INSTRUMENTS BY BAGGING OR APPLYING A STRIPPABLE COATING
- USE OF DISPOSABLE GARMENTS AND EQUIPMENT
- METHODS FOR ISOLATING THE SOURCE OF CONTAMINANTS
- TECHNIQUES FOR SECURING CLOSURES AND COMPONENT INTERFACES (E.G., WHERE BOOTS AND GLOVES ATTACH TO SUIT)
- METHODS FOR MINIMIZING RESPONDER CONTACT WITH CONTAMINANTS DURING PPE REMOVAL
- METHODS FOR DISPOSING OF CONTAMINATED EQUIPMENT AND SOLUTIONS

HAZ MAT TEAMS MUST:

- ESTABLISH A DECON PLAN FOR EACH INCIDENT
- DISSEMINATE PLAN AND ENSURE ALL PERSONNEL ARE FAMILIAR WITH IT
- FOLLOW SPECIFIC PROCEDURES
- UNDERSTAND THE RISK OF PPE REUSE
- UNDERSTAND EMERGENCY DECON

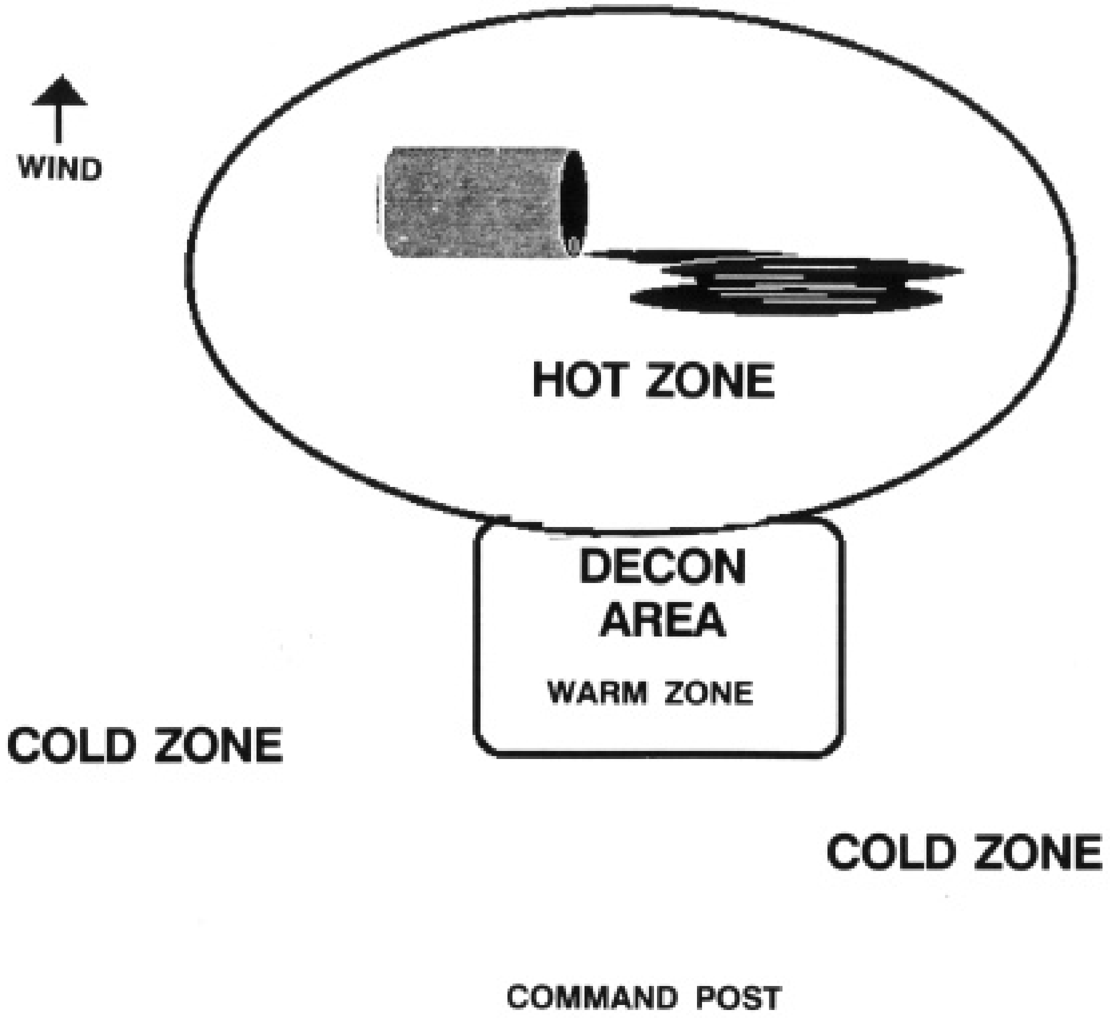
DECONTAMINATION SOLUTIONS

The following hazard chart should be used as a guideline for selecting solutions for the type of hazard identified:

HAZARD TYPE	SOLUTION CHOICE
1. Inorganic acids, metal processing wastes	Solution A
2. Heavy metals: mercury, lead, and cadmium	Solution B
3. Pesticides, chlorinated phenols, dioxins, PCBs	Solution B
4. Cyanides, ammonia, and other nonacidic inorganic wastes	Solution B
5. Solvents and organic compounds such as trichloroethylene, chloroform, and toluene	Solution A or C
6. Oily, greasy, nonspecific wastes not suspected to be contaminated with pesticides	Solution C
7. Inorganic bases, alkali, and caustic wastes	Solution D
8. Radioactive materials	Solution E
9. Etiologic materials	Solution F

Solutions for known products within the above hazard classes:

SOLUTION	
Solution A:	5% sodium carbonate and 5% trisodium phosphate. Mix 4 pounds of commercial-grade trisodium phosphate and 4 pounds of sodium carbonate with 10 gallons of water.
Solution B:	Solution of 10% calcium hypochlorite. Mix 8 pounds of calcium hypochlorite with 10 gallons of water.
Solution C:	A solution of water and 5% trisodium phosphate which can also be used as a general purpose rinse.
Solution D:	Mix 1 pint of concentrated HCl into 10 gallons of water (always add acid to water, never add water to acid) to produce a dilute solution of hypochlorous acid—$HClO$ (a very weak acid). Stir with wood or plastic stirrer.
Solution E:	A concentrated solution of detergent and water. Mix into a paste and scrub with a brush. Rinse with water.
Solution F:	A solution of 1 cup household bleach for every 10 cups of water OR 1 cup of hydrogen peroxide (3-4%) for every 10 cups of water.


WIND
HOT ZONE
DECON
AREA
WARM ZONE
COLD ZONE
COLD ZONE
COMMAND POST

MODULE 6
HAZARD AND RISK

OUTLINE

Unit Objectives
Performing hazard and risk assessment
Incident factors
Hazardous material behavior
Student exercises

MODULE 6
HAZARD AND RISK

OBJECTIVES

The participant will be able to:

1. **List and explain the three incident priorities.**

2. **Estimate the likely harm of an incident with or without intervention using the D.E.C.I.D.E. process.**

3. **Identify the presence of a hazardous material, the stage of the incident,**
   the harmful nature of the material,
   the potential modifying conditions,
   the exposure,
   the potential losses, and
   the resources needed to stabilize the incident given a simulated incident.

4. **Identify the hazardous material and its characteristics given assorted reference material.**

PERFORMING HAZARD AND RISK ASSESSMENT

In order to minimize the danger to everyone affected by a hazardous material release, the hazardous materials technician must be able to perform a hazard and risk assessment. It is during this phase of response that decisions are made whether to intervene or not intervene. If a decision is made to intervene then the appropriate defensive or offensive strategies must be employed. The key elements of that assessment are to identify what has happened, what is happening at the present time, and forecasting what is likely to happen.

A **hazard** is defined as a danger or peril. These dangers can usually be determined through the use of reference materials and pre-plan information. Hazard information includes a product's flammability, toxicity, reactivity, and chemical protective garment compatibility.

A **risk** is the probability of suffering a harm or loss. Unfortunately risk values cannot be "looked up" in a book or accessed via computer. Risk is evaluated by a knowledgeable person who reviews all of the available data and evaluates the probabilities of harm against the benefits which may be achieved. The risks can change many times during an incident, so attention must be paid to constantly re-evaluating the situation. Emergency responders can key on several factors which influence the degree of risk:

☐ *Hazard class and quantity of material(s) involved.* Risks generally are greater when you must deal with bulk quantities of hazardous materials in storage or transportation than when the substances are in limited-quantity containers. However, this must be balanced against the specific materials or class of materials involved.

☐ *Container type, the type of "stress" applied, and the ability of the container to adapt to the stressor.* Emergency responders must be able to analyze the type of hazardous materials container and pertinent safety features, and the type of stress being applied to the container.

☐ *Proximity to exposures.* This includes the size, distance, and the rate of dispersion of a chemical release. Exposures include emergency responders, the community, property, the environment, and system disruptions.

☐ *Level of available resources.* This includes the responders' training, expertise, and specialized equipment to deal with a specific incident. Response time of these specialized resources must also be considered.

Risks associated with hazardous materials response can never be completely eliminated, but they can be managed. The difference between trained responders and others is that they should be risk managers not blind risk takers.

PRE-INCIDENT

Ideally hazard and risk assessment should begin long before a hazardous materials incident occurs. Many of the requirements for pre-incident hazard and risk assessments were described in the response planning module of this course. The following are regulations which require pre-incident assessments:

[ ] SARA III
[ ] TCPA
[ ] NJRTK

In addition to the above laws and regulations there are agreements between the State and County governments to have the county health departments act as agents for the DEP; EPA and DEP regulations covering the clean-up of hazardous materials releases; and local laws enacted within communities to assist in planning and hazard and risk assessment. As a hazmat responder you must learn to use these laws to assist you in fulfilling your duty to the public.

ESTABLISH PRIORITIES

Initially, incident priorities must be set, then an assessment performed, and at that time an action plan can be developed based on the information uncovered during the assessment. In establishing the incident priorities the order of the priorities must always be:

1. **Life safety** not just for victims and spectators, but for the emergency responders as well. At all times the risk taken must be weighed against the result to be achieved. Do not trade off victims who are beyond your ability to help for the lives and safety of the emergency responders. You cannot prevent the harm which occurred before your arrival. Life safety will remain the number one priority at all times.

2. **Incident stabilization** should be your second priority and it should not be sought without considering life safety. Incident stabilization can range from stopping the release by plugging, patching, or some other means, to standing by without intervening. At all times you must be willing to accept that the best course of action is to take no action beyond isolation and evacuation. If your intervention cannot or does not produce positive results, you may be in a situation where the best method of incident stabilization is to allow the incident to run its course while you work to keep additional harm from occurring. Incident stabilization should always remain the number two priority.

3. **Property conservation** is, without a doubt, a worthy goal for emergency responders. However, property conservation may consist of deciding which property has already been lost, what additional property is going to be lost in the incident, and accepting that the incident has set boundaries. Yes, there will be times when the judicious intervention of a haz-mat technician will make all of the difference between the loss or conservation of property, but property conservation should always remain the third priority of your operation.

THE D.E.C.I.D.E. PROCESS

Once the incident priorities have been established, you can use the D.E.C.I.D.E. process to guide your assessment and intervention during an emergency. Certain basic decisions must be made and this calls for emergency response personnel to:

1. **Detect hazardous materials presence**

   Detecting the presence of hazardous materials is critical to any emergency and part of that detection is the identification of the material(s) involved.

2. **Estimate likely harm without intervention**

   Estimating the likely harm without intervention is a critical part of risk assessment. It is also a difficult step but an indispensable one. If you don't know what is going to happen, you cannot define the problem or determine how to deal with the problem. You cannot set objectives for your action plan to meet.

3. **Chose response objectives**

   Choose objectives which allow you to act in a rational manner. Identify the harm you want to prevent (do not forget the order of your priorities).

4. **Identify action options**

   Identify the action options you have, based on the objectives you have developed. Take into account all practical options before acting.

5. **Do the best option**

   When you have multiple options, pick the option which provides the greatest gain and the least loss.

6. **Evaluate progress**

   Once you have initiated your action options, make sure that what is happening is actually what you wanted to happen. If not, review your situation and select another option which will produce the desired results. At all times remember that the incident is a dynamic situation and is subject to change, both good and bad.

INCIDENT FACTORS

To assist you in using the D.E.C.I.D.E. process there are some incident factors which you must keep in mind. Among these factors are:

What is the nature of the problem?

Has the container failed or is it in danger of failing?

If the container has failed is there a reaction or ignition?

Are additional reactions or ignitions likely?

What are the hazards associated with the material?

Toxic
Corrosive
Radioactive
Etiologic
Asphyxiant
Flammable
Oxidizer
Reactive
Unstable
Cryogenic
Explosive

What is the type, condition, and expected behavior of the container?

IDENTIFICATION AND CONFIRMATION

As you perform the hazard and risk assessment, you must realize that positive identification of the material(s) involved is a must. Without positive identification you will not be able to carry out risk assessment. In order to be as accurate as possible in your identification of the material, do not use only one source of identification. In both the Awareness and Operational levels of training you were taught that there are six clues to assist you in identifying the presence of hazardous materials:

1. Occupancy and location
2. Container shapes
3. Markings and colors
4. Placards and labels
5. Shipping papers and other documents
6. Senses

Even after you have identified the material, you must confirm that identification. In addition to sources of identification such as known locations or occupancies, there are other sources including placards, labels, CAS numbers, etc., which help to confirm the identification. The use of monitoring instruments must also be considered at this point. Consider, too, if these identifiers all agree. Regardless of your method of identification, keep a record of what you have found. Record all pertinent information not just for your own purposes, but to be able to accurately pass the information on if the need arises.

After you have identified the material you must begin to develop information on the material through several reference sources (CHEMTREC, MSDS's, other publications, computer databases, local technical personnel, etc.) and look at the behavior of the material to see that it helps to confirm the identity. If you are expecting a liquid release and instead see a vapor or gas release, look again at your identification. It is possible that your identification of the material is not correct due to something you cannot see. There have been incidents where a substance was leaking and burning, yet the identified material was not combustible. In reality, the identification was incorrect. The responders could not see a pipe which passed through a wall and over the tank which appeared to be burning. The material was actually from another tank on the other side of the wall.

It is not possible to formulate an action plan unless the identity of the material is known. When the material cannot be identified you must operate from a worse case scenario. In this situation you may be beyond your capabilities, at the very least you are at a point where the minimum level of protective clothing must be Level A. Whether or not the identity of the material is known, you must always consider non-intervention as a viable action. Regardless of the course of action chosen, keep control of the scene. Use the minimum number of people needed to safely handle an incident, and keep others away to avoid additional problems.

MODIFYING CONDITIONS

Certain conditions may cause you to modify your decisions. Modifying conditions include:

<u>Location of the incident</u>

Is it in a remote area?
Are there affected populations?
How will the terrain affect the release?
Is the terrain difficult?
Is the incident in an area where there is limited access (highway, etc.)?
What bodies of water may be affected?

<u>Time</u>

of the day
of the week
of the year
response time

<u>Weather and climatic conditions</u>

Temperature
Wind direction
Wind speed
Air inversion
Precipitation

<u>Exposures including</u>

Life
Property
Equipment
The environment

What control measures are needed?

Do you have the resources available?

If you have the resources available, do you have an adequate amount and the proper level of sophistication for:

Extinguishment
Fire Fighting
Rescue
Protective measures
Communications

How good has your identification been and do you have the proper monitoring devices for:

Toxicity
Flammability
Radioactivity
Corrosiveness
Oxygen deficiency

HAZARDOUS MATERIALS BEHAVIOR

To assist you in performing a hazard and risk assessment it is important to understand the sequence of events relative to the haz-mat incident and the expected behavior of the material(s) involved.

BENNER'S DEFINITION OF HAZ-MAT—"any substance that jumps out of its container at you when something goes wrong, and hurts or harms the things it touches or impinges upon."

STRESS

Prior to your arrival some form of STRESS event caused the container to lose its integrity. A typical form of stress may have been from a mechanical source such as a motor vehicle accident, train derailment, or having been dropped. Another source of stress could be from a thermal source such as extreme heat or cold, while a third source might be from a chemical reaction occurring within the container. Stress events can also be from a combination of sources and would include situations where a mechanical stressor (i.e. motor vehicle accident) weakened the container without a loss of container integrity and another event (such as a fire from spilled motor vehicle fuels) provided enough thermal stress to finish the container. It is possible that the container could have withstood either stress event but the combination of the two events was more than the container could take.

Considerations for the effects of stress on a container include the intensity of the stress and the duration of the stress event.

In looking at the intensity of the stress consider the following:

Differential between the stressor (the source of the force) and the stressee (the container) including temperature, velocity, and pH.

The proximity of the stressor and stressee.

Barriers

When considering the duration of the stress event include:

The quantity of stressor.

The form of stress.

Transfer rate of stressing energy.

Time of application.

Any source of sustaining stress.

BREACH

When a stressed container opens up it is known as a BREACH event. A breach is defined as "an opening in a container through which matter and/or energy can or does escape". Factors which must be considered in analyzing a breach event include the type, intensity, and duration of the event.

In looking at the type of breach consider:

Has the container disintegrated?

Is runaway cracking occurring?

Have attachments opened up?

Are there punctures, splits and tears?

Intensity considerations should include:

<u>Container</u>

—Stressing mechanism
—Energy exchange vs absorption
—Pressure of stored energy
—Portion stressed

<u>Contents</u>

—Reactivity
—State
—Quantity

For duration considerations bear in mind:

The stress duration

Energy dissipation rate

Reaction rate

RELEASE

So far we have looked at both stress and breach. The combination of these two events can lead to the RELEASE event. This is when matter or energy escapes from the container. It is the point at which most hazmat incidents are reported and it is also the point at which we as responders arrive on the scene. Many times our hazard and risk assessment starts at this point, but as was mentioned earlier, the assessment must also include information about what happened prior to our arrival. Beginning your hazard and risk assessment here, while ignoring the stress and breach events, can lead to a dangerous underestimation of the problem. Take the time to determine what happened to cause this release by defining the stress and breach events. As with the stress and breach events, the release event is affected by the type, intensity, and duration of the event.

The types of releases include:

<u>Detonation</u> which is an explosive chemical reaction occurring in less than 1/100 of a second. Examples would include military munition, dynamite, and organic peroxide.

A <u>violent rupture</u> causes runaway cracking and a BLEVE occurring in a closed container can occur in less than one second.

A <u>rapid release</u> is released through pressure relief devices, damaged valves, punctures or broken piping. This can occur from several seconds to several minutes.

A <u>spill or leak</u> which is non-violent can flow through openings in fittings, splits or tears, and punctures. This action may take days.

The intensity concerns should include:

- What type of breach occurred?
- What are the characteristics of the contents?
- What is the flow rate?
- Is there a propulsion mechanism affecting the contents?
- What are the weather conditions?

In reviewing the duration of the releases look at:

- The type of breach.
- The quantity of the contents.
- The flow rate.
- The characteristics of the contents.

ENGULFMENT

If it has not already been done, at this point you must identify the material which has been released. You can now begin to determine the extent of the ENGULFMENT and forecast how it might grow. The engulfment is determined by the dispersion (scattering or spreading) of the matter and/or material from the container. This dispersion forms a danger zone which has been contaminated by the hazardous material. We would recognize this area as the HOT ZONE.

Factors which affect the dispersion of the material and consequently the engulf event include:

The type of dispersion pattern:

- Is it a cloud?
- Is there a plume?
- Is the material being dispersed in a cone?
- Is there a stream of material?
- Are there irregular deposits?
- Is there a combination of patterns?

What is the intensity or size of the danger zone depending on the:

- Type of breach and release
- Form, quantity, and character of release
    - Infrared or gamma rays
    - Pressure waves
    - Dusts, powders, fragments, shrapnel, or chunks
    - Organisms
    - Alpha or beta rays
    - Liquids
    - Vapors
    - Vaporizing liquids

- Propulsion mechanism
  - Thermal differential
  - Self-propelled
  - Wind
  - Personnel transportation
  - Gravity
  - Diffusion
- Path of travel
  - Linear
  - Radial
  - Random
  - Follow the contour
  - Upward or outward
- Dispersion pattern characteristics
  - Cloud
  - Cone
  - Plume
  - Stream
  - Irregular deposits

Duration considerations should include:

- Quantity of material
- Dispersion mechanisms
- Secondary reactions

IMPINGEMENT

The events which have occurred to this point include the container being stressed, a breach occurring, a release of the contents, and a dispersion causing an engulfment. Now we need to consider what exposures will be contacted by the material. This is known as the IMPINGEMENT. Impinge means to “strike or collide with” and “here it is being used to differentiate between being touched by and being hurt by the matter and/or energy released.” You should understand that “exposures are not always hurt, injury depends on the lethality, duration, intensity, and concentration or dosage of the impingement”.

Factors to be considered when looking at the impingement event include:

- Type
  - Short term which lasts minutes or hours such as being surrounded by a gas cloud.
  - Medium term which lasts days, weeks, or months and may linger as pesticide residue.
  - Long term which lasts years or generations such as a radioactive source contact.

- Intensity
  - The engulfing event (how big an area)
  - Barriers and shielding
  - Quantity
  - Physical state
  - Weather conditions
  - Velocity
  - Solubility
- Duration
  - Characteristics of the material
  - Quantity released
  - Recovery potential

HARM

Now you can consider the HARM event. Included for consideration in that harm are the operating personnel at the scene as well as the likely outcome without intervention (will the situation get better or worse if we intervene?).

In attempting to determine the level of harm possible consider:

- Type
  - Thermal (including heat and cold)
  - Radiation
  - Asphyxiation
  - Toxic
  - Corrosive
  - Etiological
  - Mechanical
- Intensity
  - Impingement potential
  - Toxicity
  - Corrosivity
  - Condition of exposures
  - Characteristics of material released
  - Detectability
  - Concentrations within the danger zone
- Duration
  - Detectability
  - Concentration and characteristics of the material release

As emergency responders we must be risk managers. The events analysis process provides us with some of the important data necessary to conduct an effective risk assessment. In identifying risk we must look at all of the hazards and their potential to cause us harm. Remember, it doesn't matter how "harmless" the material in the railcar is-if the railcar rolls on-top of the responders they are still "harmed"!

A key question to answer during the risk assessment process is-What do we have to gain in comparison to what are we risking. Unfortunately, we can't look into a book or a computer database for the answer. This is known as the Risk/Benefit Analysis. When conducting the risk/benefit analysis always remember:

RISK	BENEFIT (Save)	EXAMPLE
A lot	A lot	Save a life
A little	A little	Save Property
Nothing	Save nothing	Recover a dead victim

The following list was developed to provide the haz-mat team leader or on-scene incident commander with a list of questions which should be addressed and factored into the hazard and risk assessment process. The list is not intended to be all inclusive additional factors will have to be considered based on the nature of a particular incident.

HAZARD & RISK INCIDENT CONSIDERATION

1. WHAT IS LEAKING?
2. WHERE IS IT LEAKING FROM?
3. WHAT MEASURES HAVE ALREADY BEEN TAKEN?
4. WILL THE LEAK GET BETTER OR WORSE BY ITSELF?
5. WHAT DO WE NEED TO STOP THE LEAK?
6. HOW LONG WILL IT TAKE?
7. ARE THERE VICTIMS?
8. CAN THEY BE SAFELY REMOVED?
9. WHAT TYPE OF PROTECTION DO WE NEED TO ENTER THE AREA?
10. HAVE WE ESTABLISHED A HOT ZONE?
11. WHERE DO WE EXPECT THE PLUME TO TRAVEL?
12. IS THERE A POTENTIAL FOR PERSONS OFF-SITE TO BE AFFECTED?
13. WHAT OFF-SITE AREAS ARE EXPOSED CURRENTLY?
14. DO WE NEED TO EVACUATE ANY AREAS?
15. HOW WILL WE DETERMINE THE EVACUATION AREA?
16. WHO HAS THE EQUIPMENT TO CONDUCT AIR MONITORING?
17. CAN WE SHELTER IN PLACE, RATHER THAN EVACUATE?
18. WHAT OFF-SITE AREAS MAY BE AFFECTED IN THE FUTURE?
19. WHAT AREAS DO WE HAVE TO ISOLATE NOW? I.E.: TRAFFIC, DOWNSTREAM?
20. WHAT AREAS WILL WE HAVE TO ISOLATE LATER IF THE LEAK INTENSIFIES?
21. IF A LARGE SCALE EVACUATION IS NEEDED WHO WILL DO IT?
22. WHAT WILL HAPPEN IF THE WIND SHIFTS?
23. WHERE SHOULD WE STAGE INCOMING UNITS?
24. HOW WILL OUR RESOURCES BE AFFECTED IF THE WIND SHIFTS?
25. WHO ELSE SHOULD BE NOTIFIED OF THE INCIDENT?
26. WHAT ROUTES WILL CIVILIANS USE TO BYPASS AREA?
27. WHAT ROUTES WILL RESPONDERS USE?
28. HAS A MEDICAL UNIT BEEN ESTABLISHED FOR RESPONDERS?
29. HAS A SAFETY OFFICER BEEN ESTABLISHED?
30. HAVE WE ESTABLISHED AN EMERGENCY EVACUATION ALARM? DOES EVERYONE KNOW IT? WHAT SHOULD THEY DO IF THEY HEAR THE ALARM?
31. WHAT HOSPITAL WILL VICTIMS BE TRANSPORTED TO?
32. HAS THAT HOSPITAL BEEN NOTIFIED?
33. WILL ANY VICTIMS HAVE TO BE DECONNED BEFORE TRANSPORT?
34. HAVE THE PARAMEDICS BEEN REQUESTED?

SUMMARY

If it seems as though this has been a simplistic explanation of a hazardous materials incident keep in mind that it is very easy to forget to look at the whole picture. It is easy to visualize how a single container would behave, what you might have to do is look at many containers and perform a hazard and risk assessment for a very complex incident. By breaking the incident down as a series of simple events you can see what has happened, what is happening at the present time, and forecast what you expect to happen. Remember to continue your assessment throughout the incident and keep in mind that the incident is not a static, unchanging event but a dynamic, evolving occurrence. The hazard and risk assessment process is on-going. At all times look for the alternative which delivers the greatest gain and always consider that no intervention is a viable alternative.

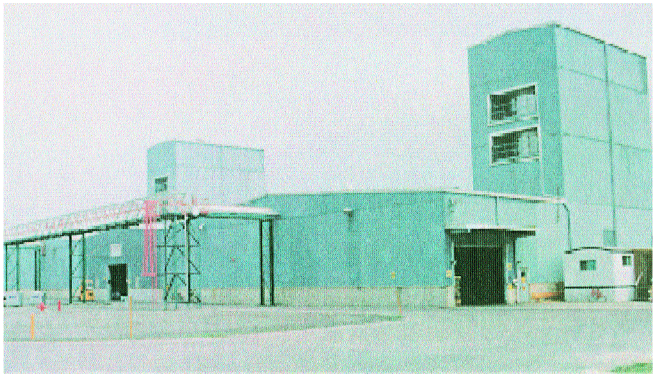
MODULE 7

RESPONSE PLANNING

OBJECTIVES

The student will be able to:

1. Identify and explain the authorities governing hazardous materials emergency response planning
2. Discuss the importance of performing a local level hazard analysis and capability assessment
3. Implement their jurisdiction's Emergency Response Plans
4. Explain State level involvement in hazardous materials response as outlined in the State Emergency Operations Plan
5. Develop and implement a Site Safety and Control Plan
6. Understand the importance of exercising in hazardous materials emergency response



1. REVIEW OF LAWS, AUTHORITIES AND IMPLEMENTATION

In order to perform a job safely and properly the emergency responder must have a good understanding of how things work in New Jersey. Through the Awareness and Operational courses the basic structure of emergency planning and notification was discussed.

New Jersey is unique among most of the states in this country in that it ranks number one in many areas related to development and demographics. New Jersey easily has more people, industry, roads, railroad, pipelines, and residential development per square mile than anywhere else. It also has one of the highest development to navigable waterway rankings. Add to this that New Jersey is the major conduit in the Boston to Washington transportation corridor, and more specifically, between Philadelphia and New York.

What all this means is that both our population **and** our emergency responders charged with protecting it are at great risk of experiencing a hazardous materials emergency. Having several thousand miles of highly active transportation routes (road, air, water, and rail) translates into the potential of seriously complicated response circumstances with very little known ahead of time.

The emergency responder must know and be able to operate under the laws and regulations which govern how hazardous materials emergency response is accomplished in New Jersey. A quick review of the major planning authorities is as follows:

OSHA 1910.120 (Federal)
Health and safety planning for in-plant emergency responders
Enforced by OSHA
See PEOSH Act

SARA TITLE-III (Federal)
Facility and local emergency response planning and community right to know
Enforced by the NJOEM for emergency planning and NJDEPE for community right to know
See Worker and Community RTK Act and Emergency Management Act

WORKER AND COMMUNITY RIGHT TO KNOW ACT (State)
Site specific chemical inventory
Enforced by NJDOH for publicly owned facilities and NJDEPE for privately owned facilities

EMERGENCY MANAGEMENT ACT (State)
Emergency operations plan for protecting the life and property of the public
Enforced by the NJOEM

TOXIC CATASTROPHE PREVENTION ACT (State)
Facility risk management planning for the prevention of incidents
Enforced by the NJDEPE

DISCHARGE PREVENTION, CONTAINMENT AND COUNTERMEASURE/DISCHARGE CLEAN-UP AND REMOVAL (State)
Facility large quantity reporting and emergency response planning
Enforced by the NJDEPE

PUBLIC EMPLOYEES OCCUPATIONAL SAFETY AND HEALTH ACT (State)
Health and safety planning for public sector emergency responders
Enforced by NJDOH PEOSH Service
See OSHA 1910.120

NOTIFICATION (Composite of several State and Federal laws)
Notification between the responsible party, local government, and the NJDEPE Hotline
Enforced by the NJDEPE

COUNTY ENVIRONMENTAL HEALTH ACT (State)
Service agreements between NJDEPE and county level forces
Administered by the NJDEPE

2. ANALYZING HAZARDS AND ASSESSING CAPABILITIES

A benefit of the authorities established for hazardous materials emergency planning, right to know, and emergency response is the information created by them. With the facility lists and chemical inventories (see appendices) generated by SARA, RTK, TCPA, and DPCC emergency planners and responders have a wealth of pre-incident data available to them. This data, along with the required emergency response plans from the facilities gives the responder key insight into such things as:

A. What exactly are you faced with? How many facilities are there? What do each of them do there? What kinds of substances do they handle? How much do they have? How is it stored, processed, packaged, offloaded, etc.? Who do they have to answer to?

B. What kinds of incidents have been happening in your service area? What kinds of substances and quantities were involved? Have a lot of people been hurt or evacuated?

C. Have emergency response plans been prepared by the facilities in your service area? If an incident occurs at one of them, will they need your help or do they have their own in-house responders? Have you met with their facility representative and done a walk-through of their facility? Does a service agreement exist with the facility response team and the surrounding community for offsite response?

Responders should be aware that if a facility has not prepared an emergency response plan, you must ask for it! Meet with the facility safety representatives and provide them with an *Emergency Response Reference Guide* (see appendices) to get them started.

By reviewing these data summaries and asking the right questions, emergency response agencies can assess the appropriate staffing, equipment, and training needs in order to safely and effectively respond to the majority of incidents from fixed facility operations. It is critical that whatever information is available be fully reviewed, otherwise a response agency may find themselves falling short of the appropriate level and type of response capability needed to handle incident response.

TRANSPORTATION INCIDENTS

Beyond the sphere of known hazards are those which are much more difficult to define. Often times these are the transportation incidents. In order to understand the magnitude of difference between fixed site and transportation incidents consider the following comparisons:

	INCIDENT TYPE	
PRE-PLANNING CONCERN	**FIXED**	**TRANSPORTATION**
Does this location appear on a list created by law?	y	n
Is there substance data available on this location?	y	n
Is there inventory data available on this location?	y	n
Is there incident data available on this location?	y	y
Is an emergency plan required from this location?	y	n
Can you estimate where an incident might occur?	y	n
Can you predict the type of incident release?	y	n
Is it probable that the company can quickly assist with response?	y	n

While there are exceptions to some of these parameters, when comparing fixed site and transportation incidents, it can generally be assumed that much more information is known ahead of time about the fixed site incident. Conversely, transportation incidents often pose a more serious threat because virtually nothing can be assumed in advance. In short, they can happen anywhere, at any time, and with nearly any substance (or substances). In addition, totally different sets of variables can be present. Two identical rail incidents can have completely different end results depending on where and when they occur. Proximity to population, development and environmentally sensitive areas can force emergency response to expand into areas not normally associated with fixed site locations.

Simply stated, if it can move, it has the potential to be more complicated, and therefore more dangerous.

3. LOCAL LEVEL EMERGENCY RESPONSE PLANS

A hazardous materials technician must be aware of and understand how to implement the emergency response plan for his/her jurisdiction. In actuality there are **two distinct plans** that directly affect and involve the emergency responder; the jurisdiction's Emergency Operations Plan and the responding agency's Health and Safety Standard Operating Procedure.

Often times these two documents will be referred to as one in the same. This is not true, and the emergency responder must understand the importance of their differences. Simply stated, the jurisdiction's **EOP** identifies how the protection of life and property **of the public** will be accomplished. The responding agency's **SOP** on the other hand is developed for the purpose of protecting the health and safety **of the responders.** The enforcement agencies of State government also differ for these two plans; the NJOEM oversees the development and maintenance of local level EOPs, while the NJDOH PEOSH Service oversees development and enforcement of responding agency SOPs.

EMERGENCY OPERATIONS PLAN

The EOP is the primary foundation for all emergency planning and response for a jurisdiction. Required under NJSA App. A:9-30, et seq., EOPs are done at the municipal, county, and State level. All 567 municipalities and 21 counties develop and maintain these plans, while the NJOEM keeps current the State plan.

It is also the legal basis for emergency operations for the jurisdiction's response community. It also outlines how a state of emergency may be declared, and under what rules the jurisdiction operates in time of emergency. As an incident escalates beyond municipal control, the EOP guides local forces in requesting assistance from county government. The county EOP functions as a coordination and resource support document to its municipalities, and guides county forces in acquiring additional resources and for requesting State assistance if necessary. Both at the municipal and county level, the jurisdiction's Emergency Management Coordinator is responsible to ensure that an EOP is developed, approved, maintained, and distributed, and is made available to anyone wishing to review it.

The NJOEM is the State agency charged with the authority for coordinating development and approval of these plans. A checklist and guidance document for developing the EOP is distributed by the NJOEM to county and municipal OEMs.

Every EOP is organized using the same format and includes explanations of how the jurisdiction performs emergency operations. It is made up of a Basic Plan and 15 functional Annexes, each addressing a specific function of emergency operations.

For each function the annex will cover the following 11 areas:

Introduction: the agencies involved in the function

Authorities: the laws and regulations governing the function

Purpose: the purpose of the annex

Situation: the relevant hazards and response capabilities

Operations & Control: how notification and incident command are accomplished

Responsibilities: who is in charge of specific duties

Continuity of Government: the chain of command for that function

Administration & Logistics: who handles administrative and resource support

Annex Development & Maintenance: who keeps the annex current

Definitions: definitions for unique terms

Appendices: a directory of information, data and procedures specific to the function

Specific to the Hazardous Materials Annex, the required appendices include:

Chemical handling facilities

Facility and transportation maps

Evacuation and traffic rerouting procedures

SOPs

Resources

Response agreements

Training

RESPONDING AGENCY SOP

In contrast to the jurisdiction's EOP is the individual responding agency's standard operating procedure. While many of the items discussed in this SOP are similar to those outlined in the jurisdictions overall EOP, many are different; they are usually much more specific. The idea behind this SOP is to identify and discuss specific procedures for just that agency on how it will carry out hazardous materials emergency response, and do so in a manner which ensures, first and foremost, the health and safety of its responders.

Agencies typically affected by this requirement include those that would find themselves responding to hazardous materials incidents as part of their regular duties (on a day to day basis). This may include, but not be limited to Fire, Police, EMS, Public Works, Health, and Emergency Management agencies. All of these agencies must prepare an SOP for their specific hazardous materials response operation. Once all SOPs have been prepared in draft form, they should be reviewed **between** agencies to ensure that in those areas where responsibilities overlap or mesh, respective SOPs reflect the appropriate coordination.

Note that responding agency SOPs must be done at every level of government. This means that all hazardous materials response forces of the State, the 21 counties and all 567 municipalities must prepare these SOPs.

As identified in the NJ PEOSH Act, the major topics to be covered in a responding agency SOP are:

- Pre-emergency planning and coordination with outside parties
- Personnel roles, lines of authority, training, and communication
- Emergency recognition and prevention
- Safe distances and places of refuge
- Site security and control
- Personal protective equipment and emergency equipment
- Evacuation routes and procedures for responding personnel
- Emergency medical treatment and first aid
- Decontamination
- Critique of response and follow-up

In reviewing these topics it is evident that much of this activity will be covered in how the jurisdiction and its responding agencies implement an incident command system. As outlined in OSHA 1910.120, all responders must remember that an ICS must be used for all hazardous materials emergencies regardless of their initial size. ICS works equally as well for small and large scale incidents. Key to ICS and the responding agency SOP is that emergency procedures must be coordinated internally and externally, and that everyone should be aware of them and familiar with how emergency operations will be accomplished. Once your health and safety is ensured, only then can you get on with the business of incident response.

4. THE STATE EMERGENCY OPERATIONS PLAN

The State EOP is developed exactly in the same way as that for a municipality or county. All agencies involved in emergency services meet to discuss coordination and responsibilities and agree on how emergency operations are accomplished. For New Jersey the State EOP is coordinated by the NJOEM. The Hazardous Materials Annex of the State EOP is coordinated by the NJOEM's Hazardous Materials Emergency Response Planning Unit. The State keeps its plan current by reviewing and updating annually (or sooner). Once the plan is completed in draft form, each annex is circulated back to the participating agencies for approval and signature. Once all annexes are approved, the NJOEM prints and provides copies of the State EOP to the 21 State departments for their use and operation in time of emergency.

Most of the State level response to hazardous materials incidents is performed by the NJDEPE and the NJOEM. The NJDEPE regional responders function to assess and advise on environmental matters, the correct chemical response procedures and appropriate clean-up methods. The NJOEM regional responders function to coordinate overall on-site emergency management and resource support. The level of involvement of these two agencies depends entirely on the level of capability of the municipal and/or county forces present. If local forces are fully staffed, equipped and trained to handle the incident, State responders often need not even respond, and may have only to make contact via telephone or radio to verify that on-scene operations are progressing properly. On the other hand, should an incident exceed local capability, both State agencies will be there to get involved to whatever level is necessary to safely mitigate the situation. It must always be stressed that State responders are there to assist, **not** to take over.

5. SITE SAFETY AND CONTROL PLANS

These plans differ from those of government agencies for two reasons. First, facility plans are developed to satisfy OSHA for compliance with 29 CFR 1910.120. Even though the NJDOH PEOSH Service adopted this law in its entirety for the public sector, the private sector comes under OSHA as its enforcement authority. It is important to understand this distinction as it is up to each of these enforcement authorities to decide how to implement the law under their jurisdiction. *Remember . . .*

Private Sector .... > OSHA
Public Sector .... > NJDOH PEOSH

OSHA inspectors will be concerned with safe practices **inside** the fence line, and just for **that one specific site**. PEOSH on the other hand will be looking to enforce 1910.120 for the public sector from a much more generic point of view, requiring the SOP to address how operations will be conducted **no matter where the responding agency goes**. As such, PEOSH wants more detail under the 12 elements listed in the law, and rightly so, because public sector responding agencies never know where and to what conditions they will be responding **ahead** *of time*. This is why many planners agree that the risk of injury is greater to the public sector responder.

Secondly, even though the originating law has the same foundation, a site safety plan will lean towards a business perspective; at the personnel on-site and preserving the physical plant. More importantly, since a facility knows its own inventory and its internal business operation, they can predict to a much higher degree what might go wrong and how to respond to it. This allows them to provide excellent detail in emergency operations and the appropriate response procedures. It also means that their responders can often minimize the risk of exposure to unknown situations or substances.

Consequently, municipal, county and State responders must ensure that when responding along side of facility personnel at a facility, priorities and procedures be well established and agreed upon by all agencies present. In the past it was commonplace for many facilities to be concerned (or so it seemed) solely with what happened inside the fence line. Thankfully, with an increased awareness of the importance of **outside** emergency response forces, industry has come a long way in stressing outside interaction. This is also evidenced as many industries actually go outside to assist responders in their surrounding communities . . ., and much of the time this is done free of charge!

ON-SITE INCIDENT RESPONSE

What occurs at the vast majority of incidents where a facility has its own response forces is that they will remain in charge of incident command, but may rely on outside agencies for resource support. These resources may range from items such as absorbant booms and pads, diking materials and foam all the way up to full hands-on technician-level entry and mitigation. It is the latter activities which require extensive pre-planning meetings and exercises with facility personnel to ensure a smooth **and safe** response.

As mentioned earlier, a site safety and control plan is composed of a minimum of 12 elements under the law. Often times, however, many facilities elect to include additional or different information to assist on-site personnel with specific response procedures and practices. For example, a generic site safety plan as published by the US Coast Guard includes the following elements:

- Site description
- Entry objectives
- On-site organization and coordination
- On-site control
- Hazard evaluation
- Personal protective equipment
- Local emergency response plans
- Communications procedures
- Decontamination procedures
- Safety and health plan

Comparing this list of ten elements to that listed in 1910.120 (and under item 3 of this module), one can see that some items are discussed differently. This is because much more information is known about how to accomplish certain planning objectives. A big difference is that a site safety and control plan will fully describe actual chemical handling operations, transfer, storage, and shipping procedures, and other business practices. On-site personnel are then able to prepare much more effectively for **specific** incidents based on their own internal hazard analysis.

Whatever the case, public or private sector, OSHA or the NJDOH PEOSH Service, these plans are always designed to protect your health and safety when responding. Simply stated, they describe how your organization will accomplish each objective in a coordinated manner consistent with that of all other responding personnel.

WHAT IF THERE IS NO PLAN AVAILABLE FROM THE FACILITY?

There are still some chemical handling facilities which have not developed (to the best of your knowledge) a site emergency response plan. In these cases it is up to you to pursue one. For example, SARA Title-III, section 303(d)3, clearly states that:

> "**Upon request** by the local emergency planning committee, the owner or operator of the facility shall promptly provide information to such committee necessary for developing and implementing the [LEPC's] emergency plan."

Should you find that a facility in your jurisdiction has in fact not done a plan, ask for it! Use the *Emergency Response Reference Guide* format (provided in the Technician course) and meet with the facility as soon as possible. It is in circumstances such as these where the potential for emergency responders to get hurt is at its greatest, and often it is because of a shortage on information. Even though response procedures dictate *"If you don't know, don't go,"* many times responders go in anyway, having decided that while little or no data is available, right now the incident is escalating and must be brought under control. Before you know it, an avoidable accident has just happened.

6. EXERCISING

Through drills and exercises response forces from all levels of government experience interaction with each other. Exercising is a critical part of an agency's response practices, as it allows them to test certain assumptions about their capabilities. When these exercises involve agencies outside of their own jurisdiction, additional issues arise. This may include concerns such as evacuation and traffic rerouting, communication, multi-jurisdiction command, resource support, mutual aid, media interface, and even interstate coordination.

Participation in a State sponsored exercise is perhaps the best way for municipal and county forces to assess how well their procedures and capabilities are working. What often occurs is that for small scale incidents where the municipality and/or county can handle it without the need for State responders, incident management runs smoothly. Difficulties arise when incidents spread across county or state lines, and begin to affect widespread areas. In such cases there is a clear need for higher level involvement. Many issues surface simply because of the magnitude of the emergency. For example, a chemical spill that escalates to involve a fire may create a need to temporarily close down major traffic corridors and reroute traffic by alternate means. Another example might be one in which a large scale spill eventually exceeds its containment and discharges into a major waterway. In this scenario, not only environmental concerns become paramount, but shipping and other commerce activities may quickly be compromised.

The complications associated with large scale incidents can only truly be dealt with through exercising (or the real thing). Should an incident of major magnitude or complication occur without a jurisdiction having tested for it, there is a good possibility that there will be a failure somewhere in the response. On paper, a jurisdiction and its responding agencies may feel comfortable with their emergency response plans, but they must be tested. They should be pushed to their limits **and beyond** to truly assess capability.

This is why pre-incident exercising (and/or post-incident assessment) is critical. Predicting or evaluating the results of real events through exercises is the true test of evaluating emergency readiness and therefore the best way to ensure your protection and that of the jurisdiction you serve.

Talk to your regional responder from either the NJOEM or NJDEPE and ask about participating in the next State exercise. It need not even involve hazardous materials because much of the activity of response is the same from one incident type to another. If there is no exercise coming up in the near future you can just as easily initiate a scenario at your level of government, be it a tabletop, functional, or full scale. The State Exercise Design Officer is available to assist with planning an appropriate exercise for your needs.

. . . Don't forget to include industry!

RESPONDING DEPARTMENT APPENDIX HEALTH AND SAFETY PLAN FOR HAZARDOUS MATERIAL EMERGENCY RESPONSE

This Appendix addresses health and safety protection for: (Circle One)

- Fire Department
- Police Department
- Emergency Medical Services
- Public Works/Road Department
- Local Health Department

personnel in the:

- municipality of:____
- department of: ____

Emergency Responders from this department will adhere to the content of this Appendix and the Coordinated Worker Protection Emergency Response Plan for this municipality when responding to hazardous materials incidents under the scope of the Public Employees Occupational Safety and Health Act Standard, 29 CFR 1910.120.

Prepared by:

____
(Name)

____
(Title)

____
(Date of Preparation)

____
(Last update)

RESPONDING DEPARTMENT APPENDIX

This department's highest ranking response official will ensure that the provisions of the Coordinated Worker Protection Emergency Response Plan and this Appendix are followed by all responding personnel from this department. Although many responders perform different levels of activities during hazardous materials (HazMat) incidents (e.g. notification, defensive and/or offensive), the basic provisions of this ERP will apply to all personnel.

- Please indicate the appropriate HazMat incident response level taken by this department. (Check one)

A. ______ Although employees from this department are likely to witness or discover a HazMat incident, the ONLY action to be taken is to notify authorities of the release and then leave the scene. (If this item is checked, complete sections (A) through (C) ONLY)

OR

B. ______ During a HazMat incident, employees from this department may take offensive and/or defensive actions throughout the incident response effort. Circle this department's response activities from the statements below and skip to Sections (I) through (X) (beginning on Page 2).

1. Taking defensive action without actually trying to terminate the release or other cold zone support activities.
2. Terminating the release (e.g. plugging and patching, air monitoring, decontamination, etc.) or other warm or hot zone activities.
3. Both of the above [(B)(1) and (B)(2)].

A. Upon detection of a release, the following appropriate department(s) will be notified to respond to the HazMat incident:

RESPONDING DEPARTMENT	PHONE NUMBER
______________________________	____________
______________________________	____________
______________________________	____________
______________________________	____________

- SOP REFERENCE NUMBER: ______________________________ (attach)

____

____

____

____

____

- SOP REFERENCE NUMBER: ______________________________ (attach)

A description of this initial notification procedure is as follows:

B. All responding personnel from this department, who are likely to witness such a HazMat incident and would be responsible for notifying authorities, have been trained or have demonstrated competency at the Awareness Level in accordance with 29 CFR 1910.120. A listing of such personnel is available for review upon request.

C. Because this department is not responsible for taking action in an incident, but only notifies appropriate agencies of the incident and then leaves the scene, this department has no responsibility in the areas listed below during a HazMat incident:

1. Safe distances and places of refuge
2. Site security and control
3. PPE and emergency equipment
4. Emergency alerting and response procedures
5. Evacuation routes and procedures
6. Emergency medical treatment and first aid
7. Decontamination
8. Critique of response and follow-up

NOTE: DEPARTMENTS RESPONSIBLE ONLY FOR NOTIFYING AUTHORITIES—STOP HERE****

I. Pre-emergency planning and coordination with outside parties:

A. Upon detection of this release, ______________________________
(Name or Title)

of this department, will be notified to initiate appropriate response action.

B. The following devices will be used to initiate a HazMat response within this department:

1. Telephone contact/confirmation
2. Radio contact (list frequency/channels)
   a. ______________________ ______________________
   b. ______________________ ______________________
   c. ______________________ ______________________
3. Audible alarms
4. Other

- SOP REFERENCE NUMBER: ______________________ (attach)

C. A detailed description of this notification process, as it applies to responding employees within this department, is described below:

____

____

____

____

____

____

____

- SOP REFERENCE NUMBER: ______________________ (attach)

D. The following responding personnel within this department will also be notified:

NAME	TITLE	DAY/EVENING PHONE #

- SOP REFERENCE NUMBER: ______________________________ (attach)

E. The person initially notified, within this department of the release, will then notify

____

(Name or Title or Department)

who will in turn initiate response and notify appropriate authorities (e.g. local, county, State and/or Federal Agencies). The notification procedure to be utilized is outlined in section (I)(D) of the Coordinated Worker Protection ERP.

- **Not Applicable:** No employees from this department engage in the activity outlined above ((I)(E) of APPENDIX). (Circle if Applicable)

II. Personnel roles, lines of authority, training and communication:

Chain of Command:

A. In the event of a HazMat incident, the following responding personnel and alternates at this department are responsible for functions as indicated below (indicate N/A for functions not conducted by this department)

	PRIMARY NAME OR TITLE	ALTERNATE NAME OR TITLE
1. Incident Commander		
2. Safety Official		
3. Entry Teams		
4. Back-up/Rescue teams		
5. Support Personnel		
6. Other		

- SOP REFERENCE NUMBER: ______________________________ (attach)

B. The highest ranking responder of this department at the scene will secure the HazMat incident and direct the activities of each role until the Incident Commander arrives and relieves him. The Incident Commander or designee will use information provided by the Safety Official to ensure protection of all responding personnel throughout the HazMat incident. Following the arrival of the Incident Commander (indicated in this appendix), the highest ranking responder will ensure that the provisions of the Coordinated Worker Protection ERP are met for this department's employees.

Training:

A. All responding personnel have been trained or demonstrated competency appropriate to their level of activity in accordance with 29 CFR 1910.120. A listing of such personnel is available for review upon request.

B. All personnel described above will receive annual refresher training or demonstrate competency at their appropriate training level.

C. No responding personnel will engage in response activities beyond their respective level of training or equipment available.

D. All Hazardous Materials Technicians/Specialists are enrolled in an on-going medical monitoring program which includes baseline and annual examinations, examinations for responders who exhibit signs or symptoms which may have resulted from exposure and/or examinations upon termination of employment.

Communications:

A. The ____ is responsible for establishing
(Name or Title)
and maintaining communication procedures during the HazMat incident for this department.

B. Responding personnel within this department will follow communication procedures contained in Section (II) of the Coordinated Worker Protection Emergency Response Plan.

C. The following is a description of any additional communication procedures utilized by members of this department during a HazMat incident which are not contained in the Coordinated Worker Protection ERP:

***Not Applicable:** No additional communication procedures are utilized by members within this department. (Circle if Applicable)

____

____

____

- SOP REFERENCE NUMBER: _________________________________ (attach)

Emergency alerting and response procedures:

A. In the event of an emergency during the HazMat incident, responding personnel of this department will follow emergency alerting procedures contained in Section (II) (alerting) of the Coordinated Worker Protection Emergency Response Plan (ERP).

B. The following are additional alerting and response procedures used by this department which may be different than those contained in the Coordinated Worker Protection ERP. (Indicate N/A if no additional alerting and response procedures are used.)

____

____

____

____

- SOP REFERENCE NUMBER: _________________________________ (attach)

III. **Emergency recognition and prevention:**

A. The highest ranking official or his designee will assure that responding personnel from this department are notified of the identity, associated health hazards, physical and chemical properties, etc. of the released substances prior to each HazMat response. This will be accomplished using pre-entry briefings with all responding personnel using the appropriate references outlined in Section (III) in the Coordinated Worker Protection ERP.

IV. **Safe distances and places of refuge:**

A. Depending on the HazMat incident, should this department be the first to arrive at the scene, the highest ranking official or his designee will be responsible for establishing command centers, work zones, staging areas, safe distances and places of refuge for responding personnel. Responding personnel will be informed of these zones at the onset of each HazMat Incident.

B. These zones will be clearly marked utilizing methods described in Section (IV) of the Coordinated Worker Protection ERP and using the following resources available at this department. (Circle/list all that apply if different from those outlined on Section (IV)(C) of the Coordinated Worker Protection ERP):

1. Markers
2. Barricade tape
3. Flags
4. Signs
5. Maps
6. Other ______________________________
7. **Not Applicable:** No employee from this department engages in the activities outlined in Section (IV)(B) of this Appendix
   - SOP REFERENCE NUMBER: ______________________________ (attach)

V. **Site Security and control:**

A. Should this department be the first to arrive at the HazMat scene, the highest ranking official or his designee will be responsible for limiting and controlling the number of responding personnel (depending on training level, appropriate PPE and/or equipment) entering each zone (e.g. cold, warm and/or hot) using the following equipment which is available at this department. (Circle/list all that apply)

1. Use of barricade tape/fences
2. Other ______________________________
   - SOP REFERENCE NUMBER: ______________________________ (attach)

VI. **PPE and emergency equipment:**

A. The highest ranking official or his designee will be responsible for ensuring that responding personnel, from this department, are provided with (and use) PPE and respiratory protection as described in Section (VI) of the Coordinated Worker Protection ERP.

B. During each HazMat incident, the following PPE, respiratory protection and emergency equipment is available at this department for use:

TYPE OF EQUIPMENT	**EQUIPMENT LOCATION**
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

- SOP REFERENCE NUMBER: ______________________________ (attach)

VII. Evacuation routes and procedures for Responding Personnel:

A. If this department is the first to arrive at a HazMat incident, the highest ranking official or his designee will be responsible for establishing evacuation routes at the onset of the response for appropriate exiting of emergency responders (where applicable). Alternate routes, should normal existing routes become blocked, will also be established. Procedures, notifying responding personnel of such routes, will also be established.

VIII. Emergency medical treatment and first aid:

A. If this department is the first to arrive at a scene, first aid equipment and back-up personnel will be available prior to any entry into the hot zone. The following equipment is maintained by this department for this purpose.

____________________	____________________
____________________	____________________
____________________	____________________

IX. Decontamination

A. All department responders will be properly decontaminated upon exiting the hot zone as described in Section (IX) of the Coordinated Worker Protection ERP. The following disposal outer garments are available at this department and will be used, where feasible, to reduce contamination of chemical resistant clothing and increase the effectiveness of decontamination procedures: (Circle all that apply)

1. Disposable clothing
2. Disposable gloves
3. Disposable boot covers
4. Other ____

X. Critique of response and follow-up:

A. Follow each HazMat incident, ______________________________________
(Name or Title)
of this department, will assemble all responding personnel to review and critique all response activities that occurred. Documentation regarding critique and follow-up procedures will be maintained by ______________________________.
(Name or Title)

This Responding Department Appendix will be updated and modified regularly based on the following conditions:

1. New hazardous substances are produced or can be potentially encountered
2. Personnel roles, training levels and functions are changed
3. Outside party responsibilities are changed
4. Other ____

EMERGENCY OPERATIONS PLAN FORMAT

Every county and municipality in the State of New Jersey must complete and maintain an Emergency Operations Plan, which provides for coordinated preparedness, response, recovery, and mitigation to emergencies. It is the document dedicated to the protection of life and property **of the public** as well as the protection of the environment.

Every EOP is to have a “Basic Plan” and 15 “Functional Annexes.” The Hazardous Materials Annex is identical in format to all the other annexes, and covers the following areas:

- Introduction
- Authorities and References
- Purpose
- Situation
- Operations and Control
- Responsibilities
- Continuity of Government
- Administration and Logistics
- Annex Development and Maintenance
- Definitions
- Appendices (specific to each annex) For the HazMat Annex:
    1. Chemical Handling Facilities
    2. Facilities Location, Transportation, and Vulnerability Map
    3. Hazardous Materials Evacuation and Traffic Rerouting
    4. Hazardous Materials SOPs
    5. Hazardous Materials Resources
    6. Hazardous Materials Agreements
    7. Hazardous Materials Training
    8. Responding Department SOPs

EMERGENCY RESPONSE REFERENCE GUIDE for Chemical Handling Facilities

Every facility within a municipality that handles hazardous materials greater than the Threshold Planning Quantity on the USEPA Extremely Hazardous Substance list **must** provide emergency planning information to their Local Emergency Planning Committee (LEPC). In New Jersey, this information is referred to as the *"Emergency Response Reference Guide."* All of the Reference Guides supplied to a municipality are compiled, tabbed for quick reference, and identified as attachments to the municipal emergency operations plan.

As part of the municipal plan, this information serves as a planning aid for local responders. Under training standards established by OSHA 1910.120, responders are taught to identify the hazards that they may be exposed to **before** they enter a site. When they arrive at a facility during an incident, precious moments can be wasted while they try to locate a facility representative as well as what they are faced with (for example: what is stored in the tanks next to the location of a fire). With the advanced planning made possible by Reference Guides, responders can initiate an appropriate level of response at the **onset** of an incident.

In order to establish standardization from facility to facility, Reference Guides should be prepared in the following sequence:

1. **Title:** The standard block should read "Emergency Response Reference Guide for (Name of Facility)."
2. **Facility Location:** This should include the:
   A. Mailing address.
   B. Physical location (if different from mailing address).
3. **Emergency Contact Listings:** The minimum recommendation is for a primary (24 hour) and back-up telephone contact at the facility. If possible, list the titles and phone numbers for the plant manager, emergency coordinator, planning liaison, public information officer, emergency response contractor representative, and corporate headquarters representative. In some cases, a single person may perform one or more functions.
4. **Facility Concept of Operations:** This section should be broken up into three basic areas:
   A. A brief description of the facility's normal business operations. Basically, what kind of business is it?
   B. Describe how emergency operations are handled should an emergency occur. If there is no capability in this area, it should be stated that way. It is important for off-site responders to know of the limited or non-existent response capabilities of the facility.
   C. To aid responders in their pre-incident planning, a list of the emergency equipment available on-site or from outside contractors.
5. **Emergency Response Organization:** This section should describe the line of authority for the facility to insure that off-site emergency responders have access to the proper facility representatives. As part of the facility's incident command system, describe where and to whom responders should report when arriving on-scene. ICS is the standard organizational mode of the emergency response community. It is to every facility's advantage to adopt an incident management system to simplify the interaction of on-site and off-site emergency personnel. ICS provides a flexible command structure that provides for the smooth integration of units as they arrive on-scene, regardless of the size of the incident.
6. **Listing of Hazardous Materials:** Start by listing the chemicals identified in SARA Title-III that are normally found at the facility with their location, container type, and quantity. **THIS SHOULD NOT BE LIMITED TO ONLY TITLE-III CHEMICALS.** For example, if there are large fuel oil storage tanks on site, list them even though they are not regulated under SARA. Emergency responders are being trained under the rules specified by OSHA 1910.120 which tells them that if they don't know what chemicals are involved at a scene, they should assume that they are hazardous and avoid exposure. This will cause critical on-scene delays while responders look for someone who can identify the contents of what they are trained to perceive as a hazardous material container.

7. **Facility Maps:** Each map should be manageable in size, legible, and have a clear intent. The following information should be included:
    A. Site access (ingress and egress).
    B. Hazardous materials shipping routes (off-site).
    C. On-site storage and use locations for hazardous materials.
    D. Building locations, entrances, and uses.
    E. Site drainage, including storm and sanitary sewers.
    F. Locations of response equipment, emergency phone locations, and decontamination stations or areas.
    G. Location of a staging area for offsite response.
    H. Locations of first aid equipment.
    I. Utilities and their shutoff locations.
    J. Locations of water supplies (hydrants, etc.)
    K. Location of pipelines and storage tanks (underground and above ground).
    L. Potentially affected nearby populations, special facilities, and environmentally sensitive areas.
8. **Cross-Reference:** The information provided in this Reference Guide should be cross-referenced to any other emergency operations plan for the facility (such as a NJ TCPA Risk Management Plan). These references should provide specific citations to related and supporting material in the plan.

In addition, we recommend that all facilities and municipal notification points use a standardized form to report or record key information about hazardous material incidents. A sample initial contact message form is attached for your use. The form may be used as is or modified to suit specific needs, but we advise you not to shorten the form.

NOTE: Under New Jersey law, you **must** make (at least) the following notifications in the event of a release of any hazardous material:

1. The New Jersey Department of Environmental Protection's 24 hour Emergency Hotline at (609) 292-7172.
2. The designated local emergency warning points in your municipality. (Police and Fire Departments).

INITIAL CONTACT MESSAGE FORM

1. This is_______________________________________of _______________________________________
(name) (facility name)

at ____
(street address) (city)

2. Our emergency phone number is (________) ________-_________________

3. An incident occurred on ____________________________ at _______________
(date) (time)

4. The materials is/are ____ DOT # _______________

____ CAS # _______________

5. Amount:_______________________________________ ____ estimate ____ potential ____ actual

6. The material is a ____ gas ____ liquid ____ solid

7. The incident is ____ ongoing ____ terminated as of ______________________
(time)

8. The material ____ is/ ____ is not contained

9. Incident Description: ____ spill ____ air release ____ explosion ____ fire ____ other

10. There ____ are/ ____ are not injuries. Number: ______________________

11. The facility ____ has/ ____ has not been evacuated. Number: ______________________

12. The incident ____ is/ ____ is not affecting a waterway

Name of waterway:

13. Description of occurrence:

14. Potential health/environmental effects:

15. We recommend:

16. The NJDEP (609-292-7172) was notified as of ______________________

The ____ was notified as of___________
(local agency/agencies)

17. Other notifications/information: ____

____

____

SARA TITLE-III SECTION 302 LIST OF IDENTIFIED FACILITIES

MCODE	PHYSICAL LOCATION	FACILITY NAME	MAILING ADDRESS	ADDRESS (continued)	CITY & STATE	CONTACT PERSON	TELEPHONE	
PLAN	**	ATLANTIC						
0102	ATLANTIC CITY	ATLANTIC CITY MUA	1151 NORTH MAIN ST		PLEASANTVILLE NJ			
01012	ATLANTIC CITY	ATLANTIC CO UTILITIES AUTH	1701 ABSECON BLVD		ATLANTIC NJ			Y
0103	BRIGANTINE CITY	ATLANTIC CITY MUA	38TH STREET		BRIGANTINE NJ	BILL HILLER	(609) 348-5500	
0103	BRIGANTINE CITY	CITY OF BRIGANTINE		BRIGANTINE NJ				
0104	BUENA BORO	BUENA BORO MUN UTIL AUTH	SEWER PLANT		LANDISVILLE NJ	ANTHONY CASADIA		
0104	BUENA BORO	WASTE WATER TREATMENT PLANT	PLYMOUTH RD		LANDISVILLE NJ			
0105	BUENA VISTA TWP	WILMAD GLASS	RT 40 & OAK		BUENA NJ	DAVID ROMAN		Y
0108	EGG HARBOR TWP	DEPT OF TRANSPORTATION	FEDERAL AVIATION	TECHNICAL CENTER	A C AIRPORT NJ	E T HARRIS	(609) 484-5998	
0108	EGG HARBOR TWP	FED AVIATION ADMIN	TECHNICAL CENTER		ATLANTIC CITY NJ	ROBERT H WEINS	(609) 484-5787	
0108	EGG HARBOR TWP	JOMAR CORP	1230 WASHINGTON AVE		PLEASANTVILLE NJ	RICHARD MEGINLEY		
0108	EGG HARBOR TWP	LENOX CHINA TECHNICAL CENTER	65 FIRE RD	SUITES A-11 & B-10	ABSECON NJ	JOHN F. KINKELA	(609) 625-7540	
0108	EGG HARBOR TWP	RSL WOODWORKING PRODUCTS	1 FERNWOOD AVENUE	BOX 560	CARDIFF NJ	BERND LEWKOWITZ		
0108	EGG HARBOR TWP	SEAVIEW HARBOR	LONGPORT BLVD		EGG HARBOR NJ			
0110	FOLSOM BORO	C & E CANNERS INC	MAYS LANDING ROAD		FOLSOM NJ	JOE CAPPUCCION	(609) 561-6444	
0111	GALLOWAY TWP	LENOX CHINA	TILTON ROAD		POMONA NJ	JOSEPH SKLADANEK	(609) 645-3274	
0111	GALLOWAY TWP	NJ AMERICAN WATER CO	MOSS MILL RD		GALLOWAY NJ	LOUIS G. CAREY	(609) 927-6062	
0111	GALLOWAY TWP	STOCKTON STATE COLLEGE			GALLOWAY NJ			
0112	HAMILTON TWP	ATLANTIC NURSERY INC	COLOGNE AVE	RD 3-BOX 259A	MAYS LANDING NJ			
0112	HAMILTON TWP	HAMILTON TWP MUI			MAYS LANDING NJ			N
0112	HAMILTON TWP	SCHOLER BROS			MAYS LANDING NJ			Y
0113	HAMMONTON TOWN	HAMMONTON SEWER	12TH STREET		HAMMONTON NJ	DAN FRANCHETTI	(609) 561-4000	
0113	HAMMONTON TOWN	HAMMONTON TOWN WATER CO	PO BOX 105		HAMMONTON NJ	SUPERINTENDENT		
0113	HAMMONTON TOWN	HELENA CHEMICAL CO	200 N WHITE HORSE PK		HAMMONTON NJ	FRANCIS DONATO	(609) 697-1866	

MCODE	PHYSICAL LOCATION	FACILITY NAME	MAILING ADDRESS	ADDRESS (continued)	CITY & STATE	CONTACT PERSON	TELEPHONE	
0113	HAMMONTON TOWN	SPARTA SURGICAL	368 FAIRVIEW AVE	PO BOX 268	HAMMONTON NJ	JOSEPH BARBRIE	(609) 567-0712	
0113	HAMMONTON TOWN	WHITEHALL LABS	PO BOX 530	999 SOUTH GRAND ST	HAMMONTON NJ	WILLIAM E BROOKS	(609) 561-2200	
0115	LONGPORT BORO	CITY OF LONGPORT	31ST & DEVON AVES		LONGPORT NJ	GEORGE PORTSCHER	(609) 882-5759	
0119	PLEASANTVILLE CITY	ATLANTIC CITY MUA	1834 BALTIC AVENUE		ATLANTIC CITY NJ			Y
0119	PLEASANTVILLE CITY	PARIS PRODUCE	OLD TURNPIKE		PLEASANTVILLE NJ			Y
0122	VENTNOR CITY	WATER & SEWER UTILITY	6201 ATLANTIC AVE		VENTNOR NJ	THOMAS KLEIN	(609) 823-7937	Y
0123	WEYMOUTH TWP	OAKS & WEYMOUTH	11TH AVE		WEYMOUTH NJ			N

T.C.P.A.—FACILITIES, CHEMICALS AND QUANTITIES

ID #	FACILITY NAME	CHEMICAL NAME	AMOUNT ON SITE	REPORTABLE QUANTITY
5024	ADCO CHEMICAL COMPANY	TOLUENE-2,4-DIISOCYANATE	6000	100
5029	AIRCO SPECIAL GASES	DICHLOROSILANE	<2000	2000
5186	AKZO NOBEL CHEMICALS INC.	CHLORINE	500	500
5186	AKZO NOBEL CHEMICALS INC.	HYDROGEN CHLORIDE	4000	2000
5186	AKZO NOBEL CHEMICALS INC.	TITANIUM TETRACHLORIDE	850000	600
5047	ALLIED UNIVERSAL CORPORATION	CHLORINE	275000	500
5033	ALLIED-SIGNAL CORPORATION	TRIFLUOROCHLOROETHYLENE	107200	7300
5036	AMERADA HESS (PORT READING) CORPORATION	HYDROGEN SULFIDE	1117	500
5317	AMERCHOL CORPORATION	EPOXYPROPANE	107500	7700
5317	AMERCHOL CORPORATION	ETHYLENE OXIDE	171000	2700
5038	AMERICAN CYANAMID COMPANY	CHLORINE	8500	500
5048	ARDMORE,INC.	ALLYL CHLORIDE	<2000	2000
5173	AUSIMONT USA, INC.	CHLORINE	220000	500
5173	AUSIMONT USA, INC.	HYDROCHLORIC ACID	2640100	5600
5173	AUSIMONT USA, INC.	HYDROGEN CHLORIDE	6110	2000
5173	AUSIMONT USA, INC.	HYDROGEN FLUORIDE	1346300	500
5312	BASF CORPORATION	EPOXYPROPANE	2500000	7700
5312	BASF CORPORATION	ETHYLENE OXIDE	3000000	2700
5099	BAYWAY REFINING CO.	CHLORINE	114000	500
5099	BAYWAY REFINING CO.	HYDROGEN SULFIDE	69400	500
102	BERGEN COUNTY UTILITIES AUTHORITY	CHLORINE	100000	500
5379	BFGOODRICH COMPANY, THE–SPEC. POLY. &. CHEM. DIV	ACRYLONITRILE	361586	2300
306	BORDENTOWN SEWERAGE AUTHORITY–BLACKS CREEK WWTP	CHLORINE	2500	500
1405	BRICK TOWNSHIP MUA	CHLORINE	12100	500
307	CAMDEN CITY, DEPT. OF UTILITIES,MORRIS-DELAIR WTP	CHLORINE	24000	500
419	CAPE MAY COUNTY MUNICIPAL UTILITIES AUTHORITY	CHLORINE	40000	500
5071	CIBA-GEIGY CORPORATION	BROMINE	3600	100
5071	CIBA-GEIGY CORPORATION	PHOSPHORYL CHLORIDE	15400	800
5071	CIBA-GEIGY CORPORATION	THIONYL CHLORIDE	3600	250
5073	COASTAL EAGLE POINT OIL COMPANY	CHLORINE	34450	500

ID #	FACILITY NAME	CHEMICAL NAME	AMOUNT ON SITE	REPORTABLE QUANTITY
5073	COASTAL EAGLE POINT OIL COMPANY	HYDROGEN SULFIDE	2350	500
5310	COGEN TECHNOLOGIES-NJ VENTURE	AMMONIA	64000	5200
5377	COOKSON PIGMENTS, INC.	METHYL CHLORIDE	37500	12000
5318	CPS CHEMICAL COMPANY, INC.	METHYL CHLORIDE	220000	12000
5008	CREST FOAM INDUSTRIES INC.	TOLUENE-2,4-DIISOCYANATE	110000	100
5300	CYTEC INDUSTRIES INC.	ACRYLONITRILE	120600	2300
5085	DUPONT DE NEMOURS, E.I., & COMPANY, INC.	ACRYLONITRILE	50400	2300
5087	DUPONT DE NEMOURS, E.I., & COMPANY, INC.	AMMONIA	37015098	5200
5086	DUPONT DE NEMOURS, E.I., & COMPANY, INC.	AMMONIA	109812	5200
5086	DUPONT DE NEMOURS, E.I., & COMPANY, INC.	BROMINE	8375	100
5086	DUPONT DE NEMOURS, E.I., & COMPANY, INC.	CHLORINE	3292573	500
5086	DUPONT DE NEMOURS, E.I., & COMPANY, INC.	ETHYLINE OXIDE	300000	2700
5086	DUPONT DE NEMOURS, E.I., & COMPANY, INC.	HEXAFLUOROACETONE	11514	3300
5086	DUPONT DE NEMOURS, E.I., & COMPANY, INC.	HYDROCHLORIC ACID	37500	5600
5086	DUPONT DE NEMOURS, E.I., & COMPANY, INC.	HYDROFLUORIC ACID	58500	700
5086	DUPONT DE NEMOURS, E.I., & COMPANY, INC.	HYDROGEN CHLORIDE	1139978	2000

T.C.P.A. FACILITIES BY COUNTY AND MUNICIPALITY

MUNICIPALITY	ID# FACILITY NAME	PLANT NAME	PHYSICAL ADDRESS	PHONE #
● BERGEN				
CARLSTADT BOROUGH	5010 GANES CHEMICALS, INC.	GANES CHEMICALS, INC.	611 BROAD STREET	(201) 507-430
CARLSTADT BOROUGH	5307 MANHATTAN PRODUCTS, INC.	MANHATTAN PRODUCTS, INC.	333 STARKE ROAD	(201) 933-3500
EAST RUTHERFORD BOROUGH	5015 MATHESON GAS PRODUCTS, INC.	MATHESON GAS PRODUCTS, INC.	932 PATERSON PLANK ROAD	(201) 933-2400
EAST RUTHERFORD BOROUGH	5019 PMC, INC.	GENERAL FOAM DIVISION	13 MANOR ROAD	(201) 933-8540
FAIR LAWN BOROUGH	5009 FISHER SCIENTIFIC COMPANY	CHEMICAL MANUFACTURING DIVISION	ONE REAGENT LANE	(201) 796-7100
HAWORTH BOROUGH	106 HACKENSACK WATER COMPANY	HAWORTH WATER TREATMENT PLAN	200 LAKE SHORE DRIVE	(201) 599-6011
LITTLE FERRY BOROUGH	102 BERGEN COUNTY UTILITIES AUTHORITY	BERGEN COUNTY UTILITIES AUTHORITY	FOOT OF MEHRHOF ROAD	(201) 641-2552
LYNDHURST TOWNSHIP	5012 POLYURETHANE SPECIALTIES COMPANY, INC.	POLYURETHANE SPECIALTIES COMPANY, INC.	624 SCHUYLER AVENUE	(201) 438-2325
LYNDHURST TOWNSHIP	5017 SIKA CORPORATION	SIKA CORPORATION	875 VALLEY BROOK AVENUE	(201) 933-8800
MOONACHIE BOROUGH	5008 CREST FOAM INDUSTRIES INC.	CREST FOAM INDUSTRIES INC.	100 CAROL PLACE	(201) 807-0809
RIDGEFIELD BOROUGH	5014 PFISTER CHEMICAL, INC.	PFISTER CHEMICAL, INC.	FOOT OF LINDEN AVENUE	(201) 945-5400
WALLINGTON BOROUGH	5366 FARMLAND DAIRIES	FARMLAND DAIRIES	520 MAIN AVENUE	(201) 777-2500
● BURLINGTON				
BORDENTOWN CITY	306 BORDENTOWN SEWERAGE AUTHORITY	BORDENTOWN SEWERAGE AUTHORITY—BLACK'S CREEK WWTP	954 FARNSWORTH AVE.	(609) 291-9105
BORDENTOWN CITY	5293 OCEAN SPRAY CRANBERRIES, INC.	OCEAN SPRAY CRANBERRIES, INC.	104 EAST PARK STREET	(609) 298-0905
CINNAMINSON TOWNSHIP	5029 AIRCO SPECIAL GASES	AIRCO RIVERTON PLANT	UNION LANDING AND RIVER ROADS	(609) 829-7878
DELRAN TOWNSHIP	4000 NEW JERSEY-AMERICAN WATER COMPANY, INC.	TRI-COUNTY WATER TREATMENT PLANT	213 CARRIAGE LANE	(609) 547-1700

MUNICIPALITY	ID# FACILITY NAME	PLANT NAME	PHYSICAL ADDRESS	PHONE #
FIELDSBORO BOROUGH	5187 STEPAN COMPANY	STEPAN COMPANY—INDUSTRIAL CHEMICAL DIV.	FOURTH STREET	(609) 298-1222
NEW HANOVER TOWNSHIP	225 U.S. ARMY FORT DIX & TRAINING CENTER	US ARMY FORT DIX & TRAINING CENTER	DEH ENVIRONMENTAL/NR PLANT	(609) 562-3050
NEW HANOVER TOWNSHIP	225 U.S. ARMY FORT DIX & TRAINING CENTER	US ARMY FORT DIX & TRAINING CENTER	DEH ENVIRONMENTAL/NR PLANT	(609) 562-3050
NEW HANOVER TOWNSHIP	225 U.S. ARMY FORT DIX & TRAINING CENTER	US ARMY FORT DIX & TRAINING CENTER	DEH ENVIRONMENTAL/NR PLANT	(609) 562-3050
NEW HANOVER TOWNSHIP	225 U.S. ARMY FORT DIX & TRAINING CENTER	US ARMY FORT DIX & TRAINING CENTER	DEH ENVIRONMENTAL/NR PLANT	(609) 562-3050
NEW HANOVER TOWNSHIP	226 U.S. GOVERNMENT—MCGUIRE AIR FORCE BASE	MCGUIRE AFB	WRIGHTSTOWN-COOKSTOWN ROAD	(609) 724-2770
PEMBERTON TOWNSHIP	5208 SYBRON CORPORATION	SYBRON CHEMICALS INC.	BIRMINGHAM ROAD	(609) 893-1100
● CAMDEN				
WATERFORD TOWNSHIP	362 WATERFORD TOWNSHIP MUNICIPAL UTILITIES AUTHORITY	WATERFORD SEWER TREATMENT	BURNT MILL ROAD	(609) 768-2330
CAMDEN CITY	5348 STATE METAL INDUSTRIES, INC.	STATE METAL INDUSTRIES, INC.	941 SOUTH SECOND STREET	(609) 964-1510
PENNSAUKEN TOWNSHIP	307 CAMDEN CITY DEPARTMENT OF UTILITIES	MORRIS-DELAIR WATER TREATMENT PLANT	8900 ZIMMERMAN AVE.	(609) 757-7251
PENNSAUKEN TOWNSHIP	5170 OSBORN, C.J., DIVISION OF SUVAR CORPORATION	C.J. OSBORN CHEMICALS	820 SHERMAN AVENUE	(609) 662-0128
WINSLOW TOWNSHIP	301 NJ—ANCORA PSYCHIATRIC HOSPITAL	ANCORA PSYCHIATRIC HOSPITAL	202 SPRING GARDEN ROAD	(609) 561-1700

1994 HAZARDOUS MATERIALS INCIDENT DATABASE

LOCAL NAME OR MUNICIPALITY	DATE	LOCATION	SUBSTANCE(S)	STATUS OF THE RELEASE	STATE OF MATERIAL	INJ	PUB EXP	FAC EVAC	PUB EVAC	P.D. RESP	F.D. RESP
ATLANTIC COUNTY											
ABSECON	04/11/94	IN FRONT OF	NATURAL GAS	Continuous	Gas	N	N	N	N	N	Y
SUSPECTED AIR RELEASE. GAS COMP ENROUTE TO INVEST AND DO REPAIRS IF NEEDED.											
ABSECON	11/15/94	FISCA SERVICE STATION	GASOLINE	Continuous	Liquid	N	N	N	N	Y	Y
BULK TANKER LEADING PRODUCT. 3300 GAL POTENTIAL. FIRE DEPT ATTEMPTING TO CONTAIN. SPILL IS NEAR MARSH AREA. MIT IS SENDING CREW FOR CLEAN UP.											
ABSECON	09/22/94	MIKES AUTO REPAIR	GASOLINE	Terminated	Liquid	N	N	N	N	N	N
2-4,000 & 3-2,000 GAL USTS REMOVED SOIL CONTAMINATION DISCOVERED. CLEAN UP IS IN PROGRESS.											
ABSECON	03/21/94	VACANT CAR DEALERSHIP	SOIL CONTAMINATED	Terminated	Solid	N	N	N	N	N	N
SOIL SAMPLES TAKEN IN AREA OF WASTE OIL TANK SHOWED HIGH LEVELS OF HYDRO CARBONS, TANK IS THOUGH TO HAVE LEAKED.											
ABSECON	08/05/94	VIC GOODYEAR/AL TIRES	OIL MOTOR	Terminated	Liquid	N	N	N	N	N	N
SPILL DUE TO HOSE BREAKING CAUSING SPILL. CLEAN UP DONE BY DEMAIO'S INCORP.											
ABSECON	08/19/94	MAIN IN ROADWAY	NATURAL GAS	Continuous	Gas	N	Y	N	N	Y	Y
CONTRACTOR HIT MAIN IN STREET, CREW ENROUTE.											
ABSECON	08/23/94	CITGO GAS STATION	GASOLINE	Terminated	Liquid	N	Y	N	N	N	N
WHILE GETTING DELIVERY AT STATION, CALLER STATED OVERFLOW OF GASOLINE WHEN INTO STORM DRAIN. ALSO STRONG ODOR OF GASOLINE. NO CLEAN UP SCHEDULED.											
ABSECON	03/28/94	IN FRONT OF SHORE POINT POOLS	ANTIFREEZE	Terminated	Liquid	N	N	N	N	Y	Y
SPILL DUE TO MVA. CLEANUP BY FD.											
ABSECON	03/28/94	GAS LINE IN ROADWAY	NATURAL GAS	Continuous	Gas	N	Y	N	N	N	Y
CONTRACTOR HIT GAS LINE IN ROADWAY, CREW ON SCENE.											
ABSECON	08/20/94	INTERSECTION OF DELILAH RD	OIL HYDRAULIC	Continuous	Liquid	N	N	N	N	Y	N
CRANE HIT OVERPASS CAUSING SPILL. CLEANUP BEING DONE BY CONDUIT CONSTRUCTION.											

LOCAL NAME OR MUNICIPALITY	DATE	LOCATION	SUBSTANCE(S)	STATUS OF THE RELEASE	STATE OF MATERIAL	INJ	PUB EXP	FAC EVAC	PUB EVAC	P.D. RESP	F.D. RESP
ABSECON HIGHLANDS	08/23/94	IN FRONT OF	OIL TRANSFORMER NON-PCB	Terminated	Liquid	N	N	N	N	N	N
SPILL DUE TO LEAK FROM TRANSFORMER. CLEAN UP BEING DONE.											
ABSECON HIGHLANDS	06/05/94	CAPRICE MOTEL/SERVICE	NATURAL GAS	Continuous	Gas	N	Y	N	N	Y	N
CAR HIT GAS SERVICE AT MOTEL, CREW ENROUTE.											
ABSECON HIGHLANDS	10/06/94	IN FRONT OF	NATURAL GAS	Continuous	Gas	N	N	N	N	Y	N
CONTRACTOR HIT AND BROKE 2 INCH GAS MAIN. SOUTH JERSEY ON SCENE.											
ATLANTIC CITY	02/19/94	FARLEY STATE MARINA	DIESEL FUEL	Terminated	Liquid	N	N	N	N	N	N
OVERFLOW FROM TANK TO WATER. NO CLEANUP.											
ATLANTIC CITY	03/14/94	FARLEY STATE MARINA	DIESEL FUEL	Terminated	Liquid	N	N	N	N	N	N
SPILL FROM BOAT TO WATER. OWNER DID CLEANUP.											
ATLANTIC CITY	08/30/94	GARDNERS BASIN	OIL SHEEN		Liquid	N	Y	N	N	N	N
SHEEN ON WATER.											
ATLANTIC CITY	08/12/94	RESIDENCE	OIL MOTOR	Terminated	Liquid	N	Y	N	N	N	N
RESIDENT DUMPED MATERIAL INTO STORM DRAIN.											
ATLANTIC CITY	10/03/94	VACANT LOT	SOIL CONTAMINATED	Terminated	Solid	N	N	N	N	N	N
SOIL CONTAMINATION FOUND FROM SOIL SAMPLES CONDUCTED ON ABOVE DATE.											

MODULE 8
CONFINEMENT AND CONTAINMENT

Outline

Introduction

Physical States of Hazardous Materials

Container Description

Air Releases

Land Spills

Water Discharges

Groundwater Contaminants

Methods of Mitigation

Equipment and Techniques

MODULE 8
CONFINEMENT AND CONTAINMENT

Objectives

The student will be able to:

1. List 3 methods/techniques for control/confinement of air releases.
2. List 3 methods/techniques for control/confinement of land releases.
3. List 4 methods/techniques for control/confinement of discharges into water.
4. List 3 physical methods used in the mitigation of hazardous materials.
5. Demonstrate use of compressed gas capping devices given 1 ton & 100/150 lb. cylinders.
6. List 3 chemical methods used in the mitigation of hazardous materials.
7. Demonstrate an acceptable method to use an overpack drum given a damaged 55-gallon drum.
8. Demonstrate controlling and/or stopping leaks using tools and equipment available given a leaking drum.
9. Identify two safety devices given a DOT 406 tank truck.
10. Demonstrate the method of applying dome clamp given a DOT 406.
11. Demonstrate 2 methods of diking or berming to contain the liquid given an ongoing spill.

CONFINEMENT AND CONTAINMENT

No two spill related emergencies are the same. Spills can occur at Fixed Facilities, either during the processing of the material or during the loading/off loading of the material. Spills also occur in the field setting, during the transportation of Hazardous Materials.

NFPA document 471, Recommended Practice for Responding to Hazardous Materials Incidents, defines confinement as those procedures taken to keep a material in a defined or local area and containment as those procedures taken to keep a material in its container.

In order to assess the best method for confinement and containment, you must understand the material that has spilled. A minimum assessment of the material should include: identification of the spilled material involved, the physical properties of the spilled material, the current and forecasted weather, the local geography. This will allow you to answer the following questions:

1. What is the nature of the materials involved?
2. Where will the materials go now that they have been released?
3. What can be done to reduce the hazards associated with the spilled materials?

PHYSICAL STATES OF HAZARDOUS MATERIALS

Hazardous materials may be classified into three states, namely gases, liquids and solids. They can be stored or contained at a high or low pressure. All three states may be affected by the environment in which the incident occurs. The emergency responder must take into account conditions such as heat, cold, rain or wind, which can have a significant effect on the methods used to accomplish a safe operation.

During emergency releases in the field setting, environmental damage can occur before confinement or containment procedures can begin. As you begin to develop a plan, keep in mind the following questions:

1. The volume of hazardous materials released to the environment and the rate of leak, if still in progress.
2. What dangers exist to personnel involved in the area?
3. The nature of the damage to the vessel and what repairs might be attempted.
4. Is it possible to transfer the material to an alternate container?
5. Should some form of dike be constructed around the spill area?
6. The exact nature of the spill area and how the material has spread over the area.
7. Whether the material has or can reach a waterway or sewer?
8. Is there a danger of fire or explosion?
9. What effect will rain and wind have on the spilled materials?
10. What equipment and supplies will be necessary to confine the substance?

Containers used to store or transport Hazardous Materials come in many shapes and sizes, including but not restricted to paper sacks or bags used for many dry products, glass or plastic bottles, or even wood crates. Drums which may be constructed of cardboard, plastic, fiberglass and steel. Cylinders 1 pound to 1 ton tank trucks/trailers, rail cars, ships and planes.

Radioactive materials may be transported in boxes constructed of cardboard, fiberboard or wood. It may also be carried in steel drums to special rail cars designed to transport large quantities of radioactive materials.

Hazardous materials may be stored in any of the above mentioned containers. These containers may then be stored in warehouses, courtyards, open fields or even abandoned buildings.

The shapes of many containers can give some indication of the type of materials stored inside of that particular container.

Tank trucks/trailers can also give some indication of the type of material that is being transported.

1. DOT 406: May carry any of the following materials: Flammable or combustible liquids: gasoline, fuel oil or alcohol. Poisons (class B) and food products may also be carried.
2. DOT 407: Flammable or combustible liquids most chemicals
3. DOT 412: Corrosives
4. MC 331: High pressure LP gases or Anhydrous Ammonia
5. MC 338: Cryogenic liquids
6. Compressed Gas trailer compressed gases: oxygen, nitrogen, etc.

The four basic types of releases are:

A. Air releases.
B. Land spills.
C. Water discharges.
D. Groundwater contamination.

A. AIR RELEASES

If the material released has a specific gravity <1 (lighter than air), the only effective containment is to plug the leak and/or evacuate the area. This is dependent on the size of the vapor cloud created. Restriction of the air space over the incident should also be considered.

If the material released has a specific gravity >1 (heavier than air), this material will tend to hug the ground at the level of release or lower. In this case, the only effective containment is to evacuate the area downwind and downhill of the material where it can find an ignition source, and flashback directly to the source of the leak. With some materials the use of fog patterns to disperse the vapor cloud has worked. Refer to your reference material for additional material before trying this technique.

B. LAND SPILLS

This would include the escaping of a material from a container and leaking onto the ground. Also included in this would be contamination from by-products or combustion. An example would be a fire at a chemical warehouse where the temperature did not reach 1800 degrees Fahrenheit, hot enough to destroy the chemicals stored in the warehouse. The easiest method for confinement of a land spill is an earthen dike. The basic dike is constructed with dirt. The materials, manpower to construct this type of dike are usually available and inexpensive.

However, over time both vertical and horizontal seepage through and around the dike will occur. This process can be slowed by the use of “visqueen” or “poly” plastics, (a form of Polyethylene). The Polyethylene is used as a base in the construction of a dike or a drainage ditch.

A good alternative is to transfer the product remaining in the vessel to another container. It still may be necessary to dike around the original spill, while you wait for the second container to arrive.

C. WATER DISCHARGES

This form of contamination has been researched longest and because of that, there are more ways to contain spills in, on and under the water (if the spilled material has a specific gravity >1 is insoluble or slightly soluble in water). The best method for confinement is an overflow dam. Additional staging of material and manpower downstream will need to occur. This is in case the first dam breaks and allows the release of the contaminates down stream. This system works best on slow moving waterways. Also, you could evacuate a depression in the waterway and allow the spilled material to collect there. However, the faster the waterway, the less likely for this method to work.

If the spilled material has a specific gravity <1, is insoluble or slightly soluble in water the best method of confinement is a floating boom. There are several different types of booms on the market. Also, there are sorbent booms on the market. These booms instead of confining the spill, absorb the spill. Neither product works well in rough water or fast currents. Another option is the use of underflow dam or siphon dam. An underflow dam is a dike constructed with a pipe placed in the dike. The pipe is placed lower on the upstream side and higher on the downstream side. This allows for the following of the waterway through the piping and traps the contaminants on the upstream side. As with the overflow dam, it will be necessary to have additional manpower and supplies downstream in case of a break in the dam. Chicken wire fencing and hay can be used to create a fixed barrier. This method is generally limited to smaller waterways and creates special problems in disposal

If the material spill has specific gravity =1, is soluble or insoluble in water. There is very little that the first responder can do. If the waterway is small, you can dam the waterway and recover or filter the water. The other option is to neutralize the chemical, rendering the chemical inert. This will require the resources of the EPA, State DNR for technical assistance before it is attempted.

D. GROUNDWATER CONTAMINATION

Groundwater contamination is not normally handled by First Responders. The best thing that can be done is to make sure that no other hazards exist. Groundwater contamination plumes move slowly and allow for more technical resources to be used to handle the problem.

Remember that almost all chemicals are subject to change, such as water, from ICE to WATER to WATER VAPORS. Based on the information, you will need to assess the hazards associated, then establish an appropriate confinement plan.

METHODS OF MITIGATION

There are two basic methods for mitigation of hazardous materials incidents, physical and chemical. Recommended practices should be implemented only by personnel appropriately prepared by training, education or experience.

Physical Methods—involve any of several processes or procedures to reduce the area of the spill, leak or other release mechanism. In all cases, methods used should be acceptable to the Incident Commander. The selection of the personal protective clothing should be based on the hazardous materials and/or conditions present and appropriate for the hazards encountered.

OFFENSIVE TACTICS

When trained, experienced and well equipped personnel are available, the incident commander has numerous tactical options which may be implemented independently or in conjunction with defensive techniques remote from the incident. Situations well suited for aggressive offensive operations are:

1. The hazmat is in gaseous form and will migrate away from the leaking container. Migrating toxic vapor clouds warrant quick and responsible action by the I.C.
2. The spilled material is in solid, powder form and weather conditions or other tactics threaten to carry the hazmat off the work site.
3. Defensive tactical options have been exercised to the fullest extent and have failed their objective.

Offensive techniques require placing personnel at greater risk since they call for operating in close proximity to the container and its contents. Never place personnel in an offensive mode until the condition of the container and the hazard and risks have been evaluated.

Successful offensive operations are preceded by thorough recon. This may be as simple as having a trusted individual relaying basic observations about a confirmed, known material like motor oil to the IC or as complex as having a complete entry team survey and document the work site before sending in a repair crew.

No emergency situation justifies taking unreasonable risks. Rapid withdrawal from the hot zone is in the incident commander's offensive bag of tricks and should always remain open as an option.

Leak control tactics are simple. Plug the hole and you don't have a problem anymore. When leak control plans are being made, don't overlook obvious options like:

- Stop the leak by placing the hole above the liquid or solid level. Even gases stored in a liquefied state can be significantly controlled by placing the liquid level below the opening. Simply standing up a drum may do the job.
- Use the designed openings to stop the leak. Valves can be closed, caps tightened, and lids replaced.

Situations that cannot be controlled by simple common sense techniques, like closing the valve, can usually be handled by one of the following techniques:

1. Plug or patch the opening so that the leak is controlled at the source.
2. Limit the magnitude of the problem by lowering the pressure in the container.
3. Limit the spread of the contaminant by vapor suppression agents such as foam.
4. Neutralize the hazmat using another chemical.

1. **Absorbtion—**the process whereby a material with a very large internal surface area is applied to a liquid spill to absorb the liquid. Some of the materials typically used as absorbents are sand, clay, charcoal, and polyolefin-type fibers. These materials can be used for confinement. Absorbents are used on relatively small spills of up to a few hundred gallons. When absorbents become contaminated, they are considered to be a hazardous material and must be treated and disposed of accordingly.
2. **Dilution—**refers to the application of water to water miscible hazardous materials. The goal is to reduce the hazard to a safe level.
3. **Dikes, Dams, Diversions, and Dispersion—**refer to the use of physical barriers to prevent or reduce the quantity of liquid flowing into the environment. Dikes or dams usually refer to concrete, earth and other barriers temporarily or permanently constructed to hold back the spill or leak. Diversion refers to the methods used to physically change the direction or flow of the liquid. Vapors from certain materials, such as liquefied petroleum gas (LPG), can be dispersed using a water spray.

DIVERSION TECHNIQUES

A flowing land-based spill can be quickly diverted to another location by placing a barrier (normally dirt) in advance of the spill. To be successful, the barrier must be built well in advance of the spill. Like working a running brush fire, you have to work well in advance of the problem and be prepared to sacrifice some territory to save the prime real estate.

Constructing a diversion barrier requires teamwork. A typical four-man crew can build a twenty-yard diversion wall eight inches high in ten minutes.

DIKING TECHNIQUES

Dikes are effective if they can be constructed quickly and contain 90% of the hazmat at the desired location. They can be constructed from practically any available materials. Several readily available items are: dirt, tree limbs, boards, roof ladders, pike poles and plastic tarps or salvage covers. When the situation is serious, bagged materials such a tree bark, sand, kitty litter, etc. can be commandeered and used to construct sturdy barriers. These items are normally stored outside of hardware and garden variety stores.

Construction of dikes by hand will usually be done by first responders using brute force. The decision to build a contaminant dike should be based on a quick size up of resources vs. the quantity of material on the ground. A common error made on size-up is to underestimate the number of people required to build a dike and overestimate the amount of spilled products.

Slow moving or heaving materials should be confined by building a circle dike. Faster moving products can be confined by constructing a "V" shaped dike in a low area.

All dike construction should begin with large materials for reinforcement, followed by an outer layer of lighter material such as dirt. Plastic or salvage covers are then placed over the dike and a final seam of dirt is placed along the leading edge of the dike between the plastic and the ground.

There are several limiting factors to dike construction. First, and most obvious, is the fact that dikes are ineffective when the hazmat is in a gaseous state. Liquids and, to a certain extent, solids can be diked if the materials are available and crews are properly trained and equipped. Limiting factors include:

1. The surrounding area is concrete or asphalt and there is no easily accessible soil. This area may have to be sacrificed or materials will have to be trucked in.
2. The ground may be frozen solid. If snow is available it may be used as a partial barrier in conjunction with other materials like ladders and plastic. Otherwise, materials like sand may have to be trucked in.
3. Essential equipment is unavailable. At least three pointed shovels will be required to construct a good dike. While it is preferable to construct dikes in upwind and safe areas, there may be times when breathing apparatus is required and must be dedicated to the task.

RETENTION TECHNIQUES

In some cases, retention techniques can be implemented independently of diversion or diking to achieve the same results or act as a backup. Consider, for example, a leaking railroad tank car in a switching yard. The material is unknown and is leaking away from the car into a culvert which empties into a storm system. If sufficient resources are unavailable to construct a dike closer to the car, the hazmat can be contained at the drain like this:

1. Place salvage covers or plastic over the storm drain. Weigh the cover down with something heavy.
2. Shovel dirt onto the cover, burying the storm drain.
3. If a curb is adjacent to the storm drain, lay a ladder across and drape a salvage cover over the top.

If the hazmat is primarily liquid or slurry, has a specific gravity less than water, and is not water-reactive, it may be possible to flood the retention area with water from the engine or nearby hydrant. The hazmat will then float. Any leakage into the storm system should be water.

When bulk quantities of hazardous materials are leaking the situation may warrant bringing in heavy equipment to construct large retention pits. Other options such as portable chemical tanks, drafting basins and swimming pools can be made available through hazmat cleanup crews and contractors.

4. **Overpacking**—the most common form of overpacking is accomplished by the use of an oversized container. Overpack containers should be compatible with the hazards of the material involved. If the material is to be shipped, DOT specification overpack containers must be used.

   NOTE: Use nonspark generating overpack material when dealing with flammable material.
5. **Plug & Patch**—plugging and patching refers to the use of compatible plugs and patches to reduce or temporarily stop the flow of materials from small holes, rips, tears, or gashes in containers. The repaired container may not be reused without proper inspection and certification.

PLUGGING AND PATCHING

Simple homemade or hardware store-bought equipment can effectively control the majority of all hazmat container leaks. For example, a small hole in a tank truck can sometimes be plugged by driving in a wooden wedge with a hammer.

While plugs and patches can be fabricated on the scene, time can be saved by manufacturing a variety of different devices and maintaining a supply on response vehicles.

Plugging techniques are usually used in conjunction with synthetic rubber gaskets or putty to ensure a good seal by filling in the cracks around the plug. In some cases, small holes less than one inch in diameter which are not under pressure can be filled with putty or epoxy resin compounds. While these can be effective and may hold for some time, they have limitations due to material compatibility, the size of the hole being filled and head pressure behind the putty. Using putty or other compounds should be reviewed as temporary first aid.

When the container has a large gash or hole in its side it can sometimes be patched using sheet metal or an air bag. When the hazmat has leaked below the level of the opening before the arrival of first responders, patching can reduce vaporization and minimize the spread of contaminants. Patching may also be necessary if the container must be moved for access to off loading points such as valves.

Before using patching techniques, some thought should be given to the following points:

1. Estimate the approximate opening size then select a patch or device half a size larger. Devices which are too small can be drawn inside the container when tightened down.
2. Select a device that is compatible with the hazmat. Although size up is often difficult, there are several response guide books with good compatibility data in them.
3. Plan the operation with self contained breathing apparatus operating times in mind. Several trips may be required for the entry team to complete the job.
4. Organize the job and brief personnel on the tools required. The more complicated the job, the more extensive the briefing. It’s easy to forget basic tools when you’re under pressure. Forgetting the wrench you need for a simple job can add one hour to the on-scene time if the entry team has to exit the hot zone and decontaminate before reentering with the right tool.

PRESSURE REDUCTION

There are many hazardous materials containers designed to store their contents under pressure. Common examples include cylinders, process vessels, certain tank trucks and rail cars and pipelines. In addition to these, non-pressurized containers can become abnormally pressurized due to internal chemical reactions or external fires.

Regardless of the type of pressure source, containers under pressure are dangerous because:

1. Containers can rupture under stress and travel great distances whole or in fragments. This happens fast and there is no reaction time.
2. Pressure is a silent killer and is often hard to gauge. High pressure can propel valve caps, cut through protective clothing or blow off face pieces. Ultra high pressures ranging from 5,000 to 15,000 psi can penetrate the skin and cause a fatal embolism.
3. Some pressurized containers store hazmats at temperatures below minus 200 degrees F. These cryogenics can freeze tissue and damage protective clothing.

The sources of many pressure leaks are valves designed for filling and discharging product. Unless the valve has been damaged, it can be closed by turning it to the closed position. This is typically clockwise; however, there may be exceptions. If the container is in service, the source of the leak may be the associated piping or tubing. If the leak continues after closing the valve, the connected tubing can be tightened down until the leak stops.

Some pressurized vessels are charged by an outside independent source such as a pumping system The magnitude of the leak can be significantly reduced if the pump pressure is lowered or shut down entirely. Experts familiar with the system should be consulted before beginning shutdown, since an action taken by responders can trigger overpressurization in other vessels tied into the system. In some cases, the lack of pressure produces unstable chemical situations.

When dealing with larger, more complex vessels, product specialists and engineers may need to be consulted to ensure that solving one problem does not create others. A common mistake made when dealing with pressure systems is to shut down general power supplies to a facility. While this action may turn off a pump which is providing pressure to the leaking vessel, it may also ruin chemical batch processing equipment, cause dangerous pressure buildups in other locations and shut off critical safety devices.

Some containment systems are vulnerable to external heating. For example, a Liquefied Petroleum Gas container may be heated by an external fire and spring a leak through one of its attachments. As the heat is transmitted internally the pressure of the container increases proportionately. Eventually the LP gas will escape to the atmosphere through one of its designed attachments or the container will fail violently.

Effectively placed hose streams can lower the pressure in most small containers such as cylinders, but the risk associated with advancing hose lines close to containers stressed by fire can exceed the benefits.

Vapor suggestion techniques can be used offensively in conjunction with defensive spill control techniques to reduce the surface area exposed to the atmosphere. For example, the hazmat can be intentionally diverted into a low lying area by building a diversion barrier and then applying the vapor-suppression agent. In addition to traditional firefighting foams for hydrocarbon or polar solvent liquid fires, new types of vapor suppression foams are entering the market specifically for application to hazardous materials.

6. **Transfer—**refers to the process of moving a liquid, gas or some forms of solids, either manually, by pump, or pressure transfer from a leaking or damaged container or tank. Care must be taken to ensure the pump, transfer hoses and fittings, and container selected are compatible with the hazardous materials. When flammable liquids are transferred, proper concern for electrical continuity (such as bonding and grounding) must be observed.
7. **Vapor suppression—**refers to the suppression of vapors emanating from spilled materials (such as ammonia) which are readily miscible with water and water based vapor-mitigating foam concentrates. In the case of immiscible flammable and combustible liquid spills (such as petrochemicals) this method will be ineffective. Here, conventional fire extinguishing foam agent concentrates have been used to generate foam blankets to suppress the vapors of flammable and combustible liquid. It should be noted that this does not alter the hazardous nature of the material, and it must be treated before disposal. Special foam concentrates have been developed for the mitigation of spills involving hazardous materials that are either caustic or acidic in nature. Once again, although the vapor is suppressed, the basic hazardous material is not altered and must be treated prior to disposal. It should also be noted that in general, no reliable permanent control results from the application of vapor suppressing foams to spills of hazardous materials, regardless of their nature. Therefore, this method generally is used in conjunction with some form of dam or diking or with sorbents to provide effective confinement.
8. **Venting—**a process that is used to deal with liquids or liquified compressed gases where a danger, such as an explosion or mechanical rupture of the container or vessels is considered likely. The method of venting will depend on the nature of the hazardous material. In general, it involves the controlled release of the material in order to reduce and contain the pressure and diminish the probability of an explosion.

Chemical Methods—the application of chemicals to treat spills of hazardous materials. Chemical methods may involve any one of several actions to reduce the involved area affected by the release of a hazardous material. For purposes of this practice, controlled combustion is considered a chemical method of control. However, it should only be used by qualified personnel trained specifically in this procedure. The selection of personal protective clothing should be based on the hazardous materials and/or conditions present and appropriate for the hazards encountered.

1. **Adsorbtion—**chemical bonding to the surface after wetting whereas absorbtion involves only wetting of the surface. The resulting solid material may still be hazardous and must be disposed of properly. Confinement and treatment of large fuel spills may involve different techniques because of the larger volume of liquid involved.

2. **Controlled Burning**—in some emergency situations where extinguishing a fire will result in large, uncontained volumes of contaminated water, or threaten the safety of responders or the public, controlled burning is used as a technique. It is advised that consultation be made with the appropriate environmental authorities when this method is used.
3. **Dispersion**—surface active agents, and biological additives. Certain chemical and biological agents can be used to disperse or break up the materials involved in liquid spills. The use of these agents results in the lack of containment and generally results in spreading the liquid over a much larger area. Dispersants are most often applied to spills of liquid on water. The dispersant breaks down a liquid spill in many fine droplets, thereby diluting the material to acceptable levels. Use of this method may require the prior approval of the appropriate environmental authority.
4. **Flaring**—a process that is used with high vapor pressure liquids or liquiefied compressed gases for the safe disposal of the product. Flaring is the controlled burning of material in order to reduce or control pressure and/or dispose of a product.
5. **Gelation**—the process of forming a gel. A gel is a colloidal system consisting of two phases, a solid and a liquid. The resulting gel is considered to be a hazardous material and must be disposed of properly.
6. **Neutralization**—the process of applying acids or bases to a spill to form a neutral salt. The application of solids for neutralizing can often result in containment of the spilled material. In applying neutralizing agents to the spills, special consideration should be given to protecting persons applying the agent, as heat is generated and violent reactions may occur.

Some hazardous materials can be neutralized by applying another material to the spill which will react chemically to form a less harmful substance. The major advantage of neutralization techniques are that harmful vapors are significantly reduced. In some cases the hazmat can be rendered harmless and disposed of at much less cost. Before this is attempted the incident commander should make sure that:

1. The hazmat has been positively identified.
2. Physical and chemical characteristics have been researched properly and it has been determined that the hazmat will not react to form a more harmful material.
3. The spill has been controlled and confined to prevent runoff after application of the neutralizing agent.

Enough neutralization agent should be on hand to complete the process without stopping so personnel receive minimum exposure. Spills should be covered from the outermost edge and shoveled in toward the center. This ensures that the spill is neutralized closest to workers. Avoid walking through unneutralized materials even if compatible protective clothing is worn. This is especially important when the hazmat is a corrosive.

Most neutralizing agents like sodium bicarbonate and soda ash can be purchased in bulk and staged at key locations in bags or drums. Several good neutralizing kits are commercially available for small spills. These are normally packaged for smaller laboratory or workshop type spills of one to five gallons.

7. **Solidification**—the process whereby a hazardous liquid is treated chemically so that a solid material results. Adsorbents can be considered an example of a solidification process. There are other materials that can be used to convert hazardous liquids into non-hazardous solids. Examples are applications of special formulations designed to form a neutral salt in the case of spills of acids or caustics. The advantage of the solidification process is that a spill of small scale can be confined relatively quickly and treatment effected immediately.
8. **Venting and Burning**—involves the use of shaped charges to vent the high vapor pressure at the top of the container and then with additional charges to release and burn the remaining liquid in the container in a controlled fashion.

RELEASES IN WATER: MATERIALS THAT FLOAT

Technique	Application or Construction Method	Use	Advantages	Disadvantages
Booms	Varies; needs deployment device	Water with not too much current	Can be used on large area; many varieties available	Useful only in waves less than 2-4 feet and currents less than 0.7 knots
Weirs	By boat	Calm water	Is not easily clogged; collects and contains	Not useful in rough water
Pneumatic barriers	Use air compressor or diffuser to deploy	Shallow water only	Does not create a physical barrier to vessels	Useful in rough water Useful only in shallow water and thin layers of containments
Herding	Apply chemicals on water	Rough water such as shore lines	Useful in rough water	Chemicals hard to obtain Is not 100% effective

ESTIMATING SPILL AREA SIZE

THE FOLLOWING SPILL AREAS IN SQUARE FEET WERE DETERMINED BY RELEASING A NON TOXIC DYED WATER OVER VARIOUS SURFACE TYPES.

LEVEL PAYMENT

AMOUNT OF LIQUID	AREA IN SQUARE FEET
ONE GALLON	4 BY 8 FEET, OR 32 SQUARE FEET
FIVE GALLONS	12 BY 12 FEET, OR 144 SQUARE FEET
FIFTY FIVE GALLONS	JUST OVER 1,200 SQUARE FEET

DIRT SURFACE

AMOUNT OF LIQUID	AREA IN SQUARE FEET
FIVE GALLONS	SOAKED IN AFTER COVERING 25 SQ. FT.
FIFTY FIVE GALLONS	COVERED 490 SQUARE FEET

GUTTER (STREET)

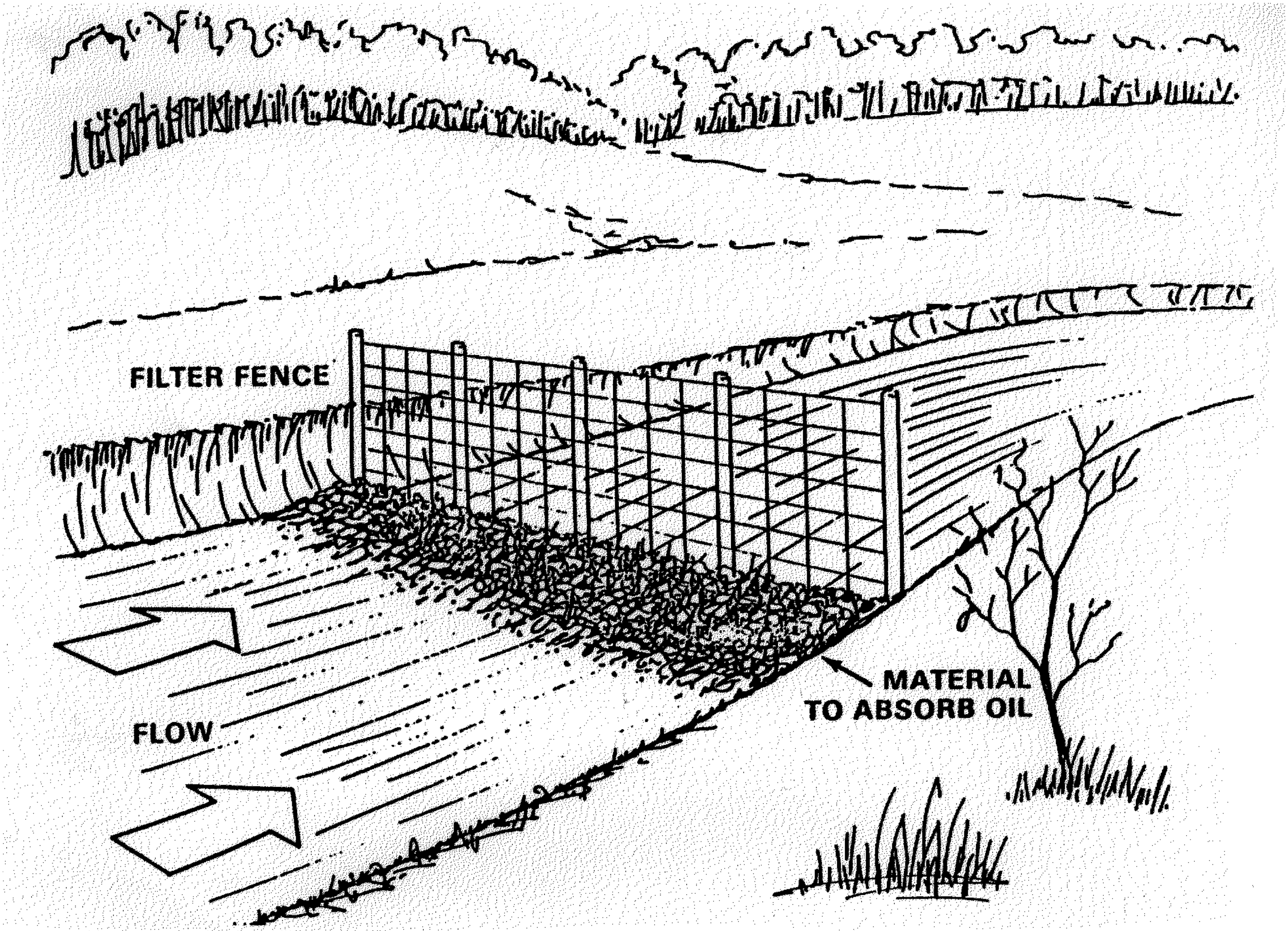
FIVE GALLONS	135 FEET IN THREE MINUTES
FIFTY FIVE GALLONS	460 FEET

IN SUMMARY, LIQUIDS OF WATER-LIKE VISCOSITY, SUCH AS GASOLINE OR LIGHT FUEL OILS, TENDED TO TRAVEL APPROXIMATELY 30-35 SQUARE FEET PER GALLON. SPILLS TRAVEL ABOUT 30 FEET/GALLON IN A CLEAN GUTTER.

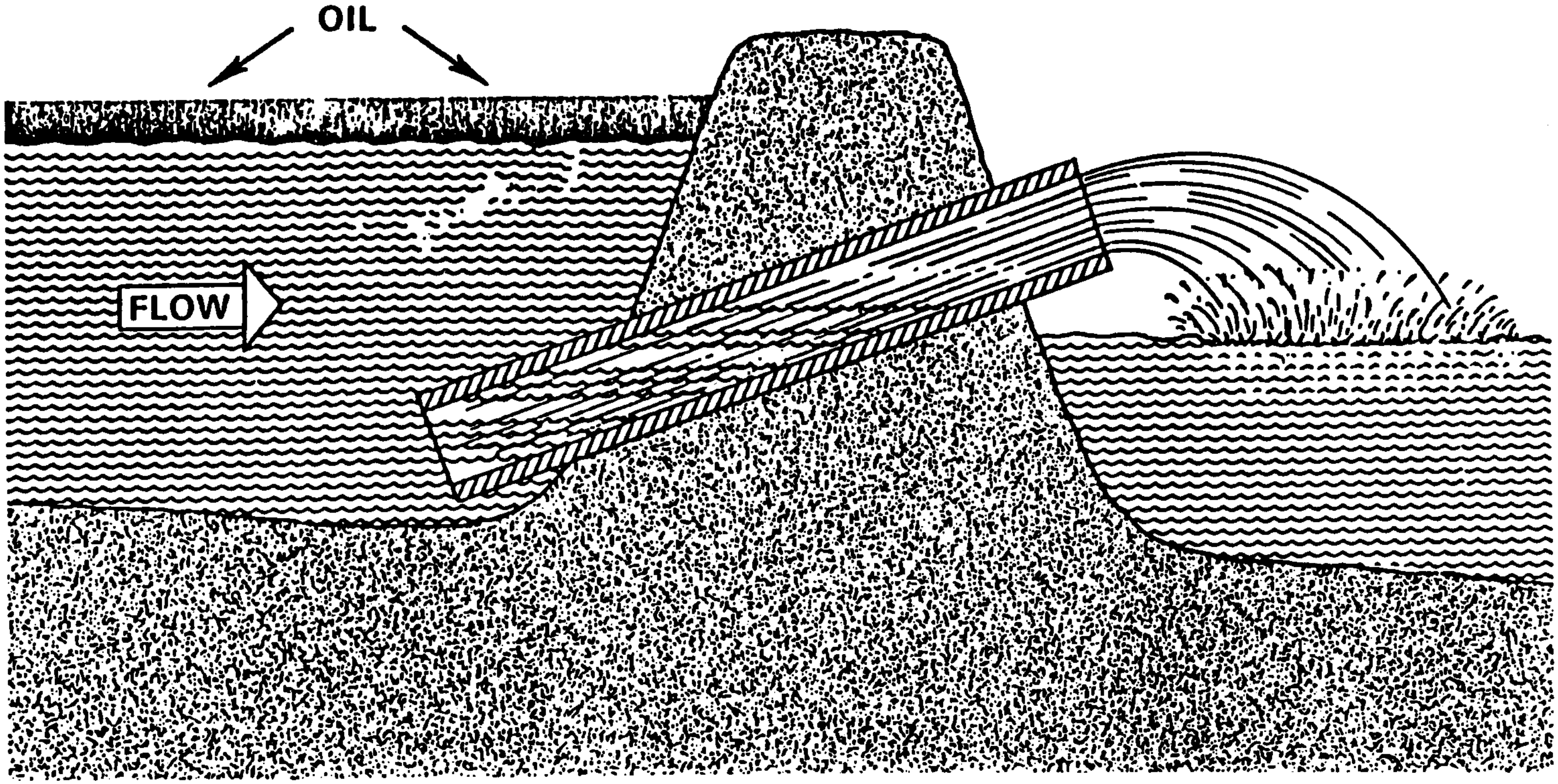
NEW JERSEY STATE POLICE
OFFICE OF EMERGENCY MANAGEMENT
HAZARDOUS MATERIALS EMERGENCY RESPONSE PLANNING UNIT

RELEASES ON LAND

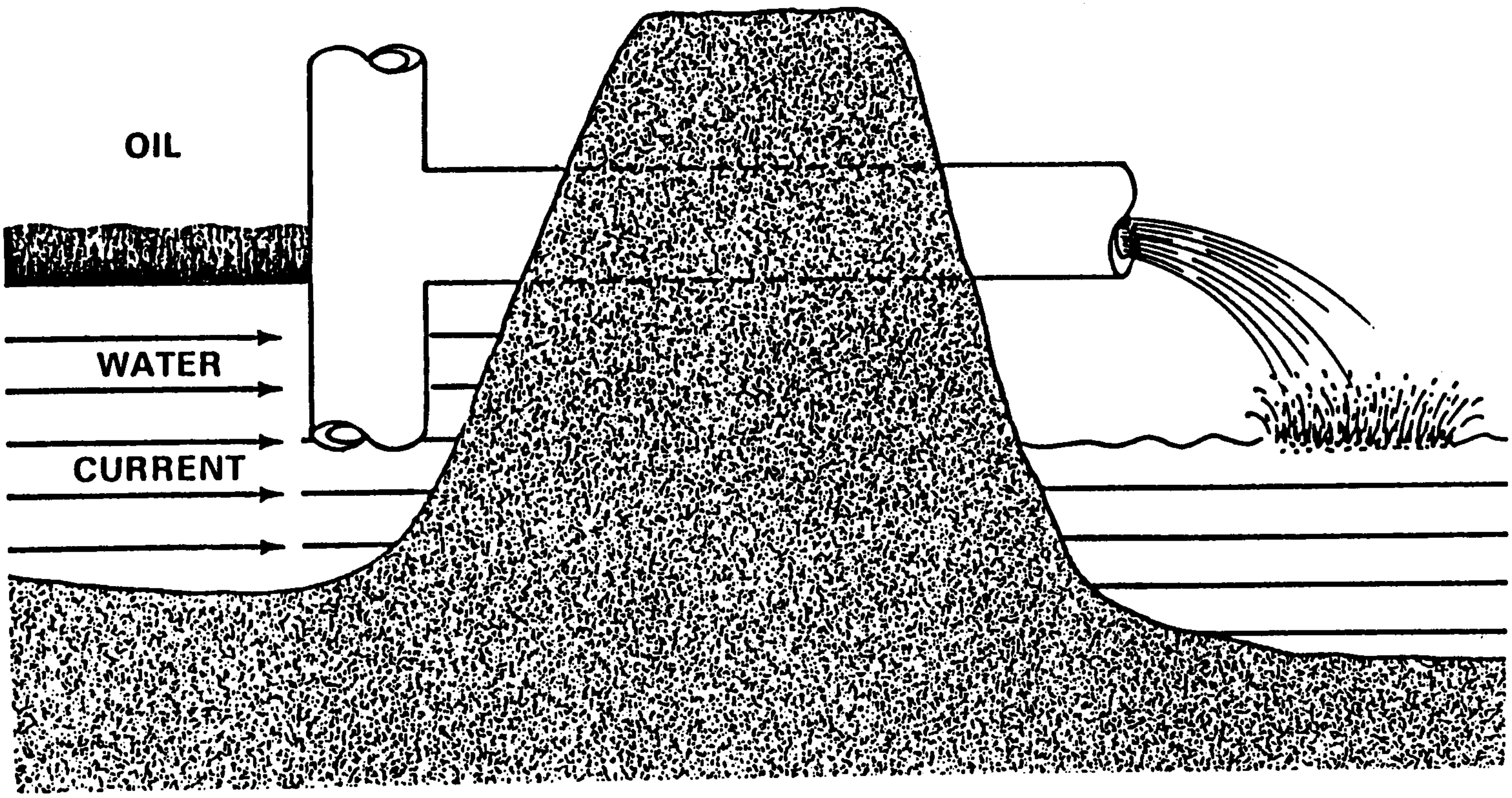
Technique	Application or Construction Method	Use	Advantages	Disadvantages
Earthen Dikes	Compact earth with earth-moving equipment (height depends on earth type)	Flat or sloped surface	Material is on site Equipment is common	Liquids seep through soil Some surface soils are not suitable
Foamed polyurethane	Use trained personnel to construct	Hard, dry surfaces	Dike holds up to 3 feet of water	Dike leaks on wet ground Equipment is not common
Foamed concrete	Use trained personnel to construct	Flat ground; slow-moving spill	Concrete adheres well to substrates (clay/shale/grass)	Equipment is not common Concrete must set for a time; will not hold high hydraulic heads 15 feet
Excavation	Use earth-moving equipment; line if	Soft ground; natural cavity	Material is on site Equipment is common	Large amounts of material must be moved Liquids seep through soil Some surface soils are not suitable
Excavation and Dikes	Use earth-moving equipment; line if possible	Soft ground	Technique needs less space than separate operations Material is one site Equipment is common	Large amounts of material must be moved Liquids seep through soil Some surface soil ??????????


FILTER FENCE
FLOW
MATERIAL TO ABSORB OIL

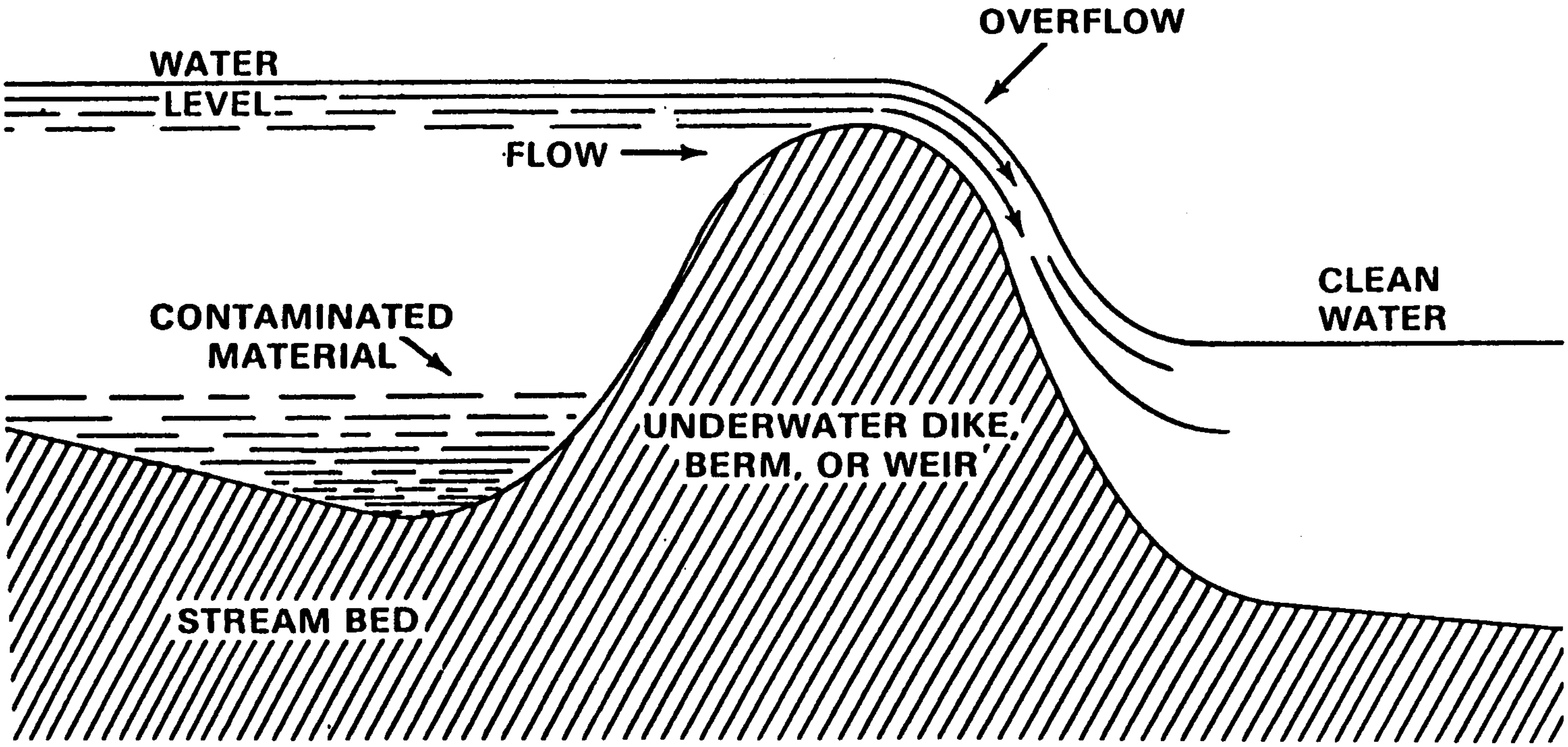
SIPHON DAM
(Underflow Dam)



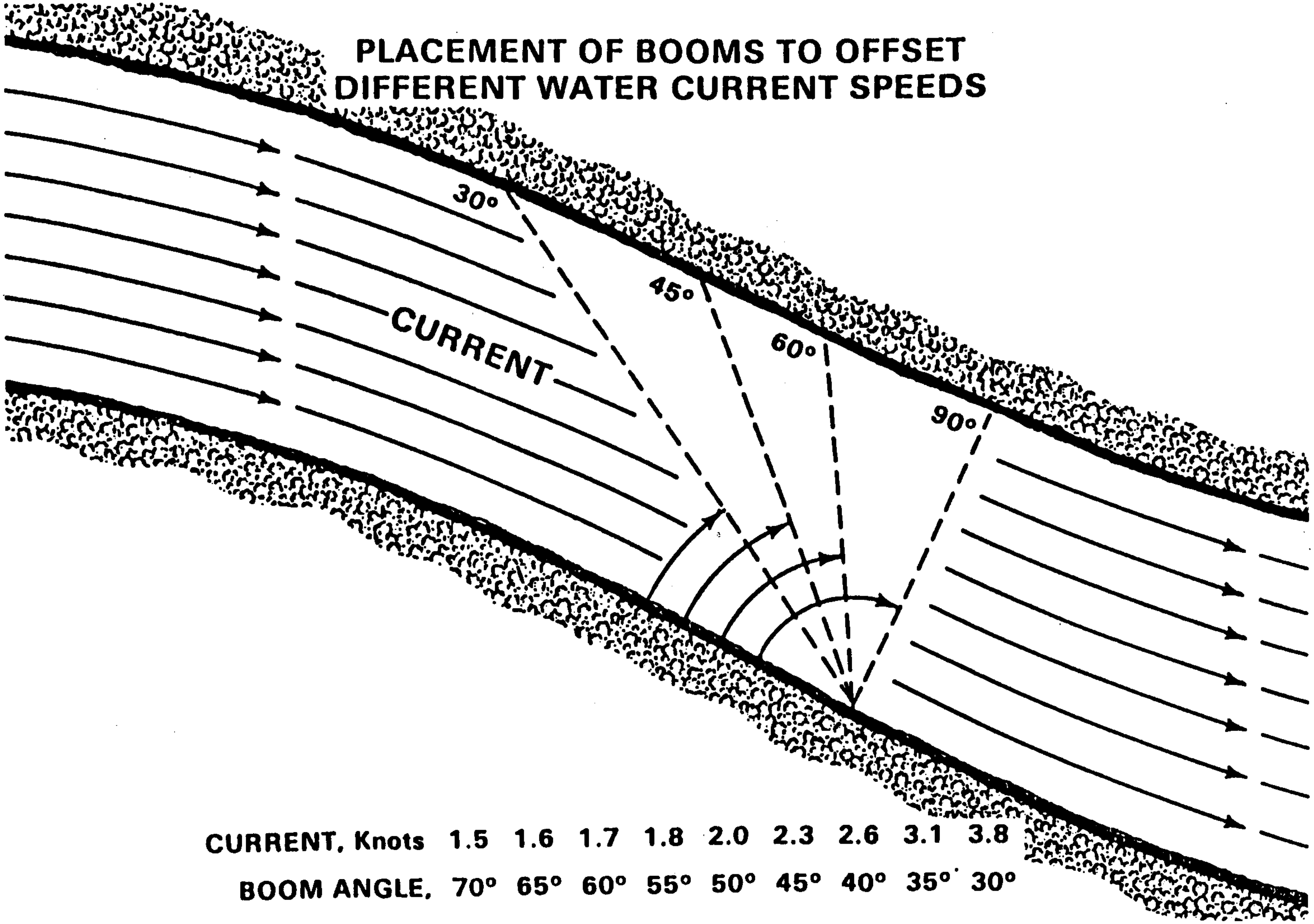
T SIPHON DAM
(Underflow Dam)



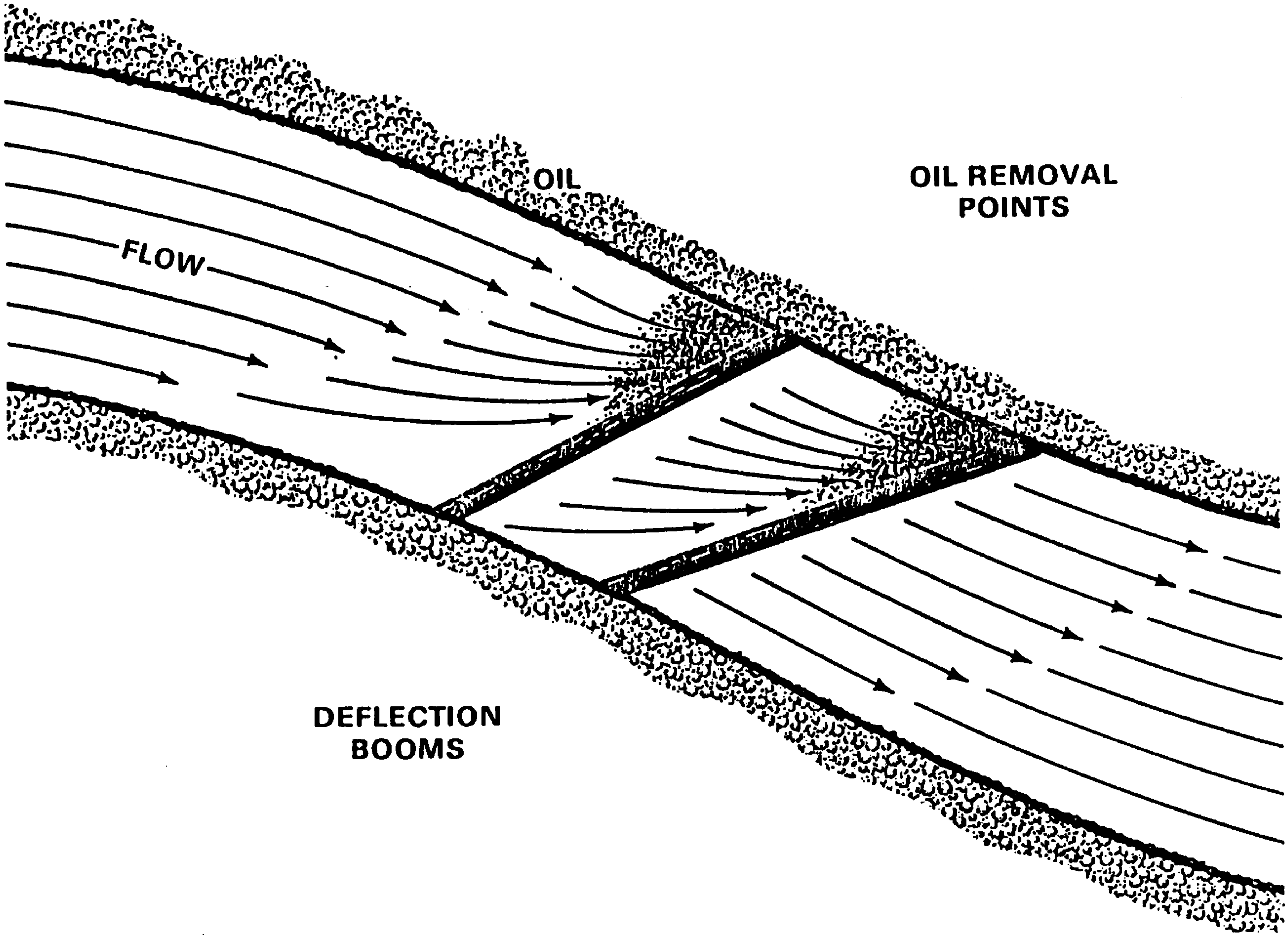
OVERFLOW DAM

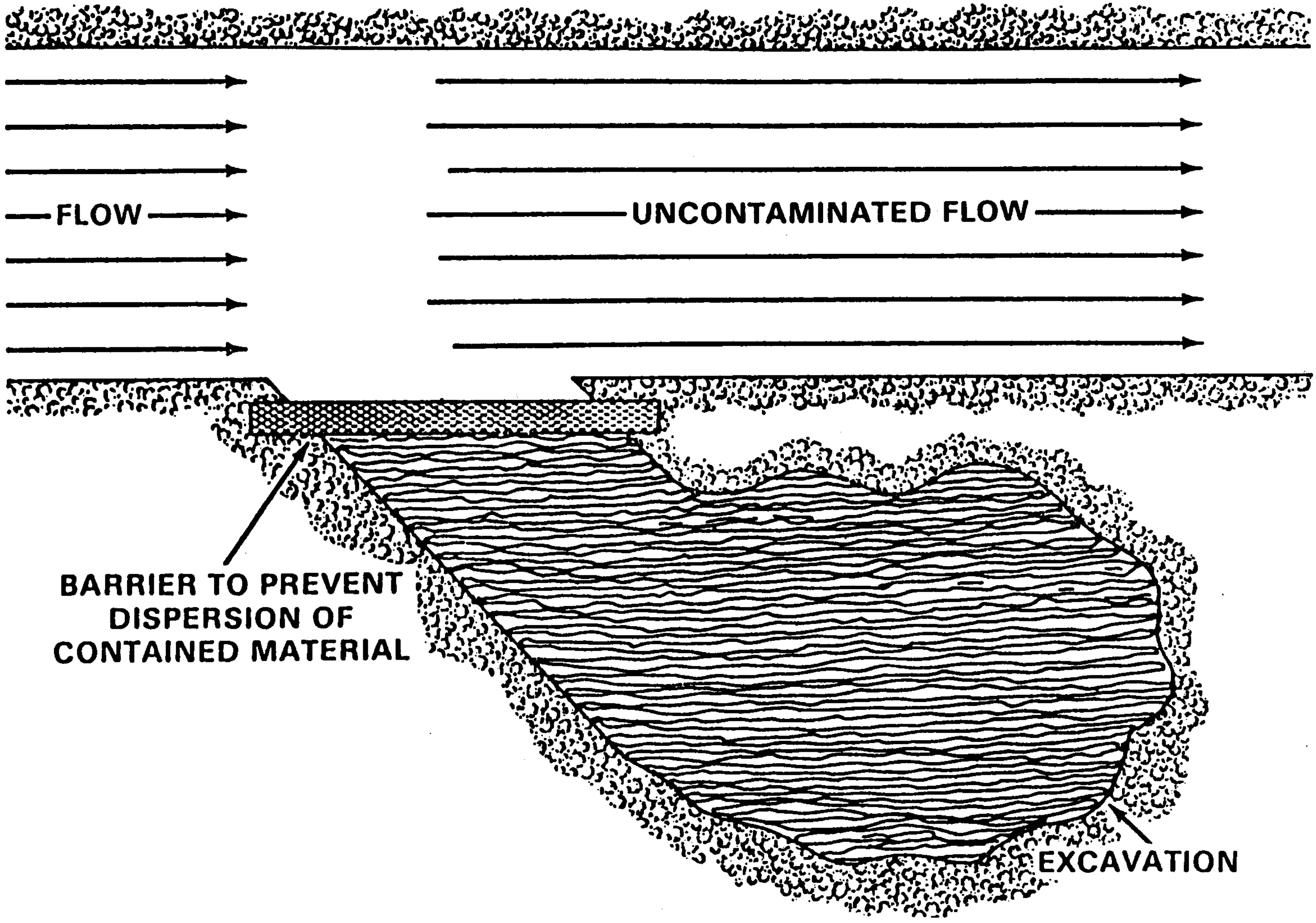


PLACEMENT OF BOOMS TO OFFSET DIFFERENT WATER CURRENT SPEEDS

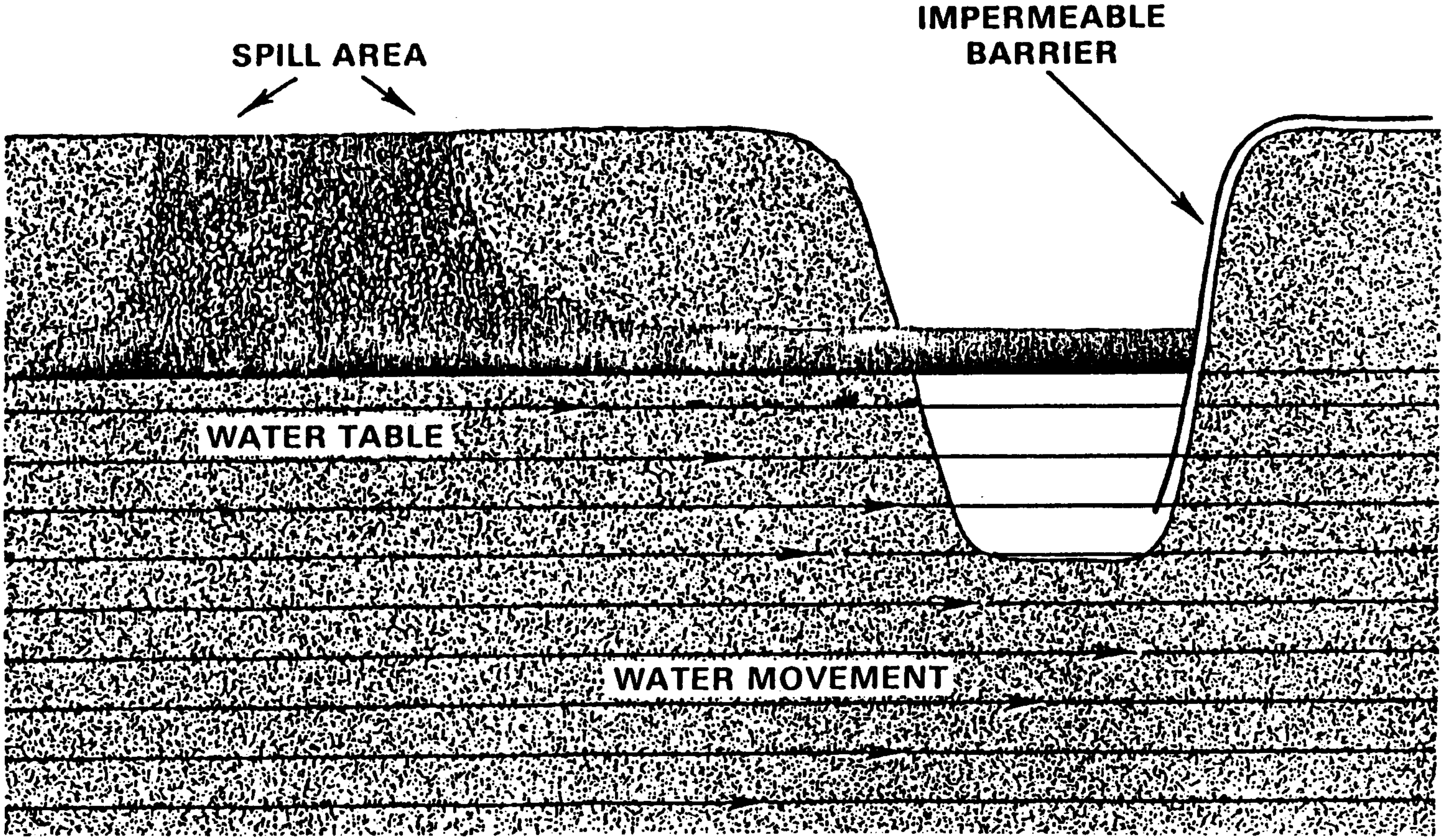


CURRENT, Knots	1.5	1.6	1.7	1.8	2.0	2.3	2.6	3.1	3.8
BOOM ANGLE,	70°	65°	60°	55°	50°	45°	40°	35°	30°

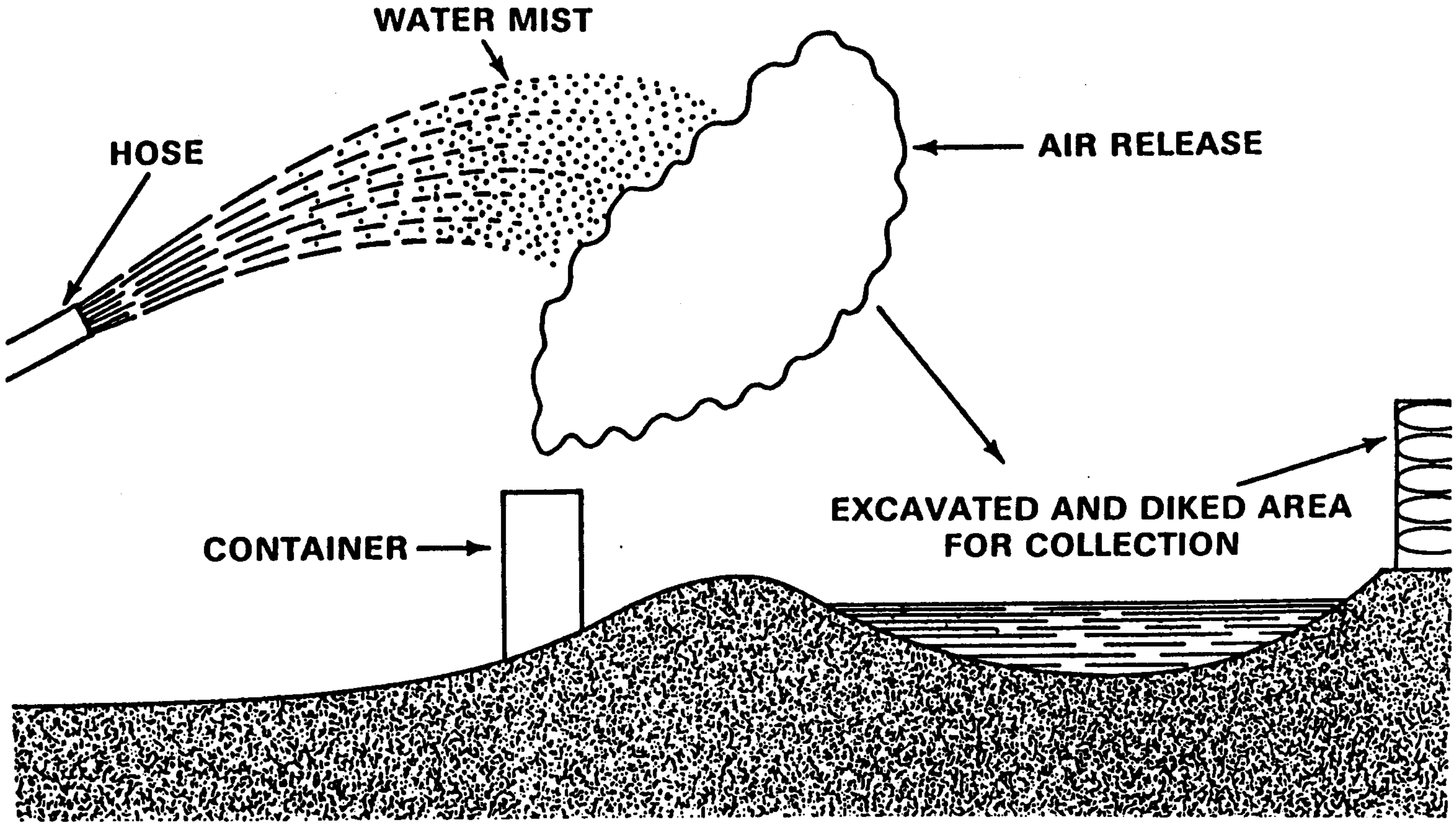

OIL
OIL REMOVAL POINTS
FLOW
DEFLECTION BOOMS


FLOW
UNCONTAMINATED FLOW
BARRIER TO PREVENT DISPERSION OF CONTAINED MATERIAL
EXCAVATION

DITCH RECOVERY



MIST KNOCKDOWN



EQUIPMENT AND TECHNIQUES

A variety of techniques for short term leak abatement have been developed over the past few years as more and more organizations have become involved in response work. Most of these techniques involve the use of tools and equipment that is readily available or easily and inexpensively manufactured locally. The type of equipment and tools needed to temporarily patch or plug a container is, of course, dependent upon the kind of container one is dealing with and, to a lesser degree, the lading of that container. What follows is a general discussion of techniques and equipment useful for leak control in various containers.

Tools

In many cases leak control is best accomplished by simply tightening fittings such as bungs, caps, pipes or flange bolts. Obviously, a variety of tools may be necessary to accomplish this. A good, basic mechanics tool kit should be carried on response vehicles for leak control and should contain, as a minimum:

rubber mallet
nylon mallet
18" and 36" pipe wrench
10" or 12" crescent wrench
open end wrench set
box end wrench set
slip joint plier
common plier
18” flat blade screwdriver
medium weight ball peen hammer
linoleum knife

vise grip pliers
6' pry bar or pinch bar
lock back knife
explosion proof handlight
18" to 36" bolt cutters
bung wrenches (2)
diagonal side cutting pliers
needle nose pliers
screwdriver set-common
screwdriver set-crosspoint
tin snips

In addition to the tools, some expendables should be carried as well:

teflon tape—available in a variety of widths and used for wrapping threads on fittings and connections

lead wool—inexpensive and can be very useful for peening into small cracks and leaking drum chines

duct tape—can be used to slow leakage from pipes, fittings, etc. by wrapping tightly around leaks-also can be used as gasket with wedges or plugs

rubber sheeting—old inner tubes work well-useful as gasket material for any type of patch or plug

lead foil—can be peened into breaches-also good for wrapping wedges or plugs-or peening into spaces around plugs as fillers

oakum—fibrous, resin impregnated substance that swells when wet-useful as filler material or wrap on wedges and plugs

wooden taper plugs assortment

wooden wedge assortment

assorted sheet metal screws—when backed by flat washers and rubber gasket, very useful for small holes and pinholes and some cracks

assorted pipe caps—can be used on threaded pipe ends

bungs—used to secure drums

assorted automotive clamps used to secure rubber sheeting over pipe ends, etc.

assorted threaded pipe plugs—used on internally threaded pipe ends

flat washers for sheetmetal screws

epoxy compounds—can be used as primary patch or binder and filer

More sophisticated plugs, dome clamps, and patches are available or can be locally manufactured from sheet metal with rubber gasket material and toggle bolts (T-patches), or rubber lab stoppers, rubber balls, etc. All three of these devices can be manufactured locally at little cost and can be fabricated in a variety of sizes. Each type works well on different types of container breaches. The only limiting factor is that the fissure must be large enough for the toggle to pass through. It should be noted that these devices should be snugged down but not too tightly because the toggles will not take a great deal of torque. For devices that can be applied using more torque, substitute a T-bolt for the toggle bolt, but don't over torque these devices either. Too much torque can pull the T through thin walled containers.

Another type of device that is useful is an expanding plug for stopping leaks from piping. These devices can be vented or unvented, although if system pressure exceeds 2 psi, vented plugs will probably be necessary to facilitate plug installation. One manufacture's plug includes a threaded nipple on the vent tube that a valved hose can be attached to. This feature allows responders to pipe off the material to a suitable container after plug installation.

These devices, like the patches discussed earlier, are quite simple to apply. The plug, with the vent open, is inserted into the pipe. The hex nut is drawn tight causing the rubber stoppers to be compressed along their longitudinal axis. As a result, the stoppers will expand circumferentially. After the plug is in place, the vent can be closed to shut off product flow from the appliance. Or, product can be piped to a suitable container. These plugs are most effective on low pressure systems. Personnel should stand clear of the plug if the vent is to be closed to preclude injury in the event the plug is ejected from the pipe by system pressure.

These devices are also available commercially, in kit form. One manufacturer, Edwards & Cromwell Manufacturing (16016 Perkins Road, Baton Rouge, LA 70810) markets several kits for different applications. In addition to the above mentioned kits, specialty devices, such as air bag, are available commercially. These devices consist of inflatable patch systems for large vessels that are secured against the container breach with chains or webbing and then inflated. Similar devices are available for use on pipes and small diameter container systems. Air bag devices designed for leak control use operate on relatively low inflation pressures and are not lifting devices which could crush some container walls when inflated.

Specialty kits such as Chlorine A, B and C kit are available from the Chlorine Institute, although they require special training to use and have limited application. The Chlorine A kit is for 150 pound cylinders and can be used to temporarily repair valve and wall leaks. The B kit is designed for use on ton containers of chlorine and the C kit is for emergency leak stoppage from chlorine tank car domes. For additional information, contact:

Chlorine Institute
70 West 40th Street
New York, NY 10018

It is important to note that responders will have to be trained specifically on the use of these specialty devices. Entries for leak abatement at hazardous materials incidents require that personnel be well trained in hazard recognition and the use of protective clothing and equipment as well as in the task at hand. It is recommended that skills training on leak abatement and spill control be conducted with personnel "dressed out" as they would be at an incident. Protective clothing used at chemical incidents will restrict vision and mobility and adversely affect normal dexterity.

Testing of equipment and tools should be done according to manufacturers specification, or department SOP's.

It is recommended that all PPE 4 tools be inspected upon acceptance, monthly or **after each use**. Equipment that requires charging or changing of batteries should be inspected daily.

COMPRESSED GAS SECTION

Traditionally the Technician level HAZ MAT responder has not had to handle an emergency involving a compressed gas. Incidents of this nature pose some very real and unusual hazards which every emergency response person should be familiar with. It is always recommended that you contact the company who owns the cylinder for their advice and assistance.

Today we will discuss the packages, the valves, safeties and the hazards associated with compressed gases. Before we do this a review is in order concerning the routes of exposure and the three states of matter. As emergency responders we have been taught that there are 4 routes of exposure:

INHALATION
ABSORPTION
INGESTION
INJECTION

All of these can occur with gases, but due to the high pressures, up to 6000 PSIG, **injection**, the striking object hazard is the one most people do not recognize. These will be discussed in the lecture and have been addressed in a previous section.

There are 3 states of matter, **solid, liquid and gas**. Gas is a state of matter (or a medium) that can be expanded indefinitely and that takes the shape of a container and occupies all of the available space in it. Escaped gases will eventually distribute themselves throughout the air in a room or other confined space. Some gases have odors and some do not. Most gases are invisible, but some can be seen. Remember the molecules of a gas are always in motion.

The four types of packaged gases

NON-LIQUEFIED COMPRESSED GASES
LIQUEFIED COMPRESSED GASES
COMPRESSED GASES IN SOLUTION
CRYOGENIC LIQUEFIED GASES

NON-LIQUEFIED COMPRESSED GASES contain product that is completely gaseous regardless of the pressure.

LIQUEFIED COMPRESSED GASES contain product in both a liquid and a gaseous state.

COMPRESSED GASES IN SOLUTION are very special. Acetylene is the only common industrial example of this.

CRYOGENIC LIQUID CONTAINERS are made like large vacuum bottles.

HAZARDS ASSOCIATED WITH GASES

PRESSURE
ASPHYXIATION
FLAMMABILITY
EXPLOSION
TOXICITY
CORROSION
OXIDATION
PYROPHORIC
REVERSE FLOW
LOW TEMPERATURE

Now that you understand a little about the types of gases and their hazards we can discuss how they are shipped, specifically as it relates to their packages and valves.

There are 3 types of compressed gas cylinders

HIGH PRESSURE
LOW PRESSURE
CRYOGENIC

There are 3 common valve designs in use today

PACKED STEM
DIAPHRAGM SEAL
PRESSURE SEAL

PACKED STEM VALVE are used with highly corrosive gases such as chlorine and hydrogen chloride.

DIAPHRAGM SEAL VALVES are used for high purity gases, highly reactive gases and poisonous gases.

PRESSURE SEAL VALVES are used for high pressure industrial grade gases.

The materials of construction can be brass, type 303 stainless steel, aluminum silicon bronze and steel while the seats within the valve are usually made of nylon, “Kel-F”, or “Teflon”.

Not all valves have safeties, but when they do, they will have one of the following:

RE-SEALABLE RELIEF DEVICE
RUPTURE DISC
RUPTURE DISC BACKED BY A FUSIBLE METAL PLUG
FUSIBLE METAL PLUG

RE-SEALABLE RELIEF DEVICE which is also called a pop safety is found on propane cylinders. This safety once it functions can re-seal itself after the pressure drops.

RUPTURE DISCS can weep or slowly leak but once they rupture they will allow the total contents of the cylinder to escape.

RUPTURE DISC BACKED BY A FUSIBLE METAL PLUG requires two conditions to function. First they must have a pressure high enough to rupture the disc and secondly there must be sufficient heat to cause the fusible metal to melt.

FUSIBLE METAL PLUG requires heat to melt it, usually between 157 to 170 degrees fahrenheit, and in some cases 208 to 220 degrees fahrenheit.

ALWAYS REMEMBER WHEN DEALING WITH A HAZ MAT INCIDENT INVOLVING COMPRESSED GASES THAT YOU SHOULD:

CONTACT THE SUPPLIER
KNOW THE PRODUCT(S) INVOLVED
KNOW THE PACKAGE, VALVE, SAFETY IF POSSIBLE
READ THE LABEL IF POSSIBLE
PAY ATTENTION TO THE HAZARDS ASSOCIATED WITH COMPRESSED GASES

REMEMBER

THE FIRST 5 MINUTES AT THE SCENE WILL DETERMINE THE REST OF YOUR

LIFE!!!!

HANDLING COMPRESSED GAS EMERGENCIES

HAZARDS

- FLAMMABLE TOXIC OXIDIZER RADIOACTIVE
- CORROSIVE POISON REACTIVE OTHERS

CYLINDERS

- DO NOT HEAT ABOVE 130 DEGREES F.
- DRY ICE IS THE COLDEST TEMPERATURE ALLOWED FOR SEAMLESS 3A OR 3AA SPEC CYLINDERS.
- COLDER TEMPERATURES ARE ALLOWED FOR ALUMINUM OR STAINLESS STEEL.
- CYLINDER IS NOT EMPTY UNTIL IT HAS BEEN PURGED ADEQUATELY WITH INERT GAS.
- CYLINDERS CHILLED TO CRYOGENIC TEMPS CAN SHATTER VIOLENTLY. ALLOWED TO WARM SLOWLY IN AIR.

VALVES

- TIGHTENING OF VALVE INTO CYLINDER CAN WORSEN LEAK.
- VALVE CAN BE PLUGGED OR STUCK. PRESSURIZE SLIGHTLY WITH INERT GAS TO CHECK.

FIRE

- DAMAGED CYLINDER SHALL NOT BE PRESSURIZED AS IT CAN SHATTER VIOLENTLY.
- DEPRESSURIZE SLOWLY INTO SCRUBBING OR CASCADE SYSTEM.
- FIRE CAN MELT FUSIBLE METAL SAFETY CAUSING RELEASE OF CONTENTS.
- FOR COMBINATION SAFETY DEVICE THE METAL DISK MAY STILL BE INTACT AND CYLINDER PRESSURIZED.
- FIRE CAN MELT VALVE HANDLE AND SEAT. REMOVE VAPOR TIGHT CAP/PLUG SLOWLY.

SEALANTS

- PIG PUTTY AND OTHER EXPOXIES ARE INEFFECTIVE IN STOPPING GAS LEAKS.

EXPLOSIVE GAS MIXTURE

- MUST NOT BE MOVED. EVACUATE AREA.

HANDLING COMPRESSED GAS EMERGENCIES

PYROPHORIC/FLAMMABLE GAS

- A VACUUM MUST NEVER BE DRAWN AS THIS CAN CREATE AN EXPLOSIVE ATMOSPHERE. FREEZING OF LIQUEFIED GAS CAN CAUSE THIS CONDITION.
- NEVER EXTINGUISH FIRE. SHUT OFF SOURCE OR PROTECT EXPOSURES.
- TOXIC METAL HYDRIDE FIRES CAN PRODUCE SKIN ABSORBABLE SOLID BYPRODUCTS.
- LIQUEFIED HYDROCARBON CYLINDERS HAVE A RESEATING RELIEF DEVICE.

LIQUEFIED GAS

- CASCADING IS INEFFECTIVE UNLESS VERY SMALL QUANTITY.
- A HIGH FLOW RATE LEAK CAN FREEZE SOME OF THE CONTENTS WHICH WILL SLOWLY VAPORIZE OVER TIME.
- CONDENSATION OF MOISTURE WHICH MAY FREEZE MAY OCCUR ON CYLINDER EXTERIOR.
- WEIGHT IS THE ONLY ACCURATE MEASUREMENT OF CONTENTS.

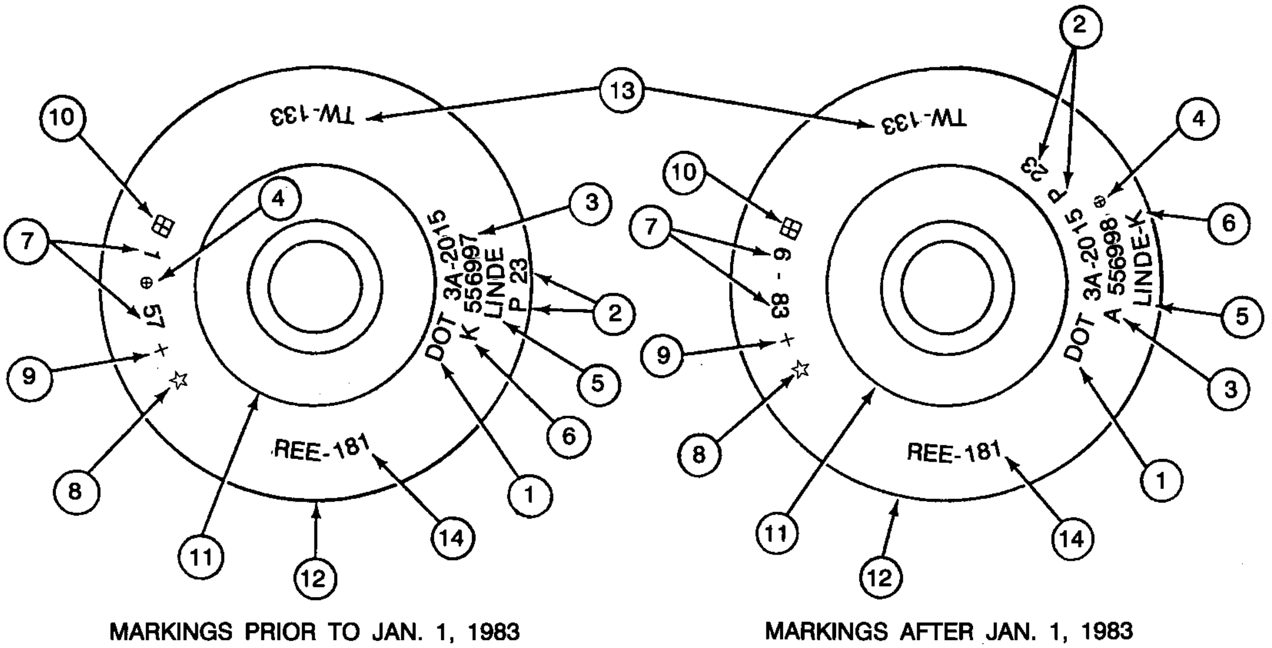
OXIDIZER GAS

- SYSTEMS MUST BE OXYGEN CLEANED.
- PRESSURIZE SYSTEM SLOWLY TO MINIMIZE COMPRESSION HEAT.
- USE ONLY STAINLESS STEEL OR BRASS FOR SYSTEM.

ACETYLENE

- NEVER CASCADE OR OVERPACK AS THIS CAN CREATE PRESSURES >15 PSIG WHICH IS UNSTABLE.
- AFTER PRESSURE RELIEF ACTIVATION SIGNIFICANT AMOUNT OF ACETONE WILL REMAIN IN CYLINDER.

Two slightly different marking systems are shown in Figure 10. The old system, in effect for many years prior to January 1, 1983, is shown on the left side of Figure 10. The new and current system, in effect after January 1, 1983, is shown on the right. Although the locations of some of the markings differ between the two systems, the markings themselves are the same and readily recognizable.



ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	DOT Specification and Service Pressure	9	Cylinder Meets 10% Overfill Specification
2	Inspector's Mark	10	Linde Brand Identification (Made to Linde Specifications)
3	Manufacturer's Serial Number		
4	Manufacturer's Registered Symbol	11	Collar
5	Registered Owner	12	Cylinder
6	Linde Style Designation	13	Tare Weight
7	Manufacturer's Test Date	14	Rejection Elastic Expansion Limit in Cubic Centimeters
8	Cylinder OK for 10 Year Hydrostatic Test Exemption		

FIGURE 10, TOP VIEW OF H.P. CYLINDER PERMANENT MARKINGS

LABELS

The Department of Transportation requires that all compressed gas cylinders and cryogenic liquid containers be marked to show the DOT Shipping Name, Identification Number and Hazard Class of the contents. This required information, in addition to other important user data, appears on adhesive-XXXXX

CYLINDERS AND CONTAINERS

Types

Compressed gas and cryogenic liquid products come in a variety of cylinders and containers which are discussed in the following paragraphs.

High Pressure Cylinders (Figure 5)—are thick-walled, metal vessels designed to contain a gas or gas mixture at pressures up to 6000 pounds per square inch (psi).

Although most cylinders are made of steel, some high pressure cylinders are made of aluminum. Linde Fibralume® cylinders, for example, are aluminum cylinders with a protective coating containing fibers of enormous tensile strength. This material discolors giving a visual warning if the cylinder is exposed to excessive heat. Exposure to heat above 450°F can weaken the walls of aluminum cylinders, posing a risk of cylinder failure.

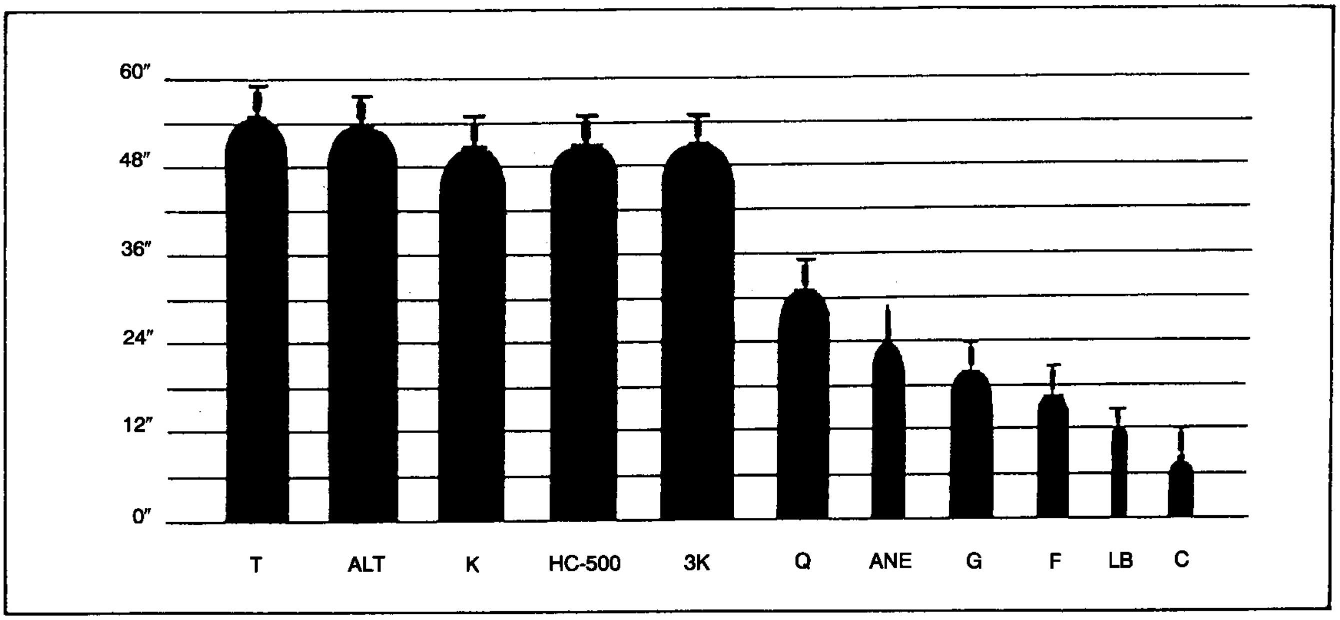
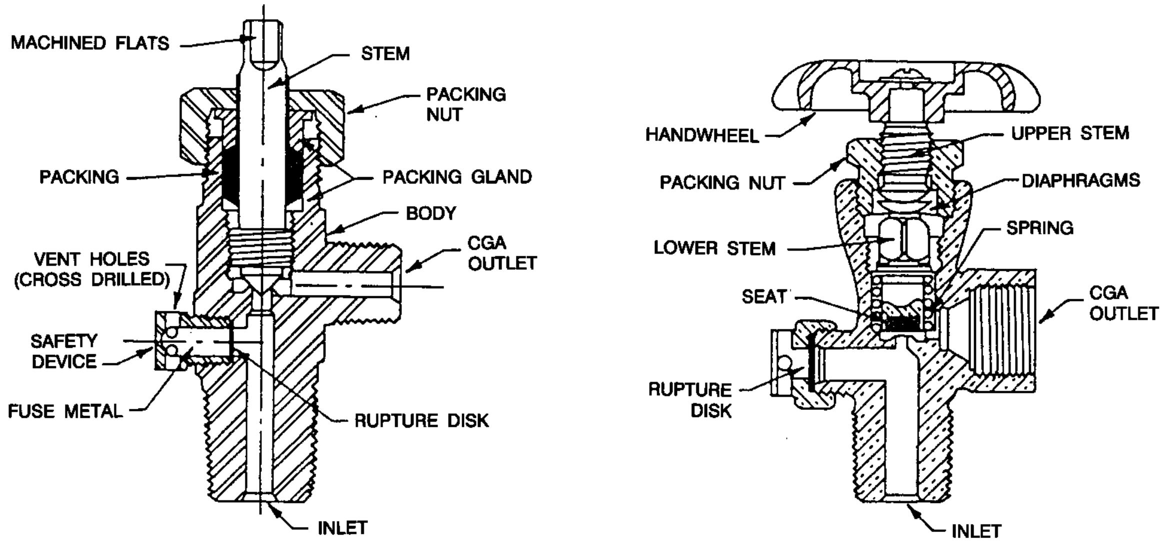


FIGURE 5, COMMONLY USED HIGH PRESSURE CYLINDERS

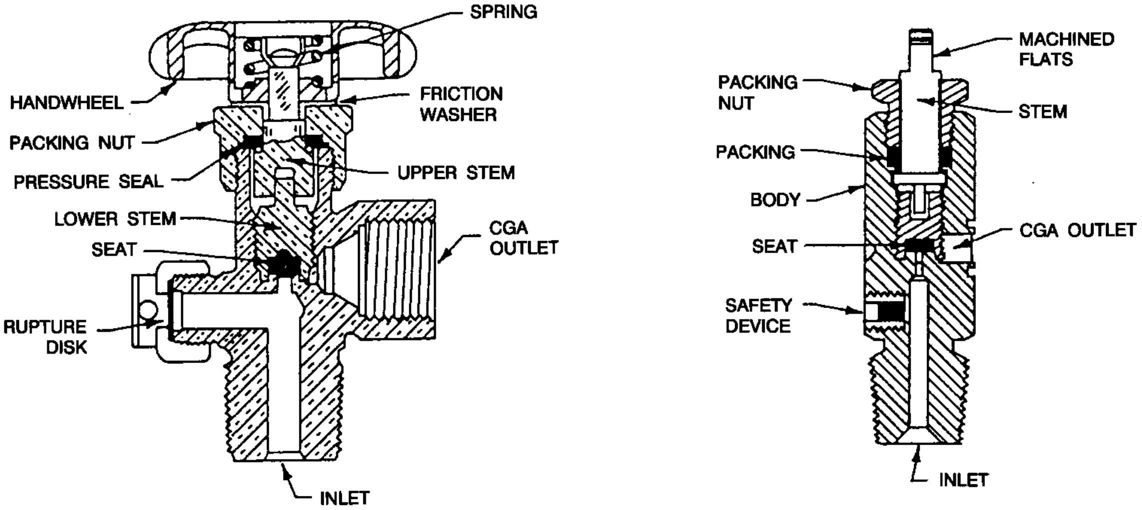
Low Pressure Cylinders (Figure 6)—are designed to contain products existing in both liquid and gaseous states at pressures up to 480 psi. Cylinder pressures between 240 and 480 psi are most common.

Low pressure cylinders are commonly made of steel with welded seams. They have considerably thinner walls and, in some cases, have flatter shoulders than those on high pressure cylinders. To provide equivalent quantities of gas, low pressure cylinders tend to be somewhat larger than corresponding high pressure cylinders.



PACKED STEM CYLINDER VALVE

DIAPHRAGM SEAL OR PACKLESS CYLINDER VALVE

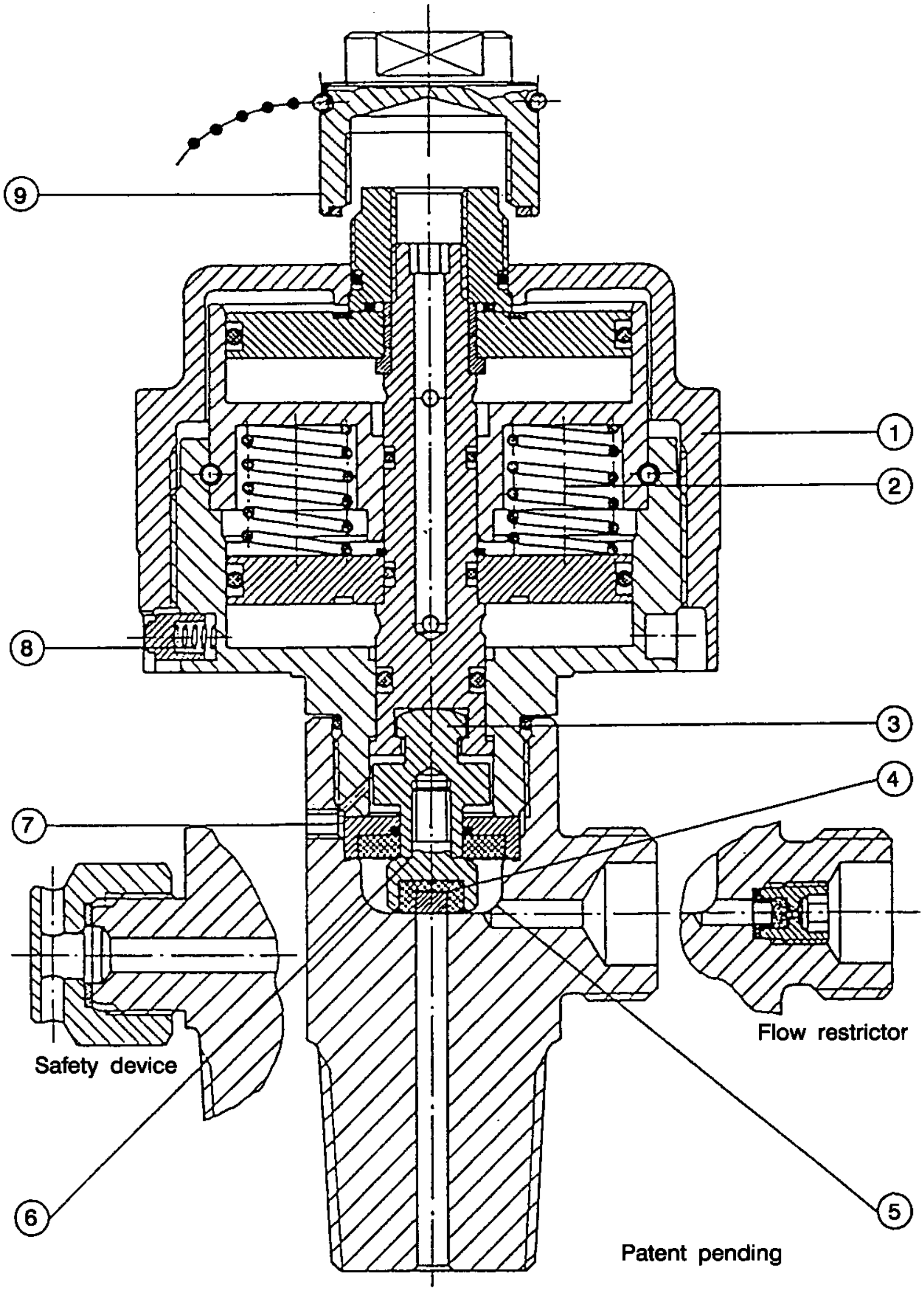


PRESSURE SEAL CYLINDER VALVE

PIN-INDEXED CYLINDER VALVE

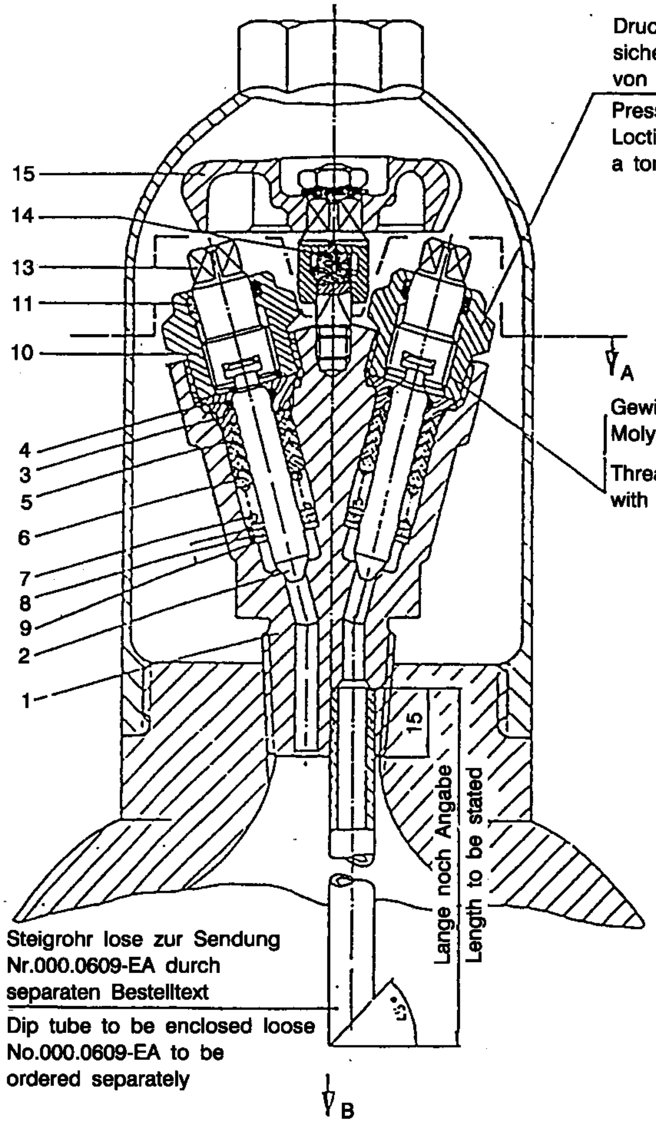
FIGURE 16, CYLINDER VALVES

SC—Specialty Gas Emergency Response



WORKING PRESSURE : 200 bar - 3000 PSI
OPERATING PRESSURE : 5 bar - 75 PSI
MAXIMUM OPERATING PRESSURE : 10 bar - 150 PSI
TEMPERATURE RANGE : -20°C/+70°C
-4°F/+158°F
He LEAK RATE : 10^{-9} mbar l/s
ORIFICE SIZE : 4 mm
MATERIAL :
—BODY : STAINLESS STEEL AISI 316 L
—SEAT DISC : PCTFE/Kel-F®/VESPEL
—DIAPHRAGMS : HASTELLOY®
IN-OUTLET CONNECTIONS : All standards

SC-Specialty Gas Emergency Response
Liquid/Vapor Valve
Carl Esser



Druckschraube mit Loctite 270 sichern und mit enerr XXX von mind. 65 Nm XXX

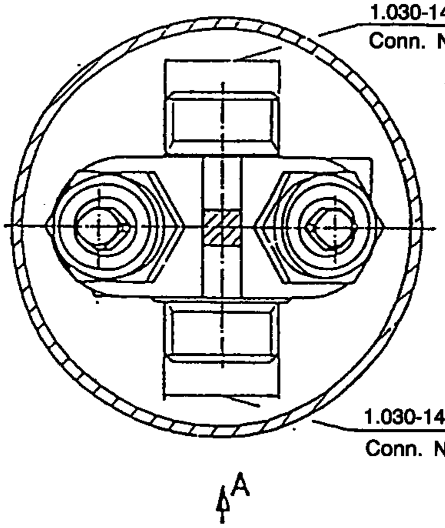
Pressure screw to be saved with Loctite 270 and to be tightened at a torque of at least 65 Nm.

Gewinde der Oberspindel mit Molykote TTF 52 gelellet

Thread of upper spindle greased with Molykote TTF 52

Steigrohr lose zur Sendung Nr.000.0609-EA durch separaten Bestelltext

Dip tube to be enclosed loose No.000.0609-EA to be ordered separately



1.030-14-NGO-RH-EXT.

Conn. No. 660

1.030-14-NGO-LH-EXT.

Conn. No. 670

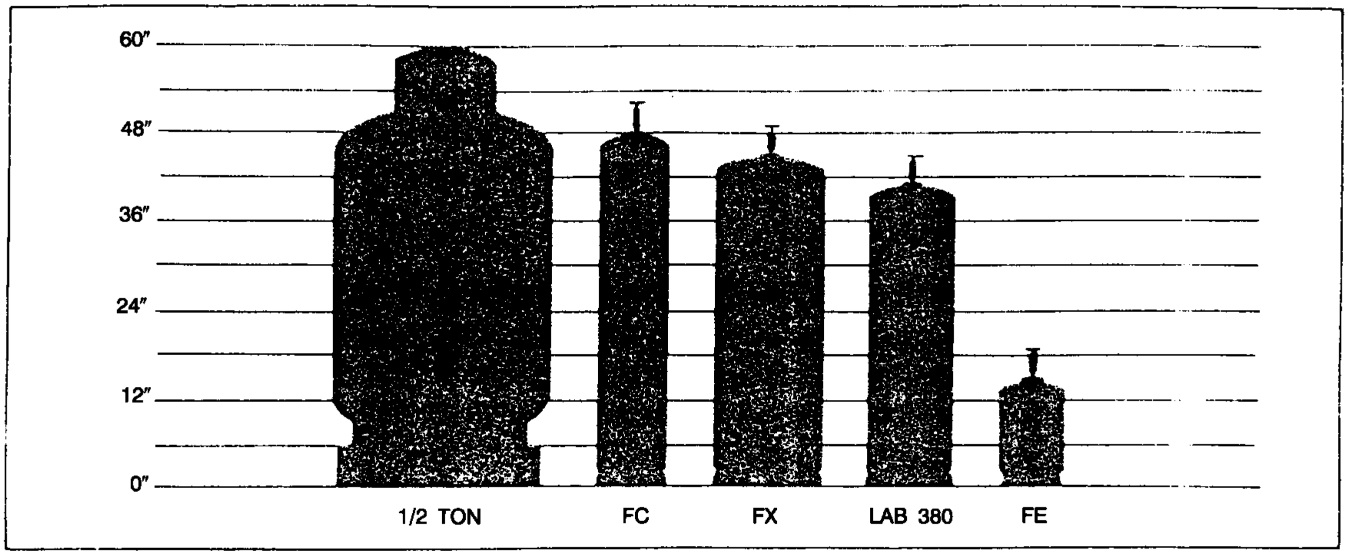


FIGURE 6, COMMONLY USED LOW PRESSURE CYLINDERS

Acetylene cylinders are a special kind of low pressure cylinder. They are completely filled with a high porosity, solid material. The cylinder identified as LAB-380 in Figure 6 is designed for acetylene.

Other types of low pressure packages are glass bulbs which are designed to contain one and two liter quantities of high-value research grade gases at atmospheric pressure. They can only be pressurized to one atmosphere (14.7 psia or 0 psig).

Cryogenic Liquid Containers (Figure 7)—are designed to contain products that exist in two states—cryogenic liquid and cold gaseous vapor. This makes them quite different than high and low pressure cylinders.

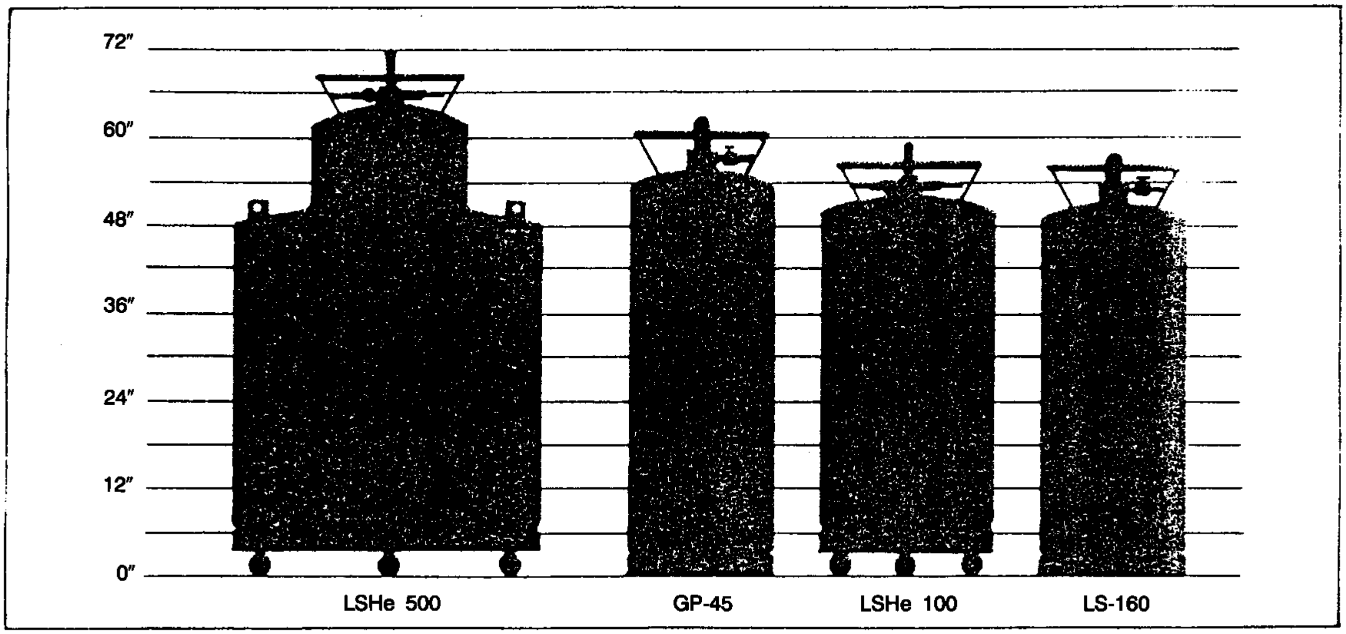


FIGURE 7, COMMONLY USED CRYOGENIC LIQUID CONTAINERS

As shown in Figure 8, cryogenic liquid containers are designed with separate vessels—an inner container and an outer casing. The space between the two vessels is evacuated to a high vacuum and is filled with a special insulation. To reduce heat leak, supports linking the two vessels are minimal, making cryogenic liquid containers more fragile than other gas cylinders. This makes it extremely important to carefully handle cryogenic liquid containers. Refer to "Moving Cylinders and Containers" on Page 26.

Since no insulating system is perfect, all cryogenic liquid containers gradually warm up. Liquid container designs take advantage of this heat leak. By warning the product, the cryogenic liquid boils to produce more gas and a higher container pressure. The increased pressure provides the force that "drives" the product from the container thus eliminating the need for an outside power source.

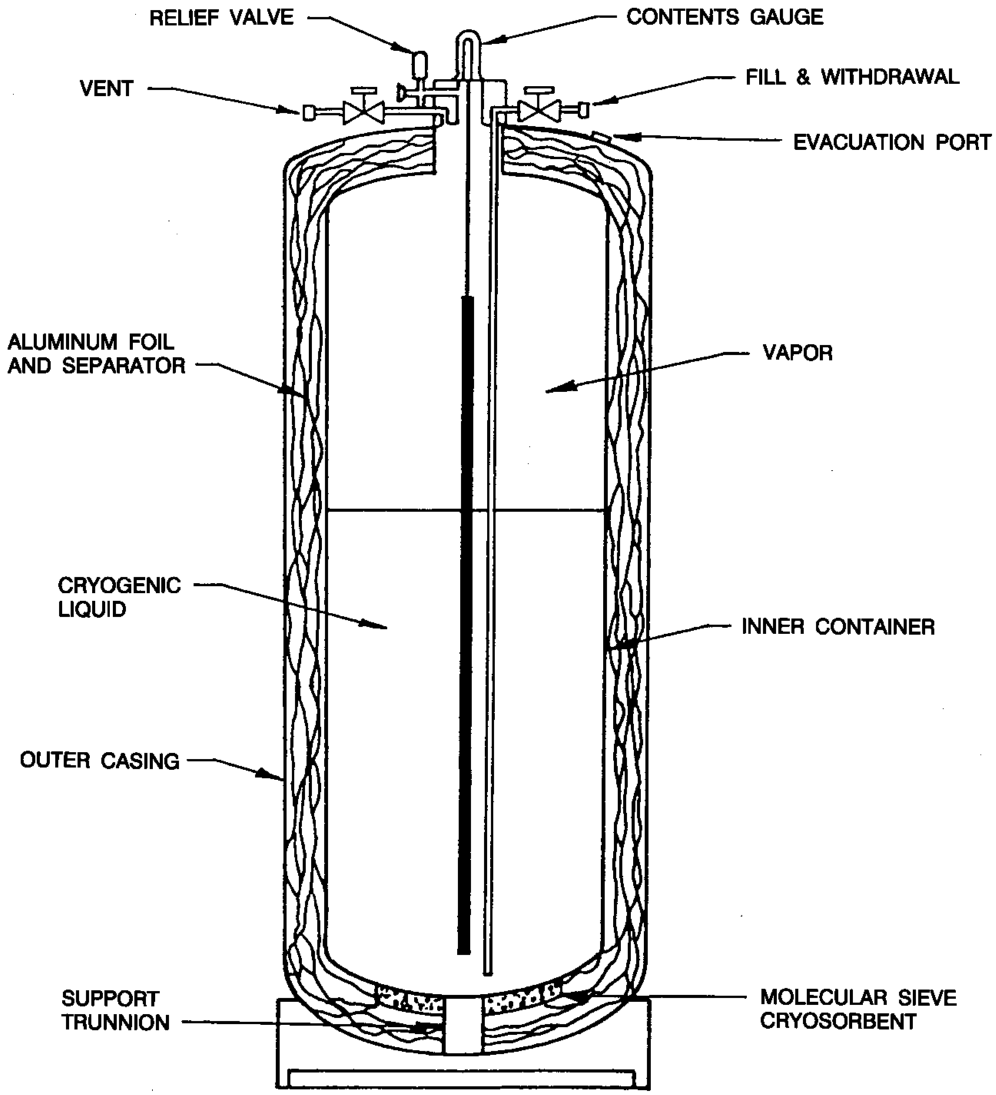


FIGURE 8, CROSS-SECTION, TYPICAL CRYOGENIC LIQUID CONTAINER

They are not variable, nor are they designed for adjustment in the field. If a liquid container fails to supply gas or liquid at the required rate, your supplier will have to service, repair, or replace the container.

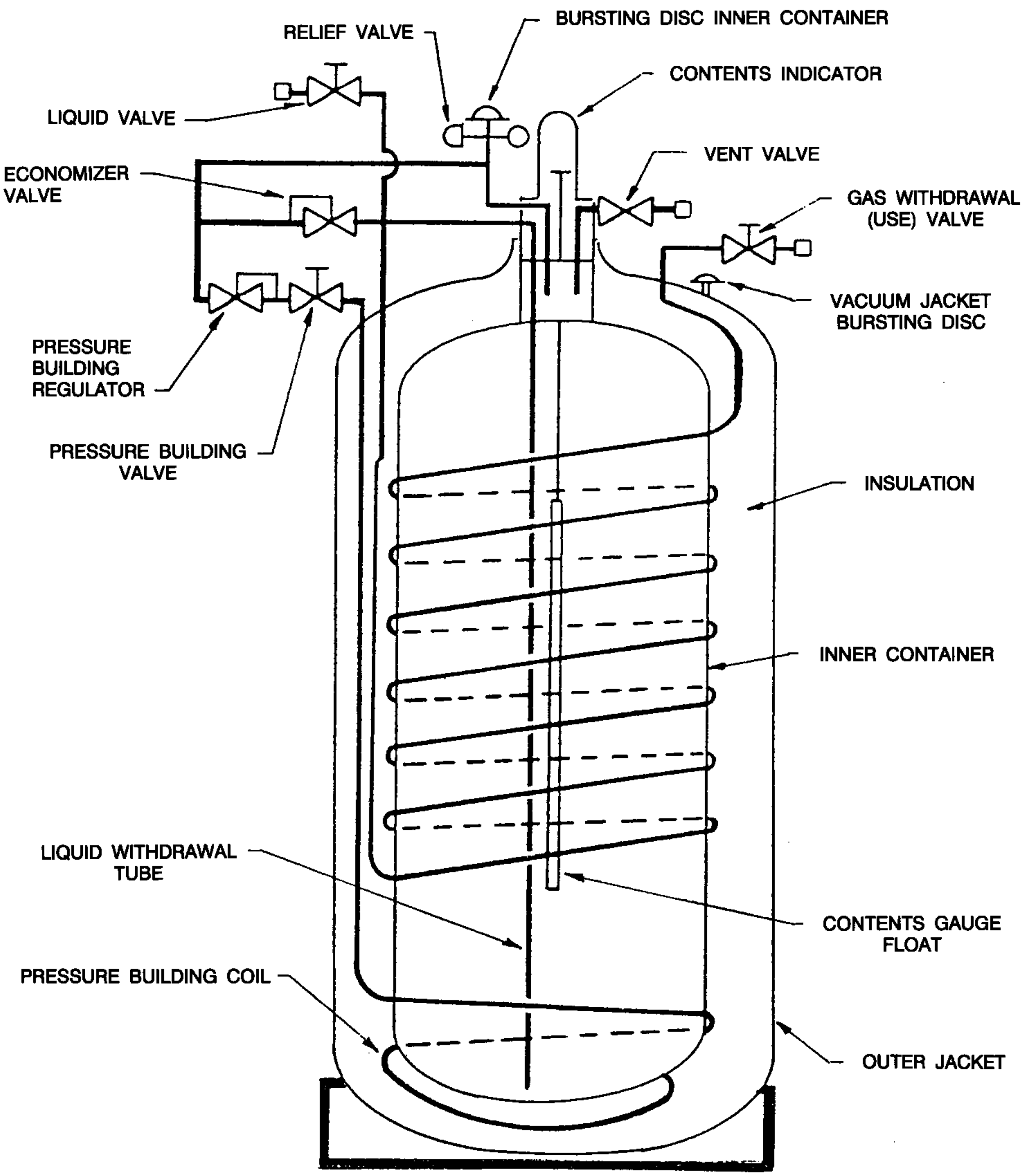
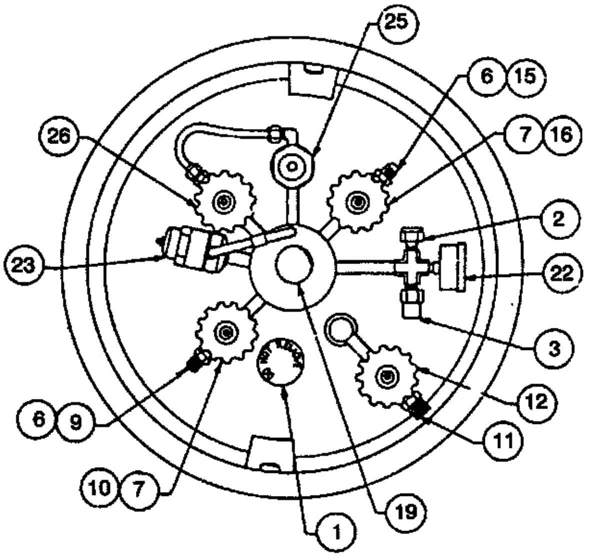


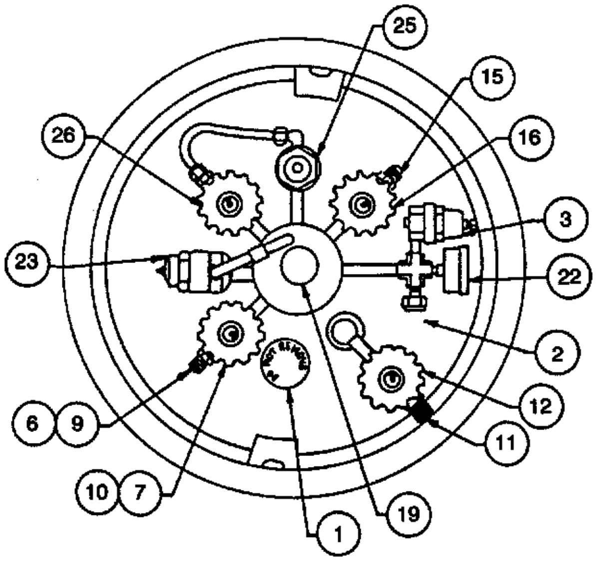
FIGURE 3-2, LIQUID CONTAINER WITH PRESSURE BUILDING COIL



LEGEND

1. VACUUM BURSTING DISK (18 PSIG)
2. CONTAINER BURSTING DISK (380 PSIG)
3. PRIMARY RELIEF VALVE (235 PSIG)
6. FILLING CONNECTION
7. FILLING VALVE
9. LIQUID WITHDRAWAL CONNECTION
10. LIQUID WITHDRAWAL VALVE
11. GAS WITHDRAWAL CONNECTION
12. GAS WITHDRAWAL VALVE (USE VALVE)
15. VENT CONNECTION
16. VENT VALVE
19. CONTENTS GAUGE
22. PRESSURE GAUGE
23. BACK PRESSURE VALVE
25. PRESSURE BUILDING REGULATOR
26. PRESSURE BUILDING COIL SHUTOFF VALVE

Figure 10—Top View of GP-45



LEGEND

1. VACUUM BURSTING DISK (18 PSIG)
2. CONTAINER BURSTING DISK (380 PSIG)
3. PRIMARY RELIEF VALVE (110 PSIG)
6. FILLING CONNECTION
7. FILLING VALVE
9. LIQUID WITHDRAWAL CONNECTION
10. LIQUID WITHDRAWAL VALVE
11. GAS WITHDRAWAL CONNECTION
12. GAS WITHDRAWAL VALVE (USE VALVE)
15. VENT CONNECTION
16. VENT VALVE
19. CONTENTS GAUGE
22. PRESSURE GAUGE
23. ECONOMIZER VALVE
25. PRESSURE BUILDING REGULATOR
26. PRESSURE BUILDING COIL SHUTOFF VALVE

Figure 11—Top View of GP-45W

DECISION TREES ON HANDLING DIFFERENT HAZARDOUS MATERIALS INCIDENTS

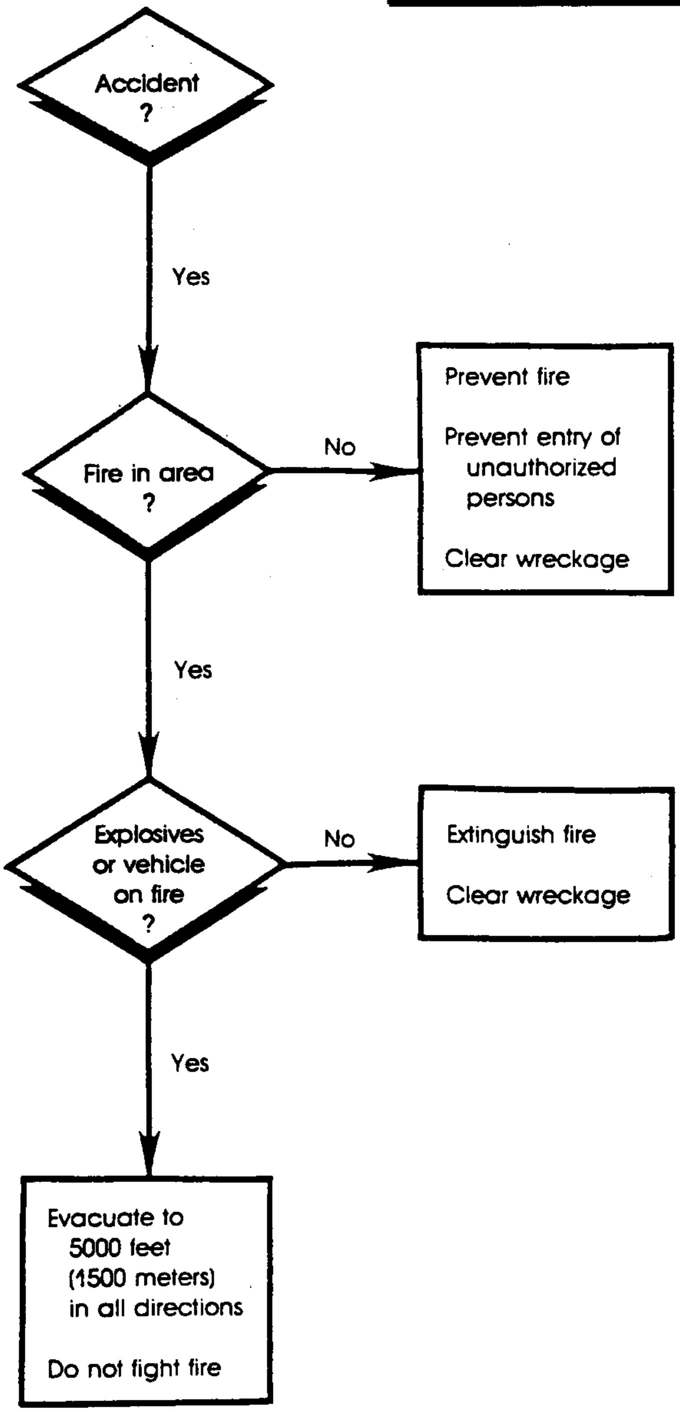
CLASS

CLASS "A" EXPLOSIVES

DIVISIONS 1.1 & 1.2

SIZE

ALL



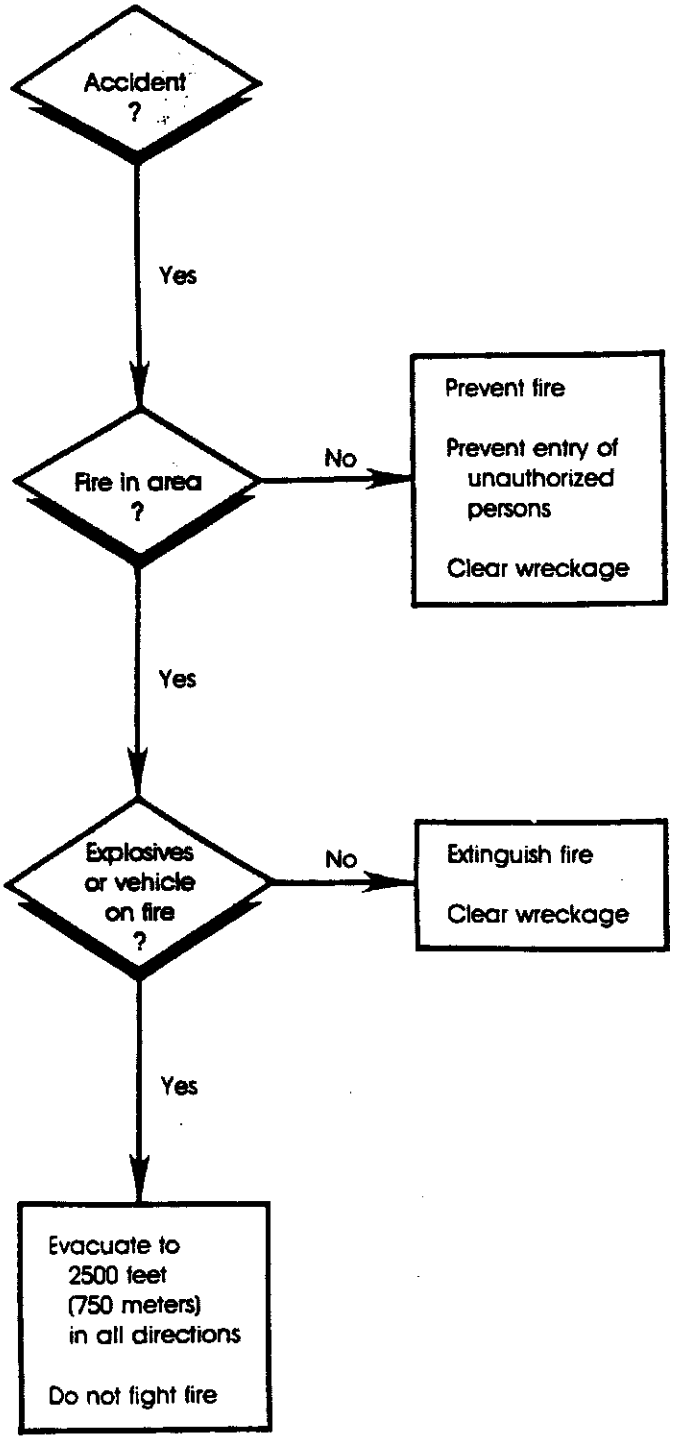
CLASS

CLASS "B" EXPLOSIVES

DIVISIONS 1.2 & 1.3

SIZE

ALL

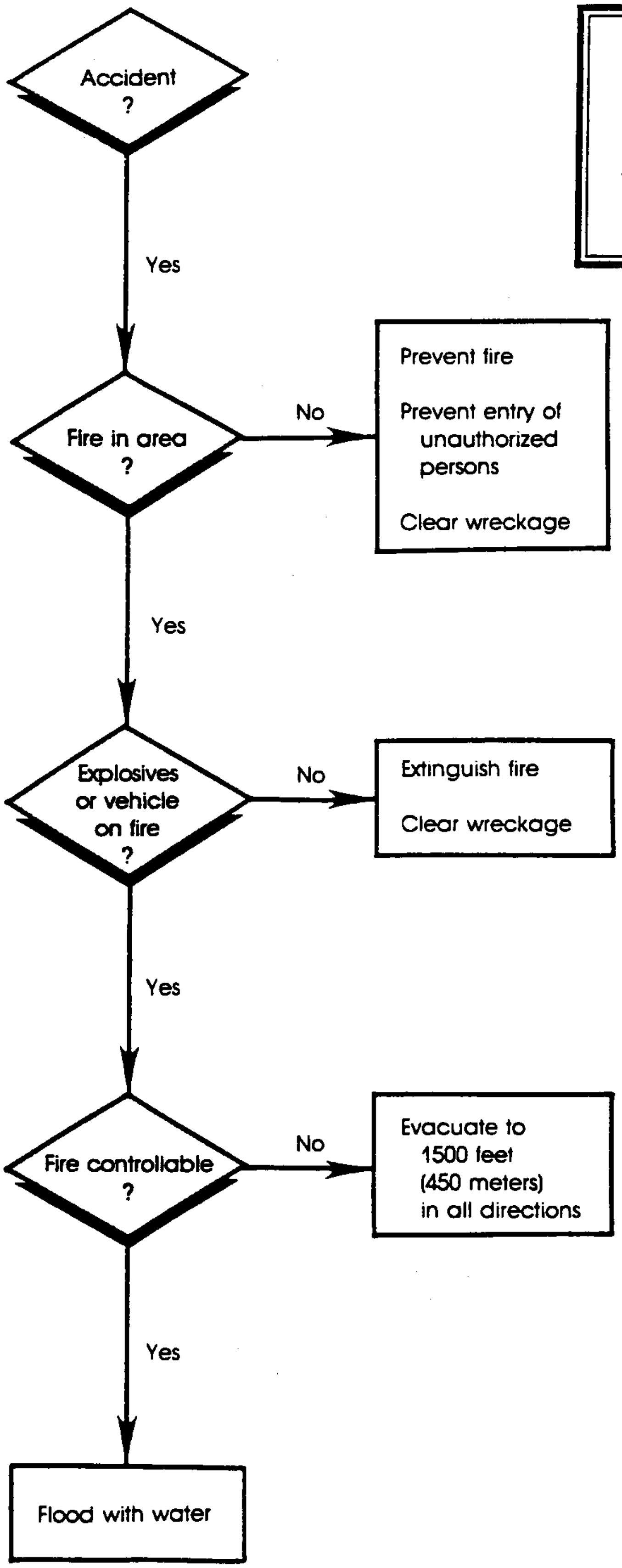


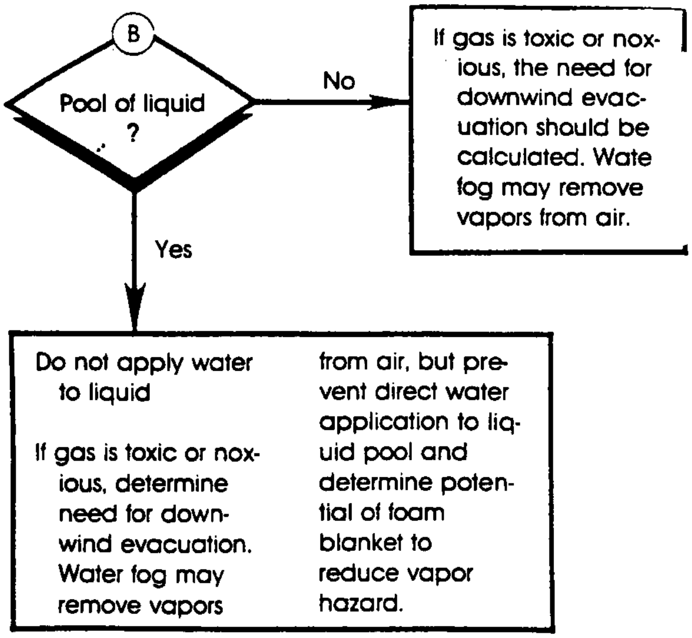
CLASS

CLASS "C" EXPLOSIVES

SIZE DIVISION 1.4

ALL

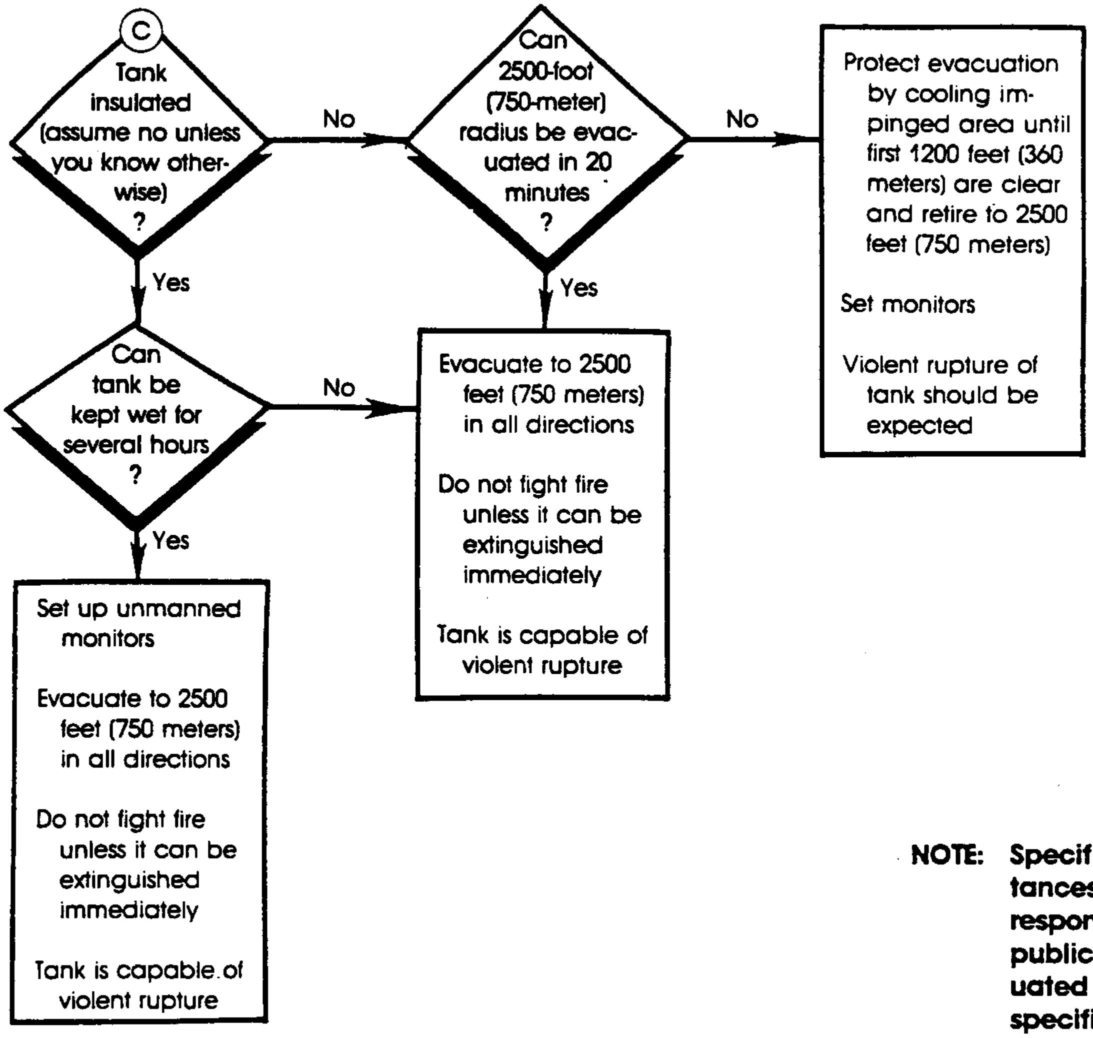




If gas is toxic or noxious, the need for downwind evacuation should be calculated. Wate fog may remove vapors from air.

Do not apply water to liquid

If gas is toxic or noxious, determine need for downwind evacuation. Water fog may remove vapors from air, but prevent direct water application to liquid pool and determine potential of foam blanket to reduce vapor hazard.



Protect evacuation by cooling impinged area until first 1200 feet (360 meters) are clear and retire to 2500 feet (750 meters)

Set monitors

Violent rupture of tank should be expected

Evacuate to 2500 feet (750 meters) in all directions

Do not fight fire unless it can be extinguished immediately

Tank is capable of violent rupture

Set up unmanned monitors

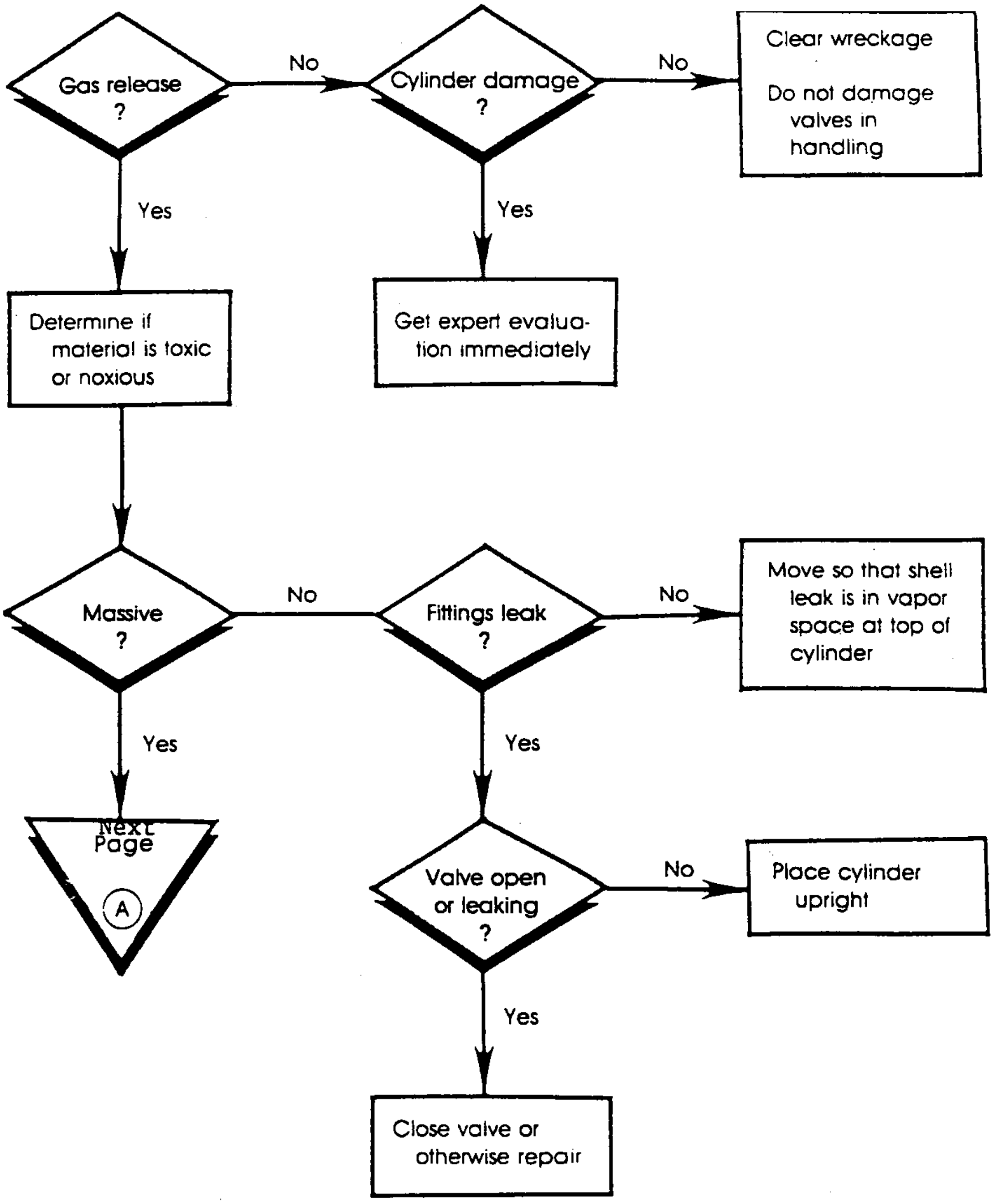
Evacuate to 2500 feet (750 meters) in all directions

Do not fight fire unless it can be extinguished immediately

Tank is capable of violent rupture

NOTE: Specified evacuation distances are for emergency response personnel. The public should be evacuated to double the specified distance.

CLASS
NONFLAMMABLE GAS
SIZE
CYLINDERS

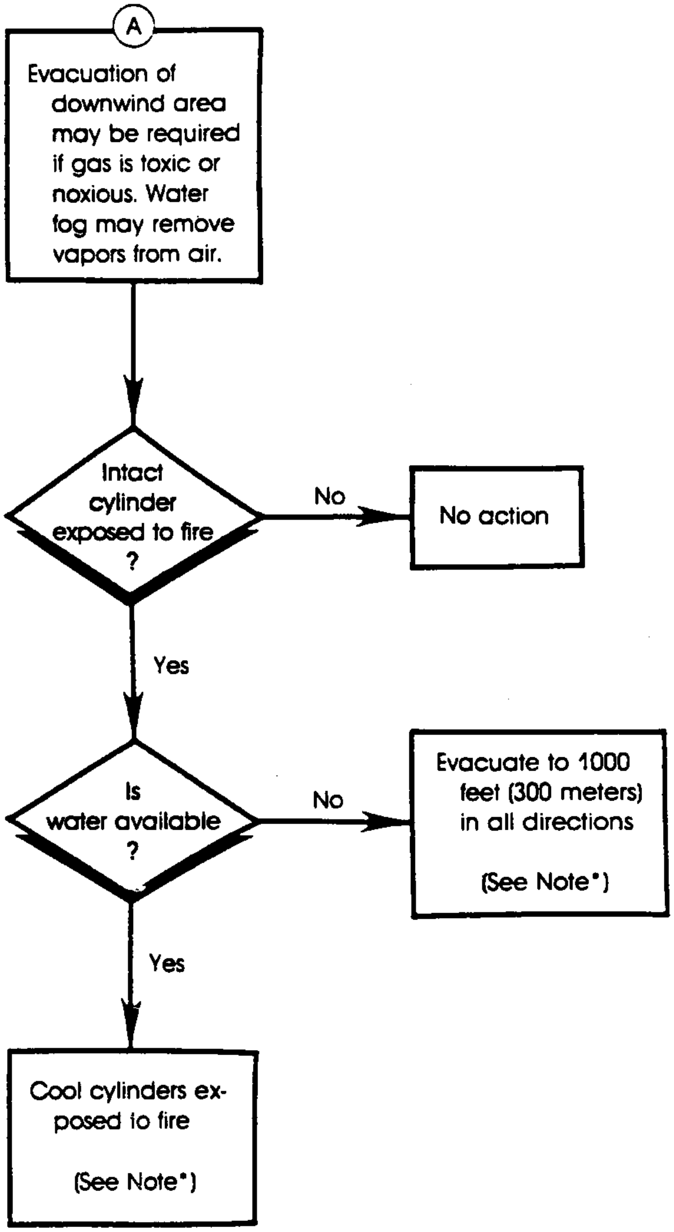


CLASS

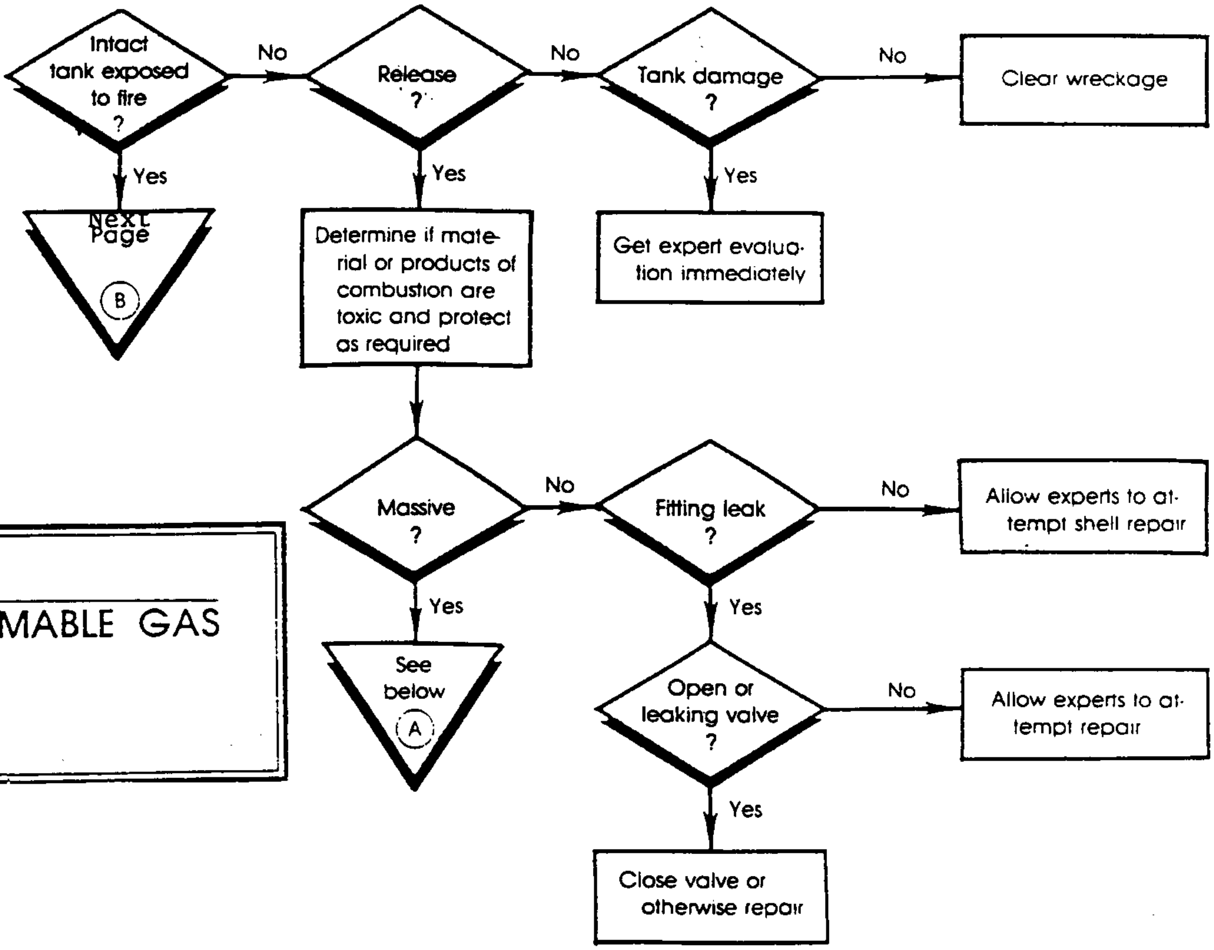
NONFLAMMABLE GAS

SIZE

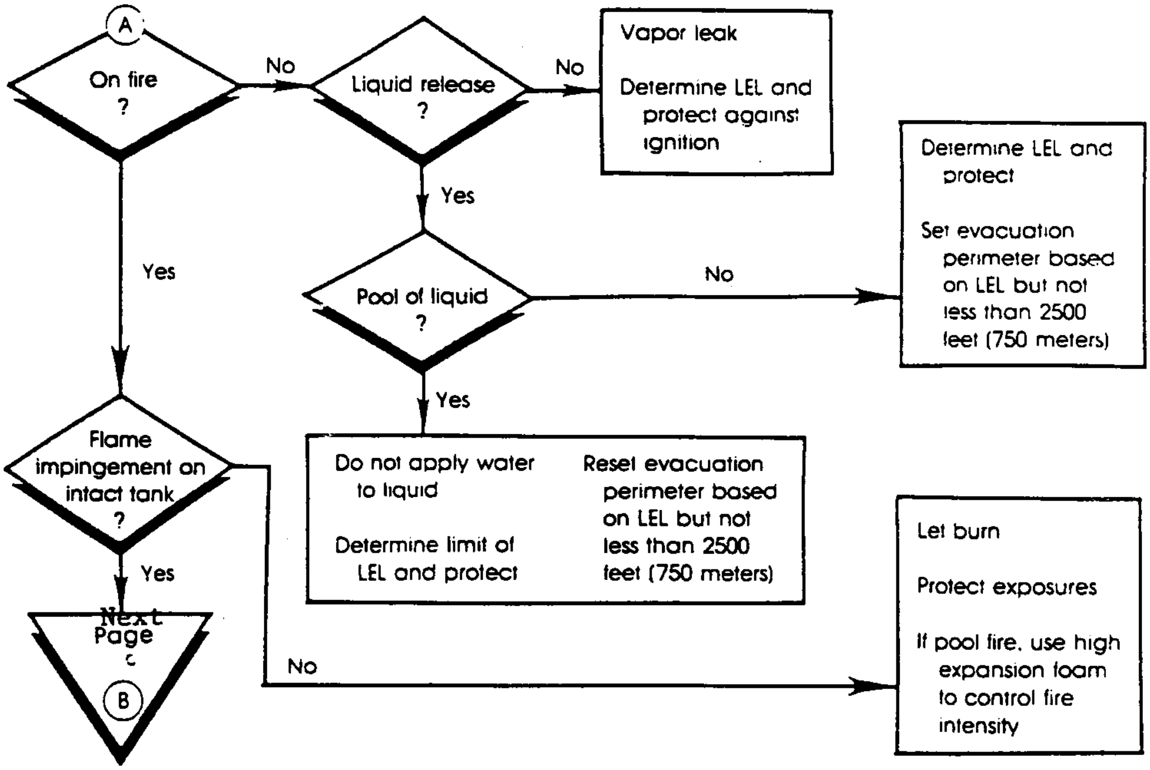
CYLINDERS



***NOTE:** **Cylinders are equipped with safety devices designed to prevent their rupture in a fire. Aerosol cans have no safety device.**

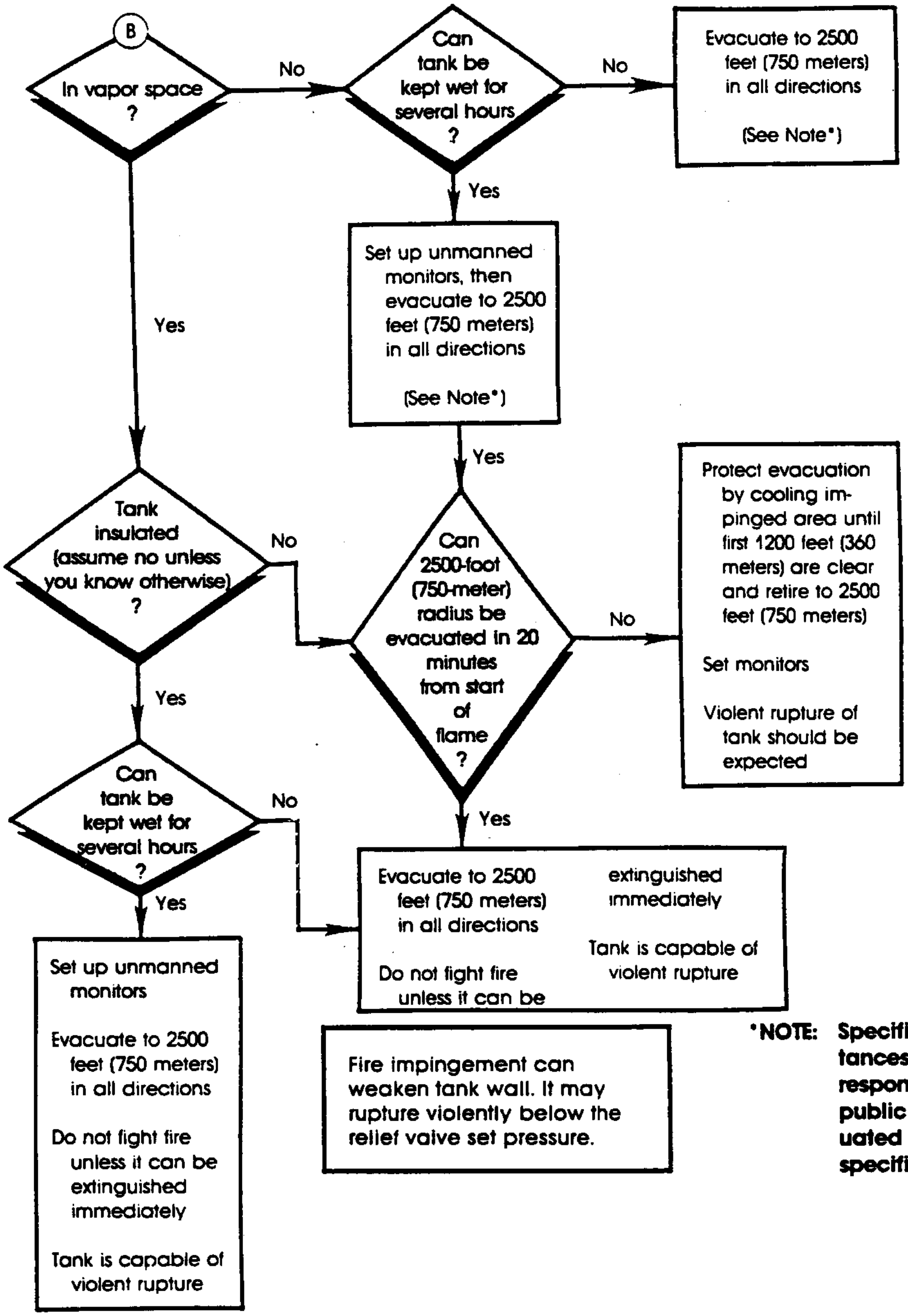


CLASS
FLAMMABLE GAS
SIZE
BULK



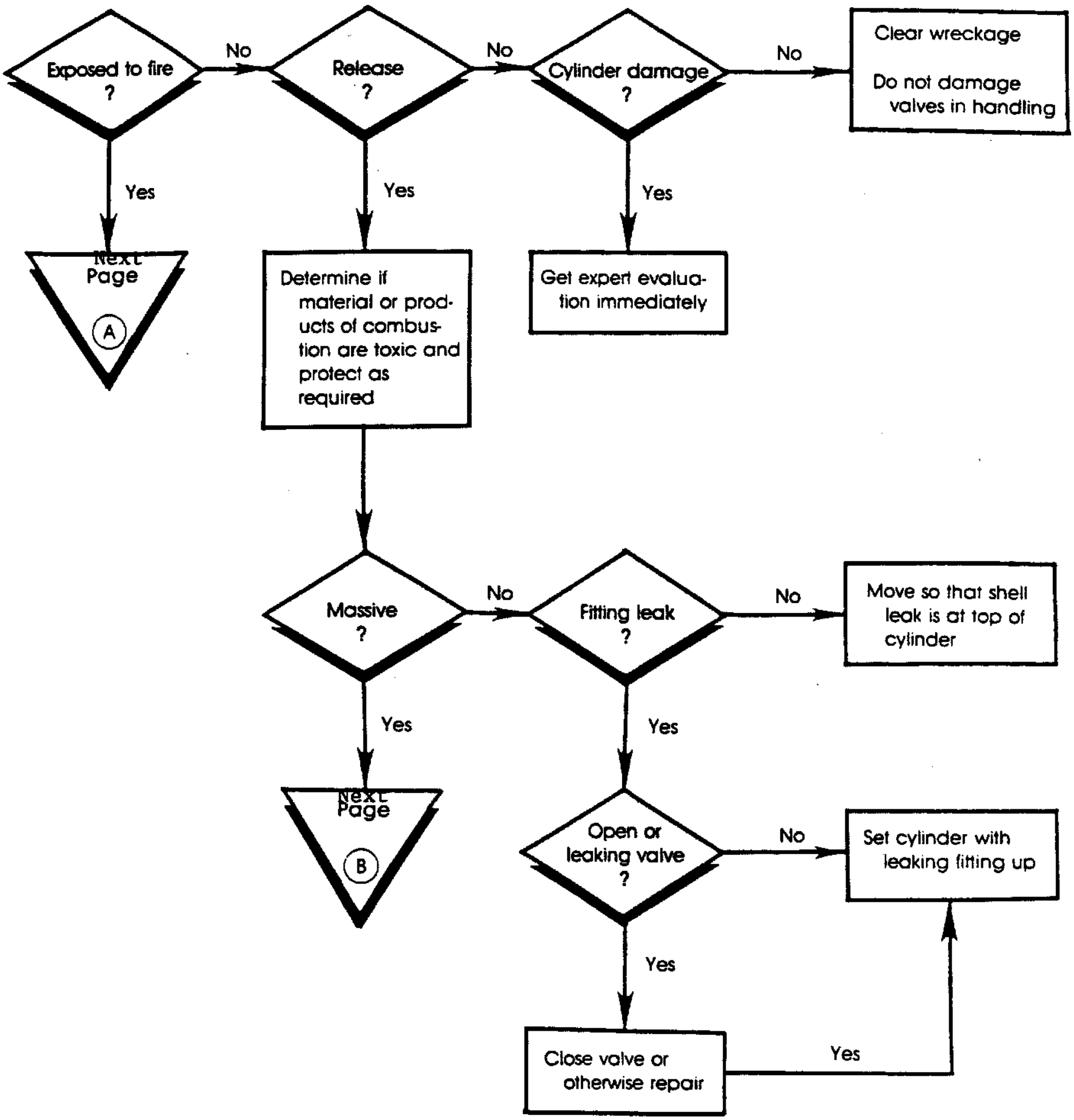
CLASS
FLAMMABLE GAS

SIZE
BULK



Fire impingement can weaken tank wall. It may rupture violently below the relief valve set pressure.

***NOTE: Specified evacuation distances are for emergency response personnel. The public should be evacuated to double the specified distance.**

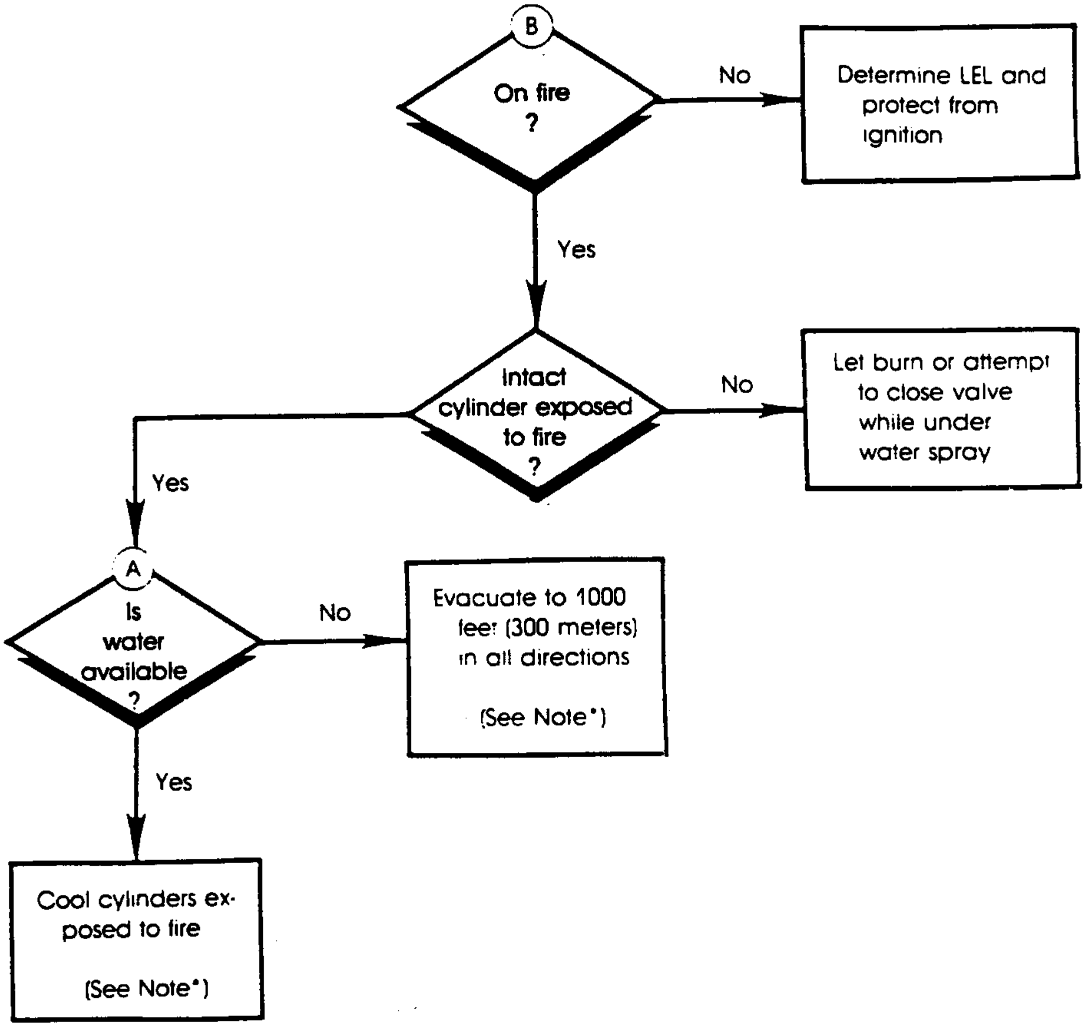

Exposed to fire ?
No
Release ?
No
Cylinder damage ?
No
Clear wreckage
Do not damage valves in handling
Yes
Yes
Yes
Next Page
A
Determine if material or products of combustion are toxic and protect as required
Get expert evaluation immediately
Massive ?
No
Fitting leak ?
No
Move so that shell leak is at top of cylinder
Yes
Yes
Next Page
B
Open or leaking valve ?
No
Set cylinder with leaking fitting up
Yes
Close valve or otherwise repair
Yes

CLASS

FLAMMABLE GAS

SIZE

PACKAGE (CYLINDERS)



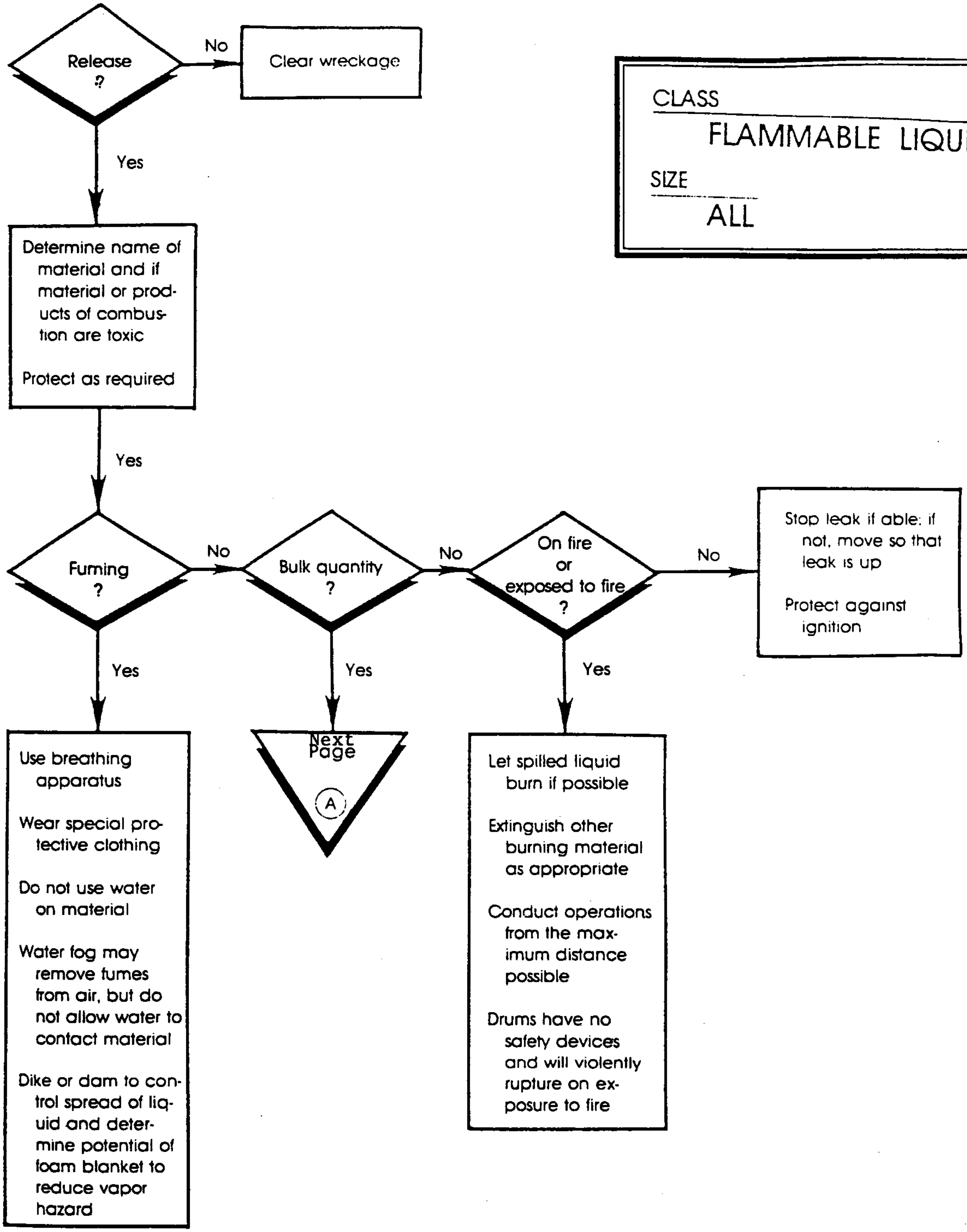
***NOTE:** **Cylinders are equipped with safety devices designed to prevent their rupture in a fire. Aerosol cans have no safety device.**

CLASS

FLAMMABLE LIQUID

SIZE

ALL

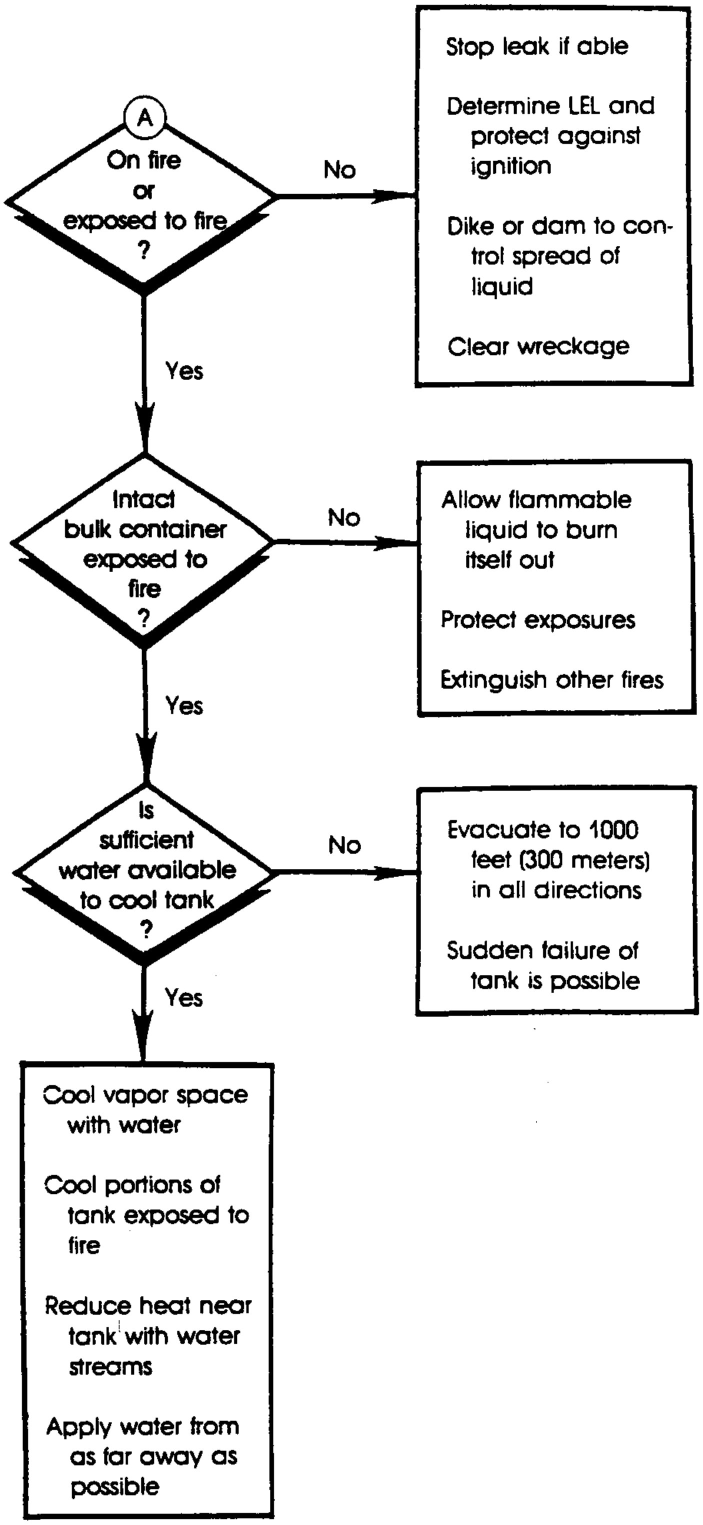


CLASS

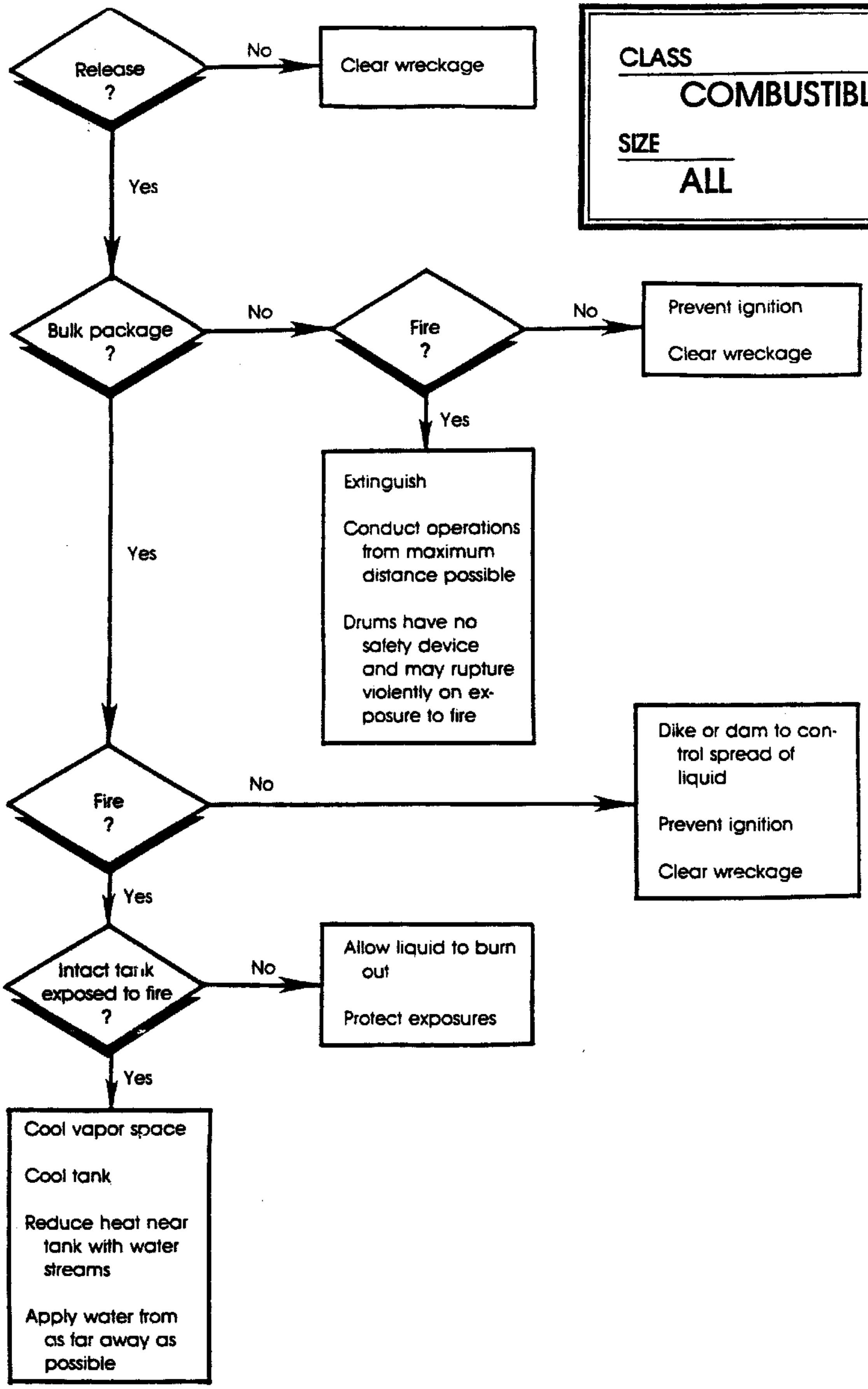
FLAMMABLE LIQUID

SIZE

ALL



CLASS
COMBUSTIBLE LIQUID
SIZE
ALL

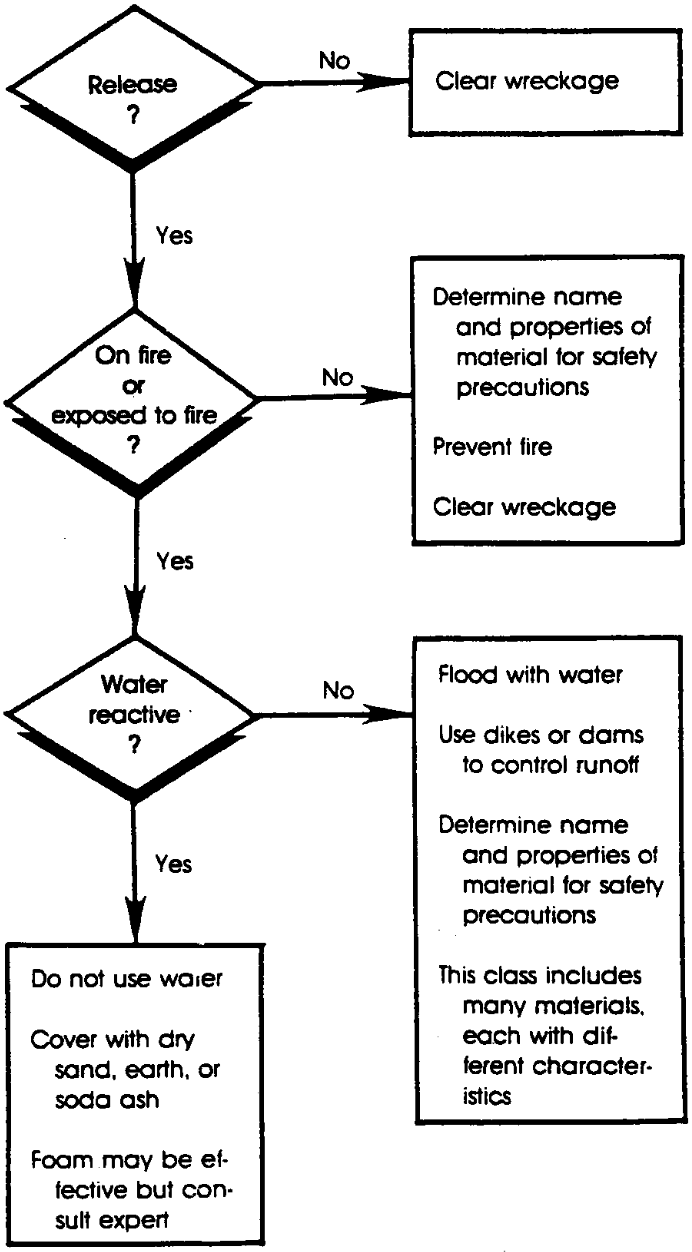


CLASS

FLAMMABLE SOLID

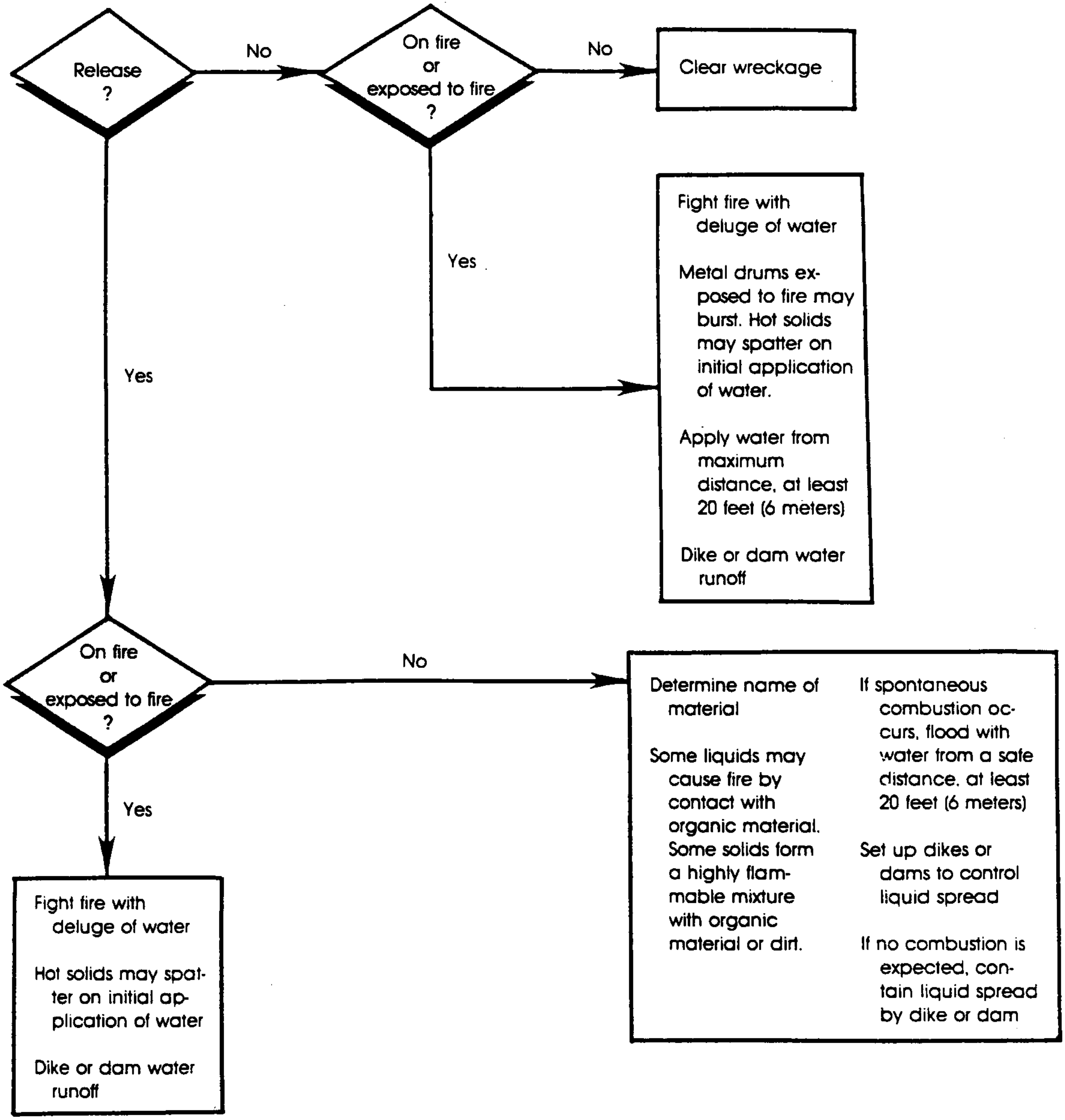
SIZE

ALL



CLASS
OXIDIZER

SIZE
ALL



Clear wreckage

Fight fire with deluge of water

Metal drums exposed to fire may burst. Hot solids may spatter on initial application of water.

Apply water from maximum distance, at least 20 feet (6 meters)

Dike or dam water runoff

Determine name of material

Some liquids may cause fire by contact with organic material. Some solids form a highly flammable mixture with organic material or dirt.

If spontaneous combustion occurs, flood with water from a safe distance, at least 20 feet (6 meters)

Set up dikes or dams to control liquid spread

If no combustion is expected, contain liquid spread by dike or dam

Fight fire with deluge of water

Hot solids may spatter on initial application of water

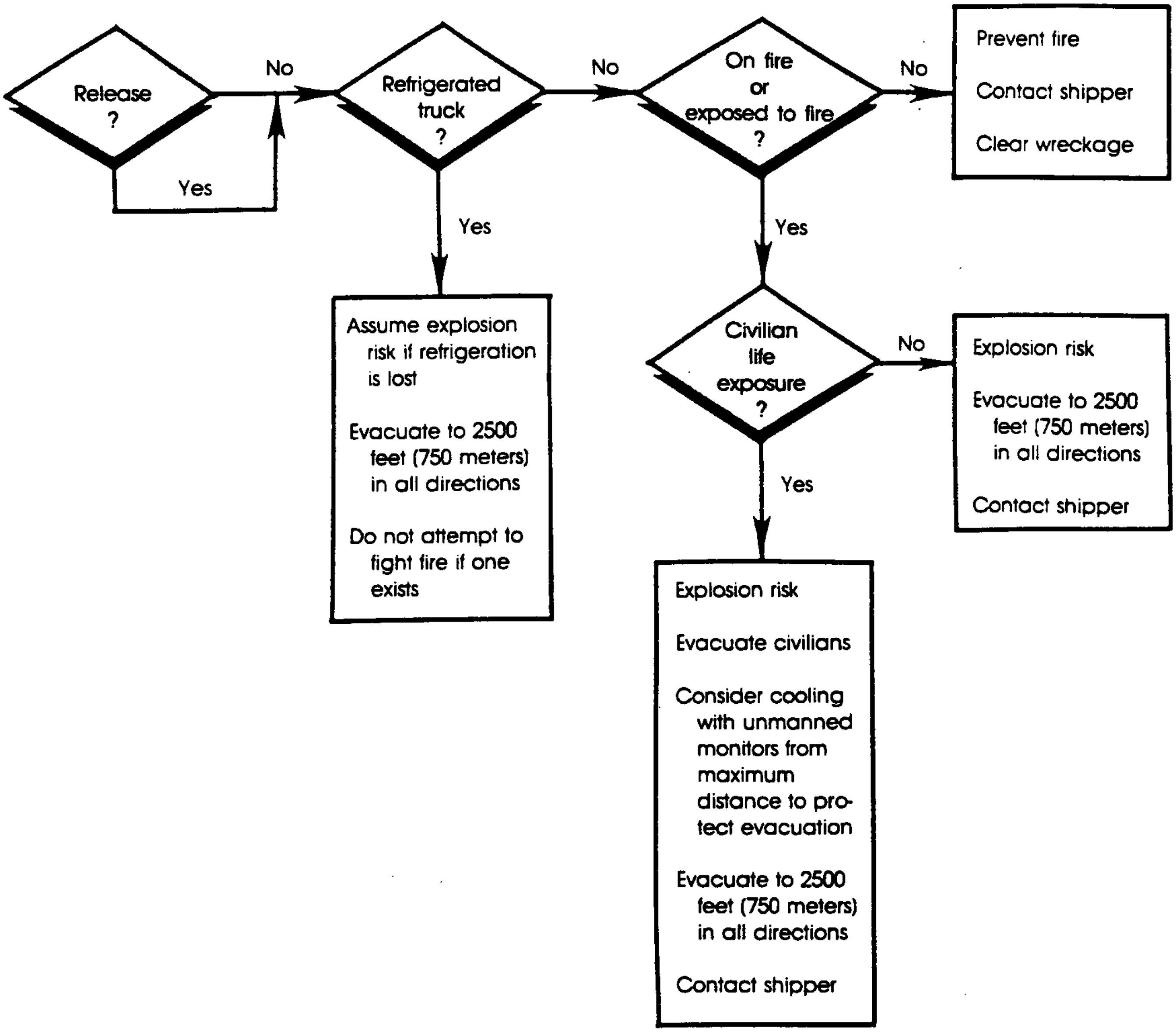
Dike or dam water runoff

CLASS

ORGANIC PEROXIDE

SIZE

ALL

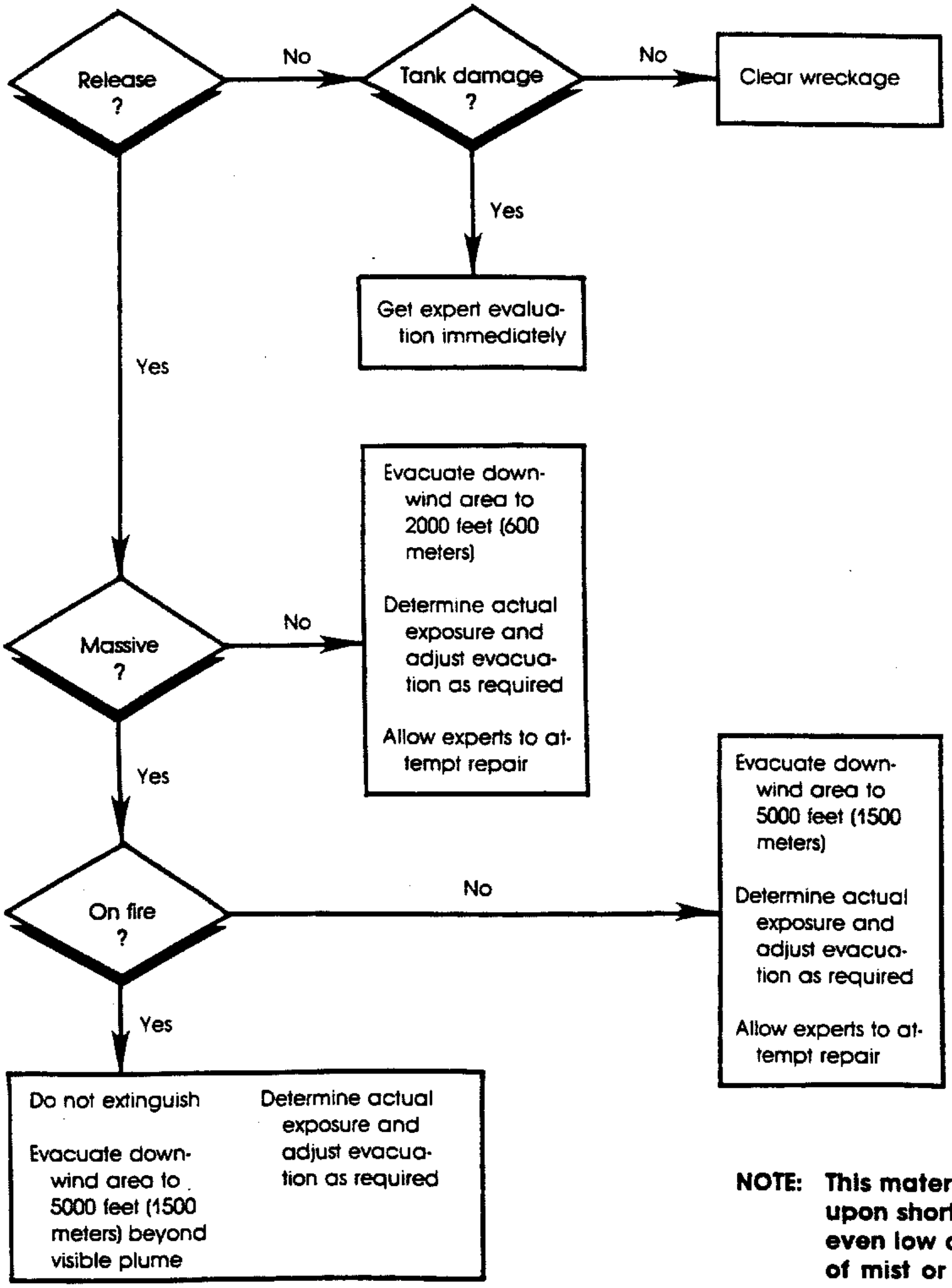


CLASS

POISON GAS

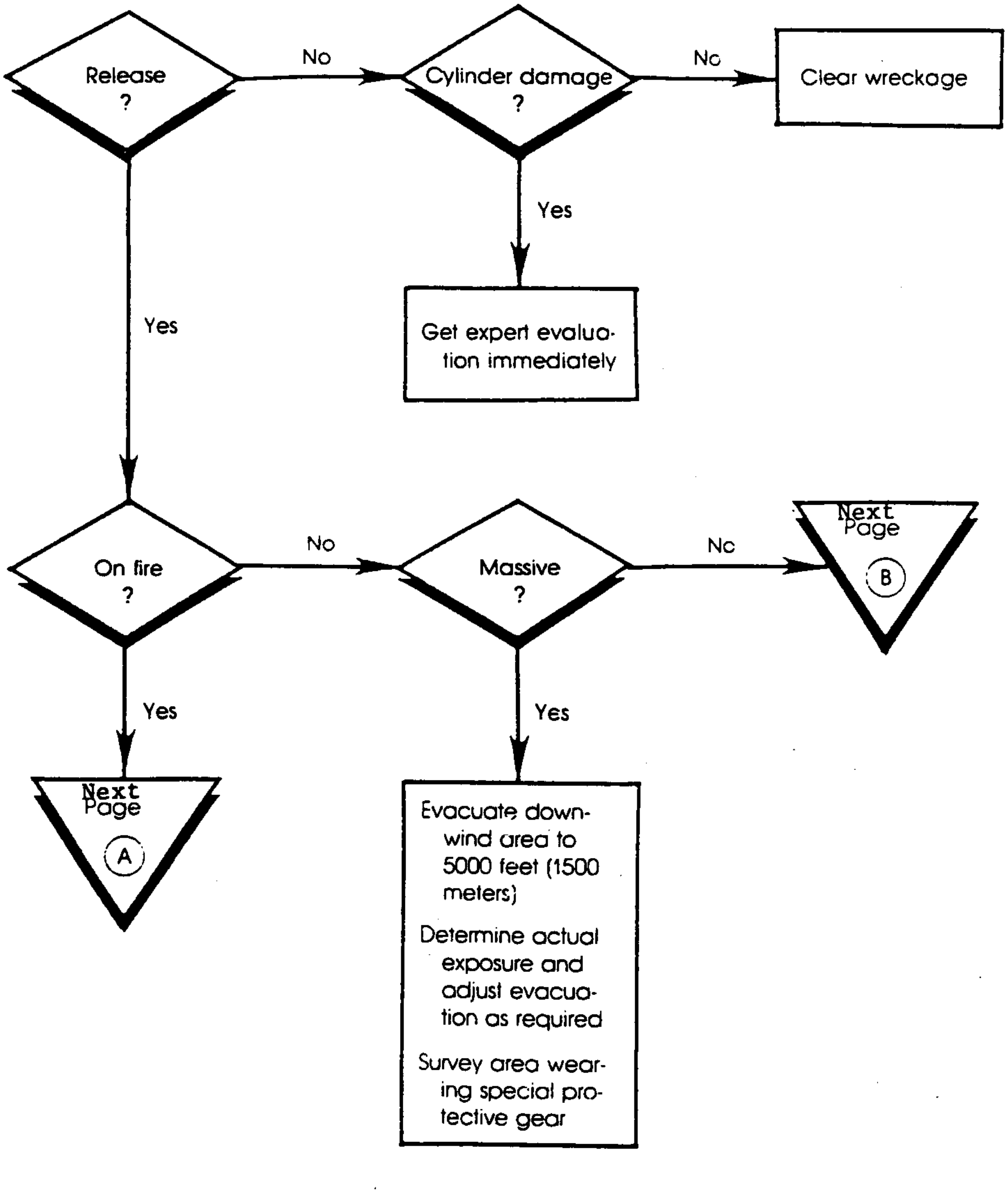
SIZE

BULK



NOTE: This material is fatal upon short exposure to even low concentrations of mist or vapor.

CLASS
POISON GAS
SIZE
CYLINDERS

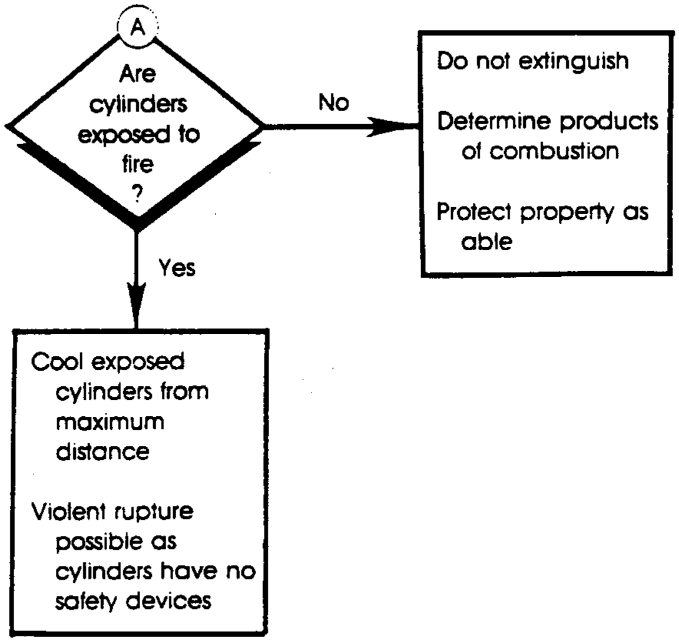


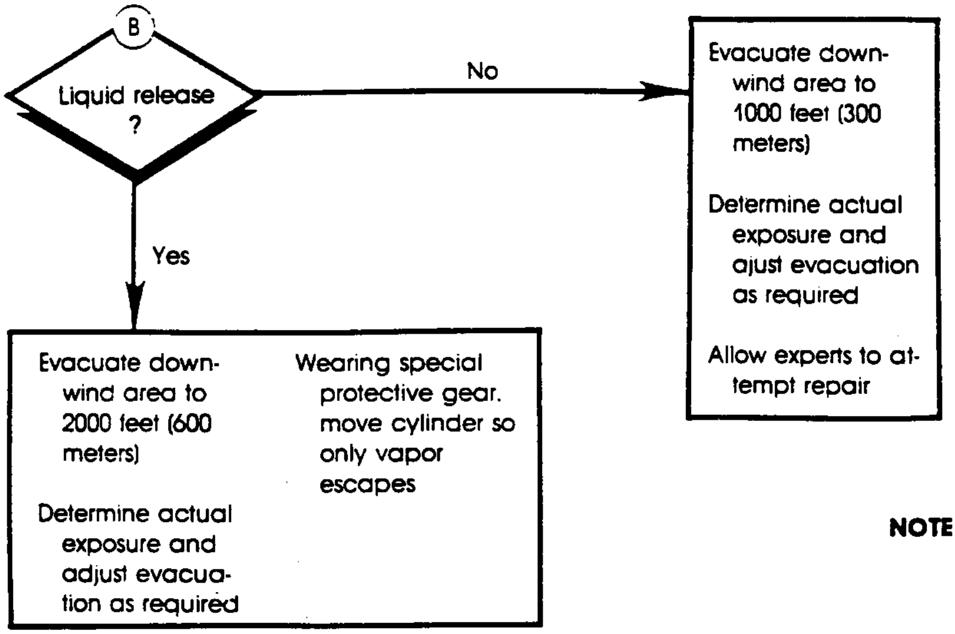
CLASS

POISON GAS

SIZE

CYLINDERS





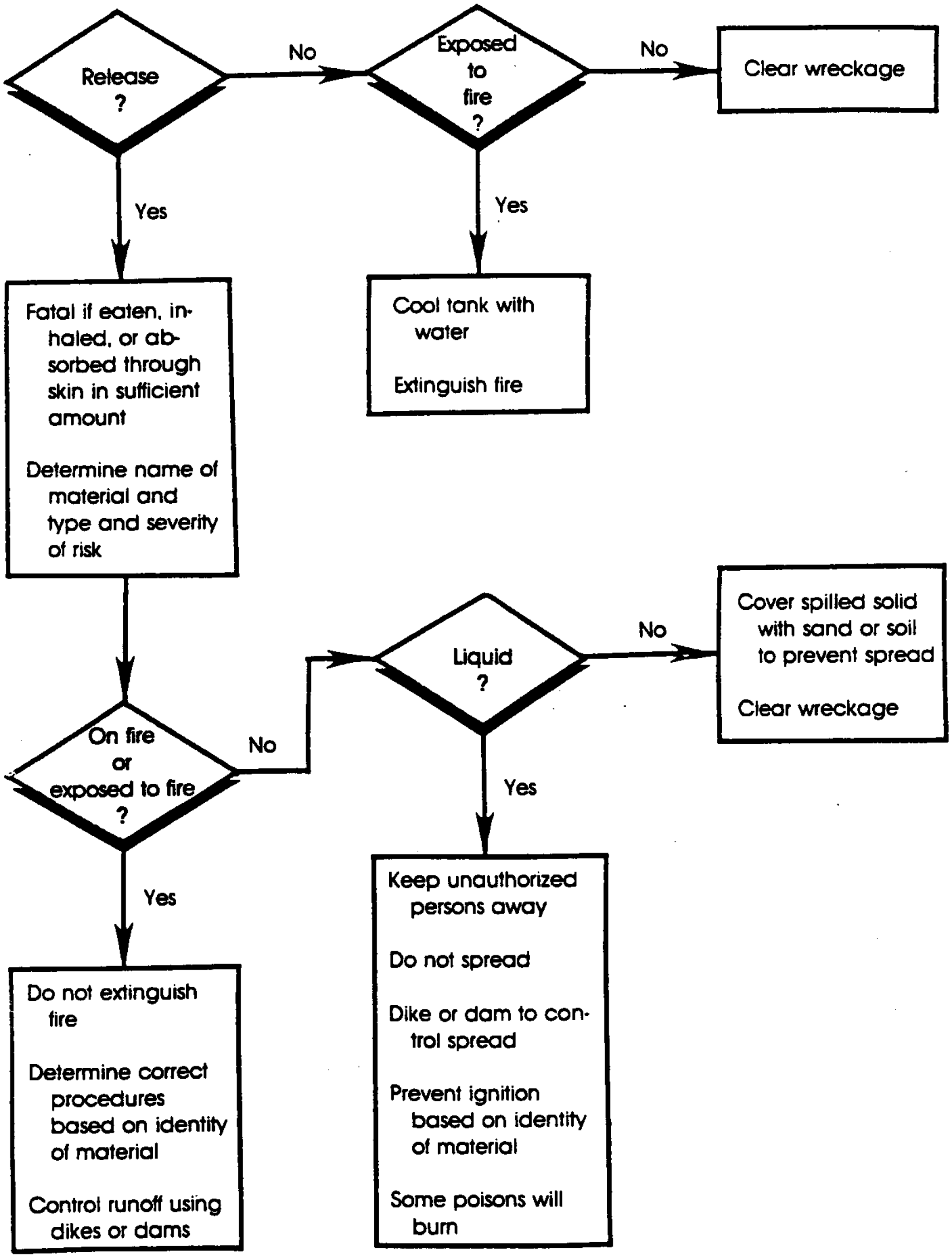
NOTE: This material is fatal upon short exposure to even low concentrations of mist or vapor.

CLASS

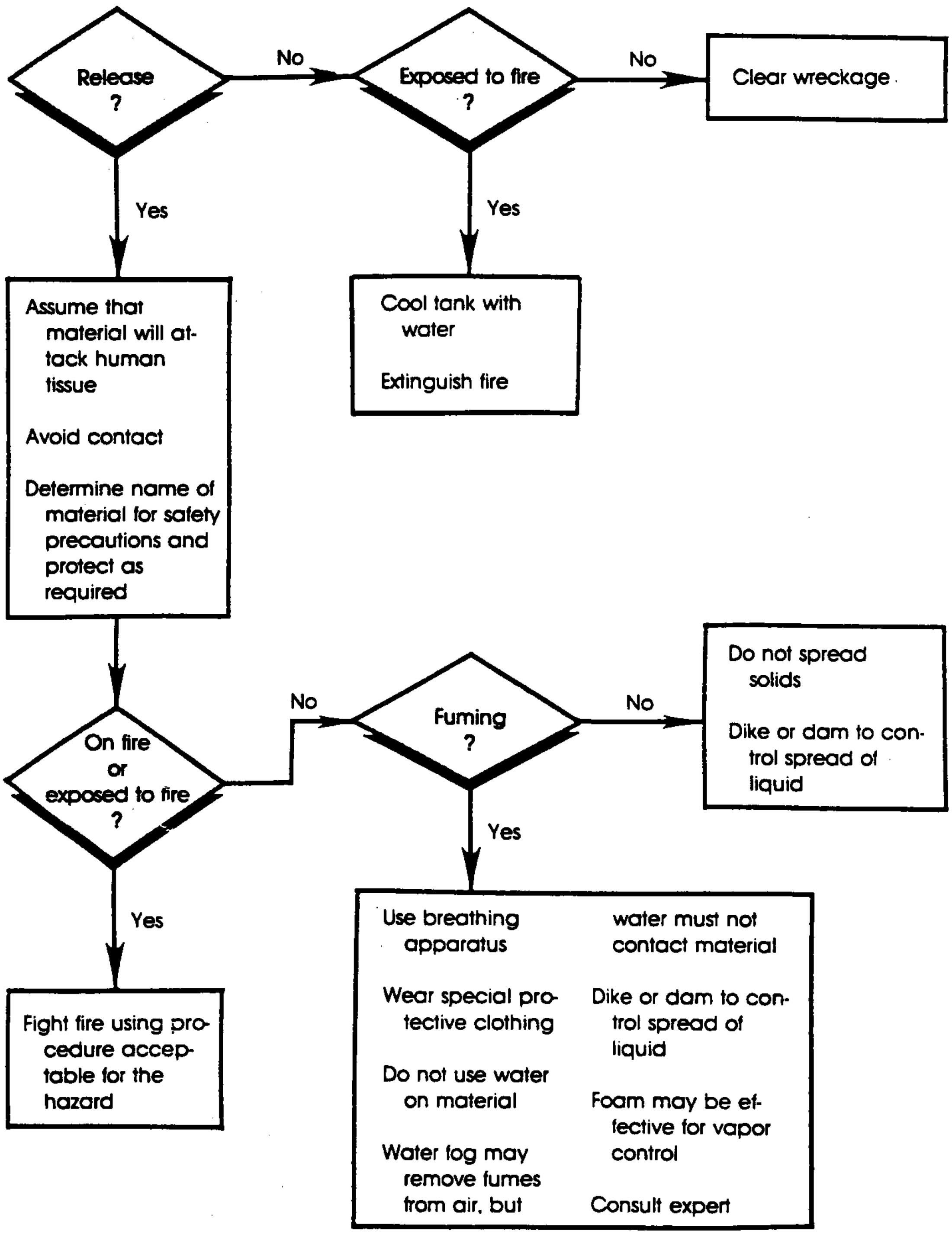
POISON B

SIZE

ALL

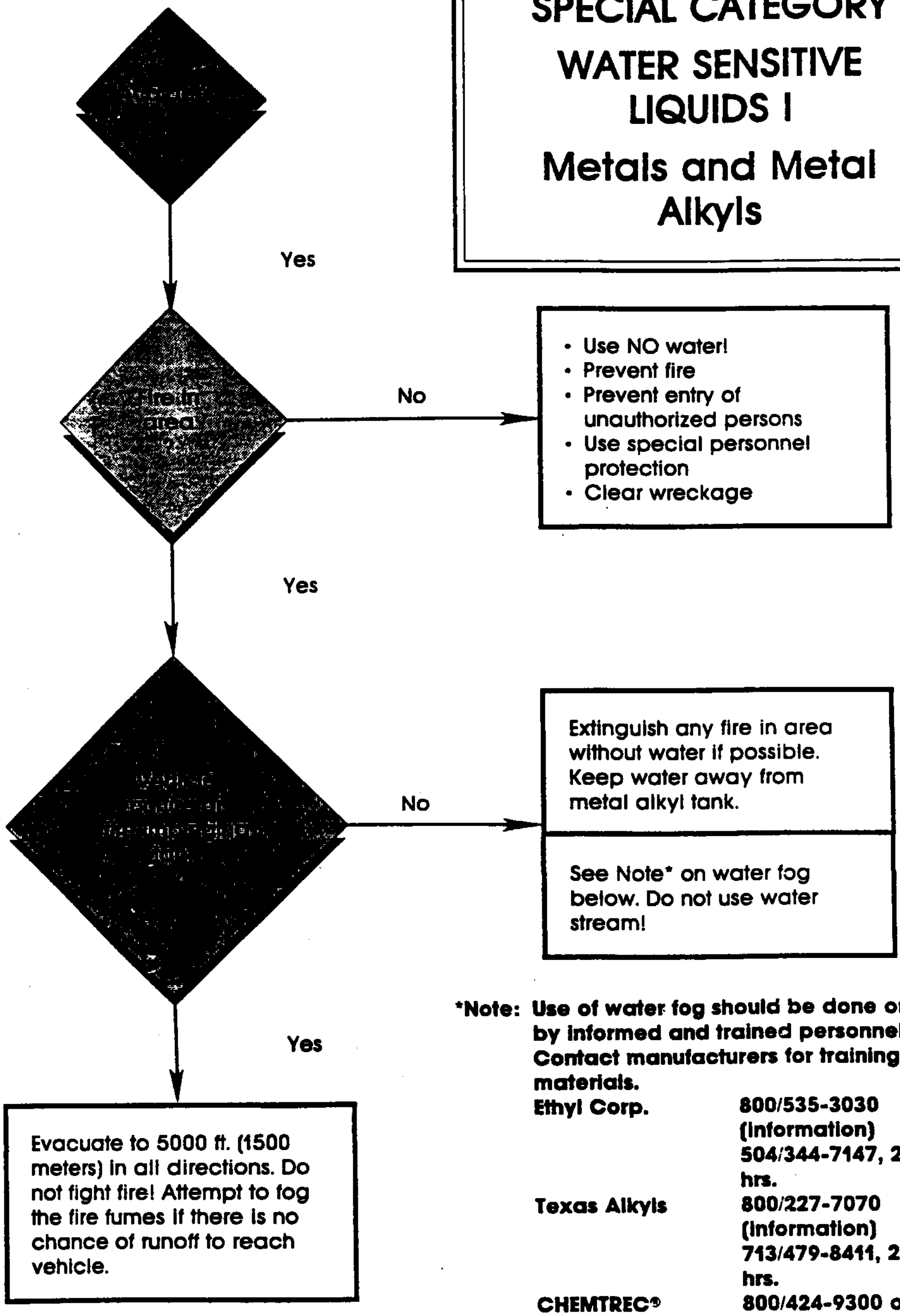


CLASS
CORROSIVE MATERIAL
SIZE
ALL



Corrosive Material

SPECIAL CATEGORY
WATER SENSITIVE LIQUIDS I
Metals and Metal Alkyls



- Use NO water!
- Prevent fire
- Prevent entry of unauthorized persons
- Use special personnel protection
- Clear wreckage

Extinguish any fire in area without water if possible. Keep water away from metal alkyl tank.

See Note* on water fog below. Do not use water stream!

Evacuate to 5000 ft. (1500 meters) in all directions. Do not fight fire! Attempt to fog the fire fumes if there is no chance of runoff to reach vehicle.

***Note: Use of water fog should be done only by informed and trained personnel. Contact manufacturers for training materials.**

Ethyl Corp.	**800/535-3030 (information) 504/344-7147, 24 hrs.**
Texas Alkyls	**800/227-7070 (information) 713/479-8411, 24 hrs.**
CHEMTREC®	**800/424-9300 or Call collect 202/483-7616**
CANUTEC	**Call collect 613/996-6666**

Appendices

APPENDIX A

RECORDKEEPING

Outline

- **Section 1—Pre-Incident**
- **Section 2—Alarm**
- **Section 3—On Site**
- **Section 4—Medical Monitoring**
- **Section 5—Post Incident**

APPENDIX A
RECORDKEEPING & THE TECHNICIAN'S ROLE IN THE INCIDENT COMMAND SYSTEM

Objectives

The student will be able to:

1. List each of the five (5) major functional areas of the Incident Command System.
2. List and describe two (2) command staff positions and their primary function.
3. List two (2) responsibilities of the functional areas.
4. Identify the functional area under which a Hazardous Materials Response Team operates.
5. List two (2) duties of the Hazardous Materials Team Safety Officer.
6. Describe four records needed to document safe operations at a site.
7. Describe four records that must be compiled before an incident occurs.
8. List and describe four areas of concern that must be addressed in post-incident records.
9. List two reasons why accurate records must be kept of hazardous materials incidents.
10. List six items to be assessed in pre-entry physical monitoring.
11. List three observed changes or physical complaints which require immediate cessation of work and physical assessment.

DEVELOPING AN INCIDENT COMMAND SYSTEM (ICS) HAZ MAT RESPONSE PLAN

The purpose of this module is to detail the unusual and unique characteristics of a hazardous material response and the required use of an Incident Command System. There are two basic hazardous material conditions which responders will respond:

A. A situation involving both a fire and hazardous material exposures.

B. A situation involving only chemicals and/or hazardous materials.

Utilization of resources is essential starting with the first response. An aggressive program of training in *recognition* and *identification* plus development/use of a *pre-incident plan* is paramount in bringing a hazardous material incident to a successful conclusion. Many incident notices may clearly identify a hazardous material response. A telephone call announcing a leaking tanker truck should automatically justify dispatching the Haz Mat team. Other alarms may not convey much information, other than an electronic alarm signal, and the first responders will be the fire fighters. The senior officer arriving on the scene may immediately detect the need for the Haz Mat team and dispatch a call for backup.

If the response plan does not cover response protocols, staging equipment, assigning resources, etc., the Haz Mat team may be seriously impeded. If the fire service should respond to a reported incident with a good deal of equipment and do not stage it properly, they may prevent the Haz Mat team from reaching the site. If the people with the training, equipment and personal protective clothing are delayed, the situation may be exacerbated and result in a major catastrophe.

> *Panama, February 1978* An evening train derailment in Fountain, Florida resulted in the rupture of a tank car of pressurized liquid chlorine. The expansion rate for this class of deadly material is over four hundred to one. Eight people died immediately and scores of others were seriously injured. The first response by a police officer and the train brakeman was accomplished by these individuals approaching the scene with handkerchiefs over their mouths. Fortunately this heroic act did not cost them their lives. After rescuing some disabled people a call was placed for a Haz Mat team. When daylight came and the Haz Mat team conducted a preliminary assessment of the train wreck the data beginning to emerge was terrifying. In addition to the chlorine, which have expanded and laying in a green cloud, the train had ammonium nitrate, petroleum products and other products that would contribute to an enormous detonation. A leaking propane tank car increased the possibility of a BLEVE. A response plan was formulated on the site. The Haz Mat team established monitoring points, formulated stabilizing efforts, and recruited other agencies for assistance. In addition to mitigating the hazards to life the material on the train had a potential for contamination of a nearby water supply for Panama City. The Haz Mat team was fully involved in this mitigation action for seven days.

Success is a tribute to the Haz Mat team that devoted tireless efforts, around the clock, to protecting the community. As described, this exhausted crew returned to Jacksonville in their yellowish-green clothing stinking of chlorine.

Good fortune is not a factor to be considered in the modern emergency response plans. The Haz Mat team will now leave a hazardous material emergency site as if they just came out of the shower. Part of the response plan must involve a vigorous decontamination program. Personnel must use and be provided with personal protective equipment of a nature to deal with the class of hazard encountered. The profiled train wreck occurred in a rural area and allowed for the formulation of a response plan “on-the-fly.” Pre-planning and the use of a response plan will assure a successful conclusion of an incident and “luck” will have very little to do with it.

In the response plan the student will note many similarities to the ICS. These are not redundant issues but both are important to the Incident Command System and the response plan. The flexibility in one system will naturally apply to the other. Other variables will exist depending on the resources within the community. Some localities may have major pieces of fire apparatus, including helicopters or fire boats, while others must do with much less. Obviously the plan must be developed around the realistic equipment resources.

COMMAND

The response plan shall clearly identify the individuals to serve as senior officers in a Haz Mat incident. Naturally this position is occupied depending on who was on duty at the time. In certain incidents more senior officers may arrive after the mitigation and containment operations are underway. The plan shall provide for transfer of command and the criteria for determining this. A senior officer should not assume command simply because of his higher position. The identified senior Haz Mat team official shall have command of the site while more senior officials may direct support operations such as community evacuations, communications, public relations, etc. The technical operations must remain under the direction of the trained members of the service.

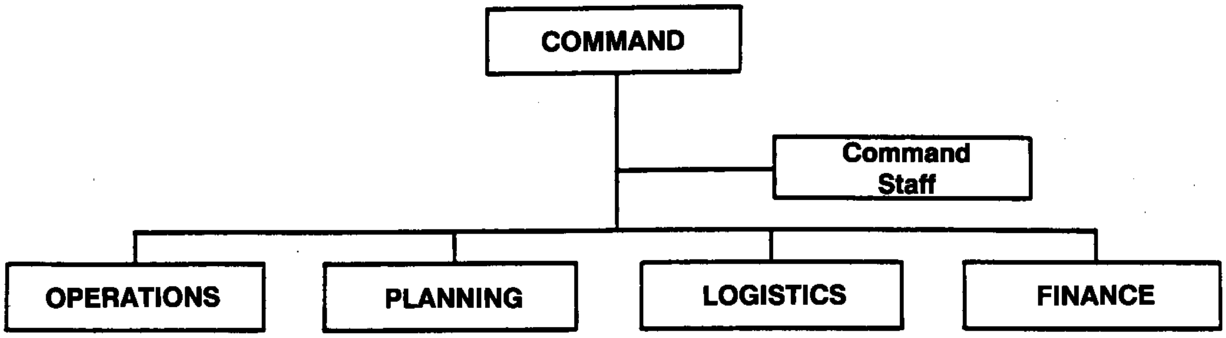
THE TECHNICIAN'S ROLE IN THE INCIDENT COMMAND SYSTEM

ORGANIZATION AND OPERATIONS

The ICS organization has five major functional areas. The functional areas are:

- Command
- Operations
- Planning
- Logistics
- Finance

INCIDENT COMMAND SYSTEM



These functional areas and their Units are described in the following pages.

COMMAND

Command is responsible for overall management of the incident. Command includes certain staff functions required to support the command function. The command function within the ICS may be conducted in two general ways.

- Single Command
- Unified Command

COMMAND STAFF

Command staff positions are established to assume responsibility for key activities which are not a part of the line organization. In ICS, three specific staff positions are identified:

- Information Officer
- Safety Officer
- Liaison Officer

Additional positions might be required, depending upon the nature and location of the incident, or requirements established by Incident Command.

INFORMATION OFFICER

The Information Officer's function is to develop accurate and complete information regarding incident cause, size, current situation, resources committed, and other matters of general interest. The Information Officer will normally be the point of contact for the media and other governmental agencies which desire information **directly from the incident**. In either a single or unified command structure, only one Information Officer is designated. Assistants may be assigned from other agencies or departments involved in the incident.

SAFETY OFFICER

The Safety Officer's function at the incident is to assess hazardous and unsafe situations and develop measures for assuring personnel safety. The Safety Officer should have emergency authority to stop and/or prevent unsafe acts. In a unified command structure, a single Safety Officer is designated. Assistants may be required and may be assigned from other agencies or departments making up the unified command.

Note: The haz mat team(s) is required to have a safety officer. The team(s) safety officer(s) will report to the hazardous materials officer. The characteristics of the incident situation will dictate how to structure the ICS positions.

LIAISON OFFICER

The Liaison Officer's function is to be a point of contact for representatives from other agencies. In a single command structure, the representatives from assisting agencies coordinate their efforts through the Liaison Officer. Under a unified command structure, representatives from agencies not involved in the unified command would coordinate through the Liaison Officer. Agency representatives assigned to an incident should have authority to speak on all matters for their agency.

ORGANIZATION OF INCIDENT TACTICAL OPERATIONS

Tactical operations at the incident include all activities which are directed toward reduction of the immediate hazard, establishing situation control, and restoration of normal operations.

The types of incidents for which the ICS is applicable are varied. They include such events as major wild and urban fires, floods, hazardous substance spills, nuclear accidents, aircraft accidents, earthquakes, hurricanes, tornadoes, tsunamis, and war-caused disasters.

Because of the functional unit management structure, the ICS is equally applicable to small incidents or normal operations. Basically, once the ICS operating concepts are adopted by an agency, the system structure will develop in a natural fashion based upon incident requirements.

The agencies which can make use of the ICS include federal, state and local. All may be working together or they may be working in combinations. The types of agencies could include fire, law enforcement, health, public works, emergency services, etc.; either working all together or in combinations depending upon the situation. Incidents may involve private individuals, companies, or organizations, some of which may be fully trained and qualified to participate as partners in the ICS. There are many ways in which incident tactical operations may be organized. The specific method selected will depend upon:

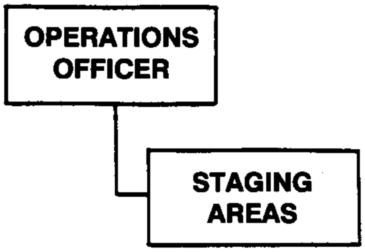
- The type of incident
- The agencies involved
- The objectives and strategies selected

OPERATIONS OFFICER

The Incident Operations Officer is responsible for the direct management of all incident tactical activities. The Officer assists in the formulation of the action plan. The Operations Officer may have deputy positions. In multi-jurisdictional situations, use of deputies from other agencies is encouraged. Deputies should be as qualified as the Operations Officer. An Operations Officer should be designated for each operational period, and that Officer should have direct involvement in preparing the action plan for that period of responsibility.

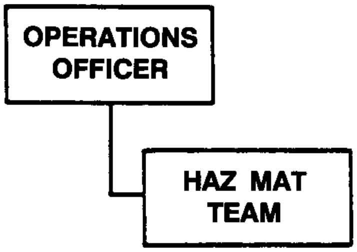
STAGING AREAS

Staging Areas are locations designated by the Operations Officer within the incident area which are used to temporarily locate resources which are available for assignment. The Operations Officer may establish, move, or discontinue the use of a Staging Area. All resources within the designated Staging Areas are under the direct control of the Operations Officer and all materials held there should be available within 3-minutes. Staging Area Managers must request logistical support (e.g., food, fuel, sanitation) from appropriate Logistics Section Units.



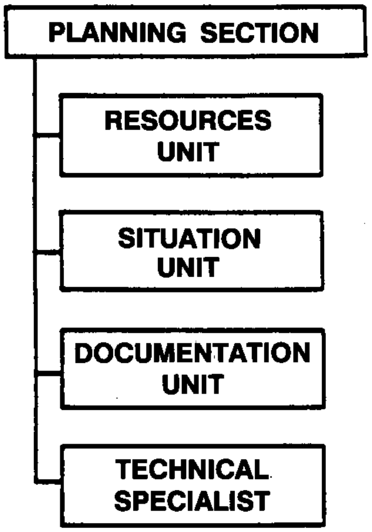
HAZ MAT TEAM

The Haz Mat Team(s) operates under the control of the Operations Officer. The number of Teams will depend primarily upon the size and nature of the incident.



PLANNING SECTION

The Planning Section is responsible for the collection, evaluation and dissemination of tactical information about the incident. The Section maintains information on the current and predicted situation, and on the status of resources assigned to the incident. The Section is also responsible for the preparation and documentation of action plans. The Section has four primary units and may have a number of technical specialists to assist in evaluating the situation and predicting requirements for additional personnel and equipment.



PLANNING SECTION OFFICER

The Planning Section Officer is responsible for the gathering and analysis of all data regarding incident operations and assigned resources, developing alternatives for tactical operations, conducting the planning meetings, and preparing the action plan for each operational period.

DEMOBILIZATION UNIT

The Demobilization Unit is responsible for developing an Incident Demobilization Plan. The plan should include specific demobilization instructions for all overhead and resources which require demobilization. (Note: many city and county agencies do not require specific demobilization due to their local nature.) The Demobilization Unit must also ensure that the plan, once approved, is distributed both at the incident and to necessary off-incident locations. It is appropriate for Demobilization Planning to begin early in the incident, particularly in developing rosters of personnel and resources, and to obtain any missing information from the incident check-in process.

LOGISTICS SECTION

The Logistics Section is responsible for providing all support needs for the incident (except air). The Logistics Section orders all resources from off-incident locations. It also provides facilities, transportation, supplies, equipment maintenance and fueling, feeding, communications, and medical services.

FINANCE SECTION

The Finance Section is responsible for meeting departmental or other agencies' fiscal or budget needs. This might mean merely documenting the amount of fuel used and completing a fire report. It can extend into very complex areas of purchasing, renting, or paying on more complex incidents.

THE TECHNICIAN'S ROLE IN THE INCIDENT COMMAND SYSTEM

The functional areas of the hazard branch in the incident command system include the following positions:

- Safety
- Operations
- Information/Research
- Resources
- Decontamination
- Entry/Reconnaissance

SAFETY

The **Safety** function is similar to that of the safety officer in the command staff. Safety in the hazard section is not discretionary. Safety is a dedicated function to the hazardous materials team, whose primary duties may include the proper selection of protective equipment and clothing. The technician ensures that once the protection level is established, each member and back-up of the entry team is properly dressed. The technician insures that medical monitoring has been performed prior to donning SCBAs and post decontamination and that the entry log is complete. The technician may ensure that the decontamination line is properly placed and ready. The technician may perform team monitoring and maintain radio or visual communications (with hand signals) with the team(s). Haz Mat teams are encouraged to develop a Safety Officer checklist to assist in meeting local SOPs.

OPERATIONS

The **Operations** function is to continually monitor the incident to determine that the action plan, as it relates to the hazard branch, has the resources available, is using the proper tactics, and will bring the incident to a successful conclusion. It ensures that all other functions are being properly executed and are ready to proceed on the established action plan.

INFORMATION/RESEARCH

The **Information/Research** function is to gather and process information from individuals or technical specialists at the incident. The function may also include researching specific chemicals or materials using reference manuals and databases carried with or available to the team.

RESOURCES

The **Resource** function is to provide information on the available equipment and personnel that may be needed or called in from nearby to assist in the incident. Such resources may include specialized material, equipment, or devices (such as soda ash, oil absorbing compounds or materials, floating boom skimmers, vacuum trucks, specialized chemical protective clothing, etc.). This information may come from pre-incident plans, contingency plans, or resource lists.

DECONTAMINATION

The **Decontamination** function is to remove harmful or unwanted material from personnel or equipment. The primary duty may include establishing a decontamination line for the entry team. Once a material has been identified (or its identity is narrowed down to a few possibilities), personal protective equipment is selected for use. The decontamination protocol is established and assigned personnel position the decontamination equipment and prepare for operations.

ENTRY/RECONNAISSANCE

The **Entry/Reconnaissance** function is to enter the hazard area or hot zone. Working in pairs, entry personnel may be assigned to specific tasks or to perform reconnaissance to gather additional information. Entry/Reconnaissance includes a back-up team ready to enter in the event of an emergency. Their function is to be ready in protective clothing similar to or better than that of the entry team to remove or rescue the entry/reconnaissance team(s).

TECHNICAL SPECIALISTS

The ICS is designed to function in a wide variety of incidents. In addition to the four designated units, the Planning Section may have Technical Specialists who may be called upon depending on the needs of the incident.

Technical Specialists assigned to the Planning Section may report directly to the Planning Section Officer; may function in an existing Unit (e.g., a fire behavior specialist and meteorologist could be made a part of the Situation Unit); or may form a separate Unit within the Planning Section depending upon the requirements of the incident and the needs of the Planning Section Chief. It is also possible that Technical Specialists could be reassigned to other parts of the organization (e.g., to Operations on tactical matters or Finance on fiscal matters).

Generally, if a type of expertise is needed for only a short time and will normally be only one person, that person should be assigned to the Situation Unit. If the expertise will be required on a long term basis and may require several persons, it may be advisable to establish a separate Unit in the Planning Section. For example, if extensive fire behavior planning will be required over several days, Technical Specialists (e.g. fire behavior specialists and a meteorologist) may be formed in a Fire Behavior Unit.

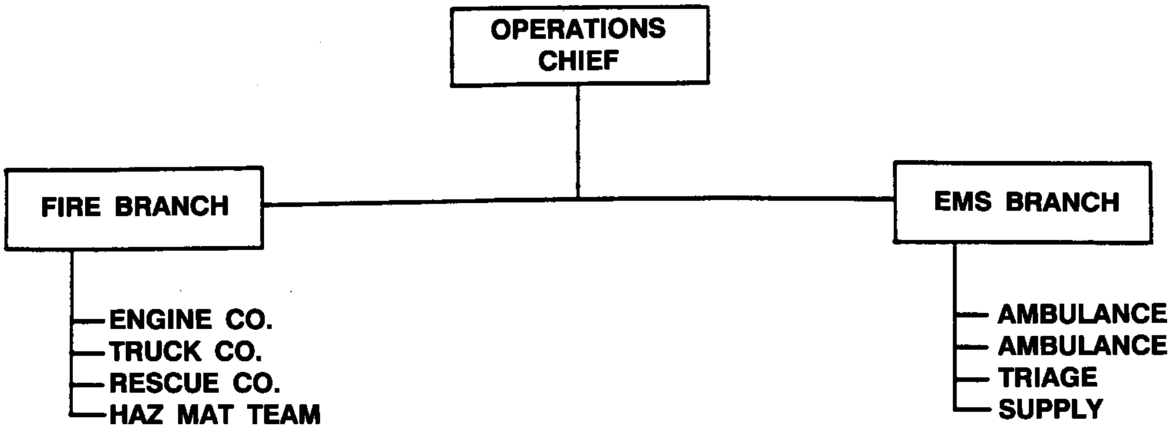
The incident itself will dictate the need for Technical Specialists. Lised below are examples of the specialists who may be required:

- Fire Behavior Specialist
- Meteorologist
- Environmental Impact Specialist
- Resource Use and Cost Specialist (e.g., crews, plows, bulldozers, etc.)
- Flood Control Specialist
- Water Use Specialist
- Toxic Substance Specialist(s)
- Fuels and Flammables Specialist
- Nuclear Radiation Fallout Specialist
- Structural Engineer
- Training Specialist
- Chemnet (Industry representative)

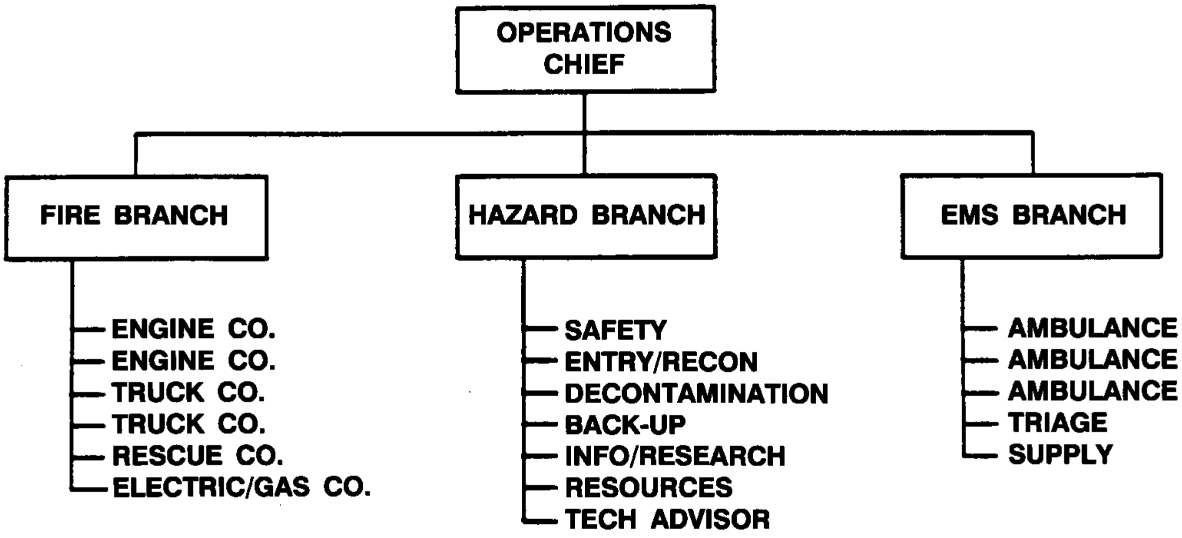
TECHNICIAN'S ROLE IN THE INCIDENT COMMAND SYSTEM

In the following examples, different ways of organizing incident tactical operations are shown and described. In some cases, the organization will be determined by jurisdictional boundaries. In other cases, a mix of functional/geographical considerations may be appropriate. The incident command system offers flexibility in determining the right approach to an incident.

Major Organizational Elements in Incident Tactical Operations



Simple format with Haz Mat Team in the Fire Sector



Variation of ICS with Haz Mat Team in Hazard Sector

RECORDKEEPING

Recordkeeping cannot be overemphasized when dealing with Hazardous Materials. Your attention to forms and checklists will set the tone for the rest of the incident, including post-incident considerations. No one expects you to memorize all of the factors that are involved with a "Hazardous Materials Incident." Checklists can help you, if for no other purpose than to be a prompting form to assist you in remembering the order of actions, making assignments, and notifying agencies of importance. A written log of events can be invaluable and very necessary when completing reports, or if necessary, testifying in court.

You know how to get personnel and equipment to the scene of an emergency. Can you release those same resources in a logical sequence so that you don't deplete your reserves and cause confusion? Have you gathered your information so that you can complete your paperwork in a timely manner? Is the information that you gathered complete or will you spend hours on the phone? Will you hold a critique of the incident for the other personnel that were involved and add their input to yours? Did problems with equipment or critical systems appear that can be corrected or at least improved upon?

We have included a few basic form designs that you may find helpful when preparing your own. Many of these were designed by other Fire Departments and Emergency Organizations. If you come up with a form that is particularly good, please share it with others. We are all looking to improve!

Are YOU prepared to command a major incident and bring it to a successful conclusion?

Reporting Requirements

Section 1—Pre-incident

Training Records

Medical Records

Medical Surveillance Program

Respirator Fit Test

Equipment Maintenance Records

Monitoring Calibration Records

Pre-Incident

Incident recordkeeping begins long before the actual incident. Records are kept on both the individuals and equipment which will respond to an incident. This includes your department's training records for all courses and drills attended by members.

Medical records should be maintained. In addition to the medical surveillance reports that are required for Hazardous Materials Team Members, and the respirator fit test records for persons who will be using respirators.

Records should be kept for equipment as well, to show maintenance and inspection of each piece. Monitoring equipment needs to be calibrated on a routine basis, which also should be recorded.

PRE-FIRE PLANNING HAZARDOUS MATERIAL SURVEY FORM

ADDRESS ________________________________ DATE ______________

BRAND NAME ________________________________

CHEMICAL NAME ________________________________

TYPE OF MATERIAL ________________________________

CLASSIFICATION

1. ☐ FLAMMABLE LIQUID
2. ☐ FLAMMABLE GAS
3. ☐ FLAMMABLE SOLID
4. ☐ UNSTABLE MATERIAL
5. ☐ COMPRESSED GAS
6. ☐ LIQUEFIED GAS
7. ☐ WATER REACTIVE
8. ☐ COMBUSTIBLE METAL
9. ☐ CORROSIVE
10. ☐ POISON
11. ☐ RADIOACTIVE
12. ☐ OXIDIZING AGENT
13. OTHER ________________________________

____

STORAGE

AMOUNT (Lb., Gal., Bbls.) ________________________________

LOCATION AND STORAGE ________________________________

SEGREGATED BY ________________________________

PROTECTED BY ________________________________

REACTIVITY: How will this material react when

	EXPLODE	BURN RAPIDLY	GIVE OFF HEAT	TOXIC VAPORS
IN CONTACT WITH WATER				
IN CONTACT WITH HEAT				
IN CONTACT WITH AIR				
IN CONTACT WITH ORDINARY MATERIAL				
IN CONTACT WITH OXIDIZING MATERIAL				

TOXICITY: What effect this material or vapors have on the human body?

☐ TOXIC
☐ CHOKING
☐ NAUSEA
OTHER ________________________________

☐ CHEMICAL BURNS ON SKIN
☐ IRRITATION OF SKIN
☐ HEADACHE

☐ ASPHYXIATING
☐ TEAR PRODUCING
☐ IRRITATION OF EYES AND NOSE

FIRE SCENE INSTRUCTIONS

BREATHING APPARATUS REQUIRED

☐ YES
☐ NO

SKIN PROTECTION REQUIRED

☐ YES
☐ NO

FULL PROTECTIVE CLOTHING

☐ YES
☐ NO

IF MATERIAL IS ON FIRE OR INVOLVED IN FIRE: ________________________________

____

____

____

____

Section 2—Alarm

Reporting Requirements

A-310 Law

Confirmation of Information

Notification of NJDEP

Alarm

Upon receipt of an alarm that a hazardous materials incident has occurred, the type of response that your department makes will be based on the information you are able to obtain.

There are several methods through which the municipality, the county, or the New Jersey Department of Environmental Protection (NJDEP), may be advised of incidents involving the release or potential for release of hazardous substances pursuant to the Spill Compensation and Control Act (N.J.S.A. 58:10-23.11, et seq.) and regulations promulgated thereunder, and pursuant to the Hazardous Waste Discharge Reports and Notices Act (A-310 or N.J.S.A. 13:1K-17, et seq.).

Upon receipt of the initial report, each agency must immediately advise the other of the details of said incident. All immediate verbal notifications of environmental incidents are to be made through the NJDEP Environmental Action Line (609) 292-7172.

Additional notification to other government departments and agencies will be made on a case-by-case basis.

TD LOG # ________

Form DEQ-023A NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
10/67 DIV. OF ENVIRONMENTAL QUALITY—BUR. OF COMMUNICATIONS AND SUPPORT SERVICES
Phone: 609-292-7172

COMMUNICATIONS CENTER NOTIFICATION REPORT

CASE NO. ____ - ____ - ____ - ____
(Yr) (Mo) (Day) (Time)

DATE ____ - ____ - ____ *(Mo) (Day) (Yr)*
REC'D BY ____________ / ________ *(Initials)*
REVIEWED BY ____________

INCIDENT REPORT BY:
Name (Site) ____________ Phone ____________
Street ____________
City ____________ State ____________
Affiliation/Title ____________

INCIDENT LOCATION: ___ Transportation ___ Facility ___ Other
Name ____________ Phone ____________
Street ____________
City ____________ County ____________ State ____________ Zip Code ____________

Date of Incident: ____ - ____ - ____ *(Mo) (Day)* Time: ____________

IDENTITY OF SUBSTANCE(S) SPILLED, RELEASED, ETC.: ___ Known ___ Suspected ___ Unknown
Name of Substance(s) (Gas, Liquid, Solid): ____________
CAS Number: ____________
Amount Released/Spilled ____________ ___ Actual ___ Potential ___ Estimated
Substance Contained (Y/N/U)
Type of Release/Spill: ___ Terminated ___ Continuous ___ Intermittent

Hazardous Material (Y/N)

NATURE OF INCIDENT: ___ Complaint ___ Munic. Notification ___ Emergency ___ Facil. Notification

INCIDENT DESCRIPTION:
___ Fire ___ Explosion ___ Air?? ___ Spill ___ MVA ___ Derailment ___ Smoke/Dust
___ Odors ___ Sewage ___ NJPDES ___ Noise ___ Illegal Dumping ___ Wildlife
___ Equip Start-up/Shutdown, Equip Fail/??past, etc.
___ Other (specify) ____________

Injuries (Y/N/U)	Public Exposure (Y/N/U)
Facility Evacuation (Y/N/U)	Police at Scene (Y/N/U)
Public Evacuation (Y/N/U)	Firemen at Scene (Y/N/U)
Contamination of ___ Air ___ Land ___ Water	Ambulance Requested (Y/N/U)
Potable Water Source (Y/N/U)	Wind Direction/Speed ___ / ____________
Receiving Water ____________	Precipitation (rain/snow) ____________

Location Type: ___ Residential ___ Industrial ___ Rural ___ Sensitive Population (Hosp., School, Nurs. Home)

STATUS AT INCIDENT SCENE ____________
____

RESPONSIBLE PARTY: ___ Known ___ Suspected ___ Unknown
Company Name ____________ Phone ____________
Contact ____________ Title ____________
Street ____________
City ____________ County ____________ State ____________ Zip Code ____________

OFFICIALS NOTIFIED (Name/Title):

NJSP: ________	/ ________	Phone ________	Date/Time ____ / ____	(T/M)
Local Health: ________	/ ________	Phone ________	Date/Time ____ / ____	(T/M)
Local Munic: ________	/ ________	Phone ________	Date/Time ____ / ____	(T/M)
USEPA: ________	/ ________	Phone ________	Date/Time ____ / ____	(T/M)

INCIDENT REFERRED TO:
___ DEO ___ DWR ___ DSWM ___ DHSM ___ DHWM ___ DOM ___ DFG ___ DPF ___ DCJ ___ DCR
Region: ___ Northern ___ Metro ___ Central ___ Southern ___ ER1 ___ ER2

1. Name/Affil: ________	/ ________	Phone ________	Date/Time ____ / ____	(T/M)
2. Name/Affil: ________	/ ________	Phone ________	Date/Time ____ / ____	(T/M)
3. Name/Affil: ________	/ ________	Phone ________	Date/Time ____ / ____	(T/M)

IMMEDIATE DEP RESPONSE (Y/N) [Emergency (Y/N) Enforcement (Y/N)]

COMMENTS ____________
____
____

COPIES: White - Lead Agency Yellow - ??? Pink - A310 Goldenrod - Other

Section 3—On Site

1. Hazardous Materials Incident First Responder Checklist
2. Haz Mat Checklist—Safety Group
3. Haz Mat Checklist—Safety Officer
4. Safety—Entry Personnel Checklist
5. Safety Checklist
6. Entry Procedures
7. Level B Entry Team Checklist
8. Level A Entry Team Checklist
9. Incident Exposure Record
10. Entry Exposure Form
11. Access Control Log
12. Haz Mat Checklist—Haz Mat Group
13. Haz Mat Checklist—Haz Mat Officer
14. Haz Mat Checklist—Information Group
15. Hazardous Material Data Sheet
16. Hazardous Material Information Checklist
17. Haz Mat Reference Worksheet
18. Haz Mat Chemtrec Form
19. Haz Mat Checklist—Recon Group
20. Containment/Stabilization Guidelines
21. Haz Mat Checklist—Resource Group
22. Haz Mat Checklist—Resource Officer
23. Haz Mat Checklist—Decontamination Group

On Site

Once you arrive on site records must be kept for safe operations. An incident control chart can be used to verify the information received on the Discharge Form. As many chemicals have similar sounding names or may involve many letters and numbers (some have over 60 characters in their name), make sure you write it down and check for accuracy.

Throughout the incident a chronological log should be maintained at the Command Post. This may be the most important document at the completion of decisions were made, actions taken and who performed them, are vital pieces of information needed in post-incident analysis.

While operations are taking place, an Access Control Log should be maintained for information as to the specific individual who may be on site at any given time. Should an on site emergency take place, the Safety Officer has to know who was on site and what they were doing. This log should also show the time an individual went on SCBA air, the estimated duration, and anticipated exit time. The type of exposure to each individual along with decontamination methods used are part of the reporting process. Finally, a record must be kept on site of all resources used, who supplied them, when and what. Upon completion of the incident reimbursement and payment may take place for resources used. Your log will be important in settling these claims.

HAZARDOUS MATERIALS INCIDENT
FIRST RESPONDER CHECKLIST

APPROACH:

______ Don’t rush in—assume hazardous materials are present.
______ Avoid entering—any spill, vapors, or smoke.
______ Position—well away, upwind and uphill.

SIZE-UP:

______ Type of incident—fire, BLEVE, spill?
______ Identify product—if readily apparent (I.D. #, placard, etc.)
______ Container—size, type, condition (use binoculars).
______ Exposures—life, property, environment?
______ Victims—injury and/or contaminated, rescue?

ESTABLISH:

______ Command—give location and size-up.
______ Second Alarm? Automatic, mutual aid, Haz Mat team.
______ Scene control—hot zone, traffic, evacuation, staging, approach route.

IDENTIFY:

______ Product name and properties—write it down.
______ Hazards—explosive, fire, poison, reactive, corrosive, etc.
______ Proper protective clothing—avoid contamination of personnel.
______ Resources:

1. Use and record information on attached worksheet.
2. Verbal information-driver, owner, etc.
3. Visual information-placards, labels, shipping papers.
4. Reference books, MSDS.
5. Chemtrec.
6. Haz Mat team leader.

AVOID ENTERING CONTAMINATED AREA UNTIL PRODUCT IS IDENTIFIED

HAZ MAT

CHECKLIST

SAFETY GROUP

HAZ MAT SAFETY OFFICER

STANDARD OPERATIONAL PROCEDURE

1. The Safety Officer shall assume the responsibility for ensuring that safe and accepted practices are adhered to throughout the course of the emergency. He is also responsible for the welfare of all personnel operating in the Hot and Warm Zones.

2. SAFETY FUNCTIONS

A. The Safety Officer shall be positioned in the Warm Zone at the access control point to the Hot Zone.

B. Entry into the Hot Zone shall be restricted to Haz Mat trained personnel and individuals possessing a particular knowledge relative to the incident.

C. Complete the Safety Sector Checklist prior to and during the entry procedures.

D. Remain in constant communications with the Team Leader, Entry Teams, the Haz Mat Officer and the Site Safety Officer.

E. Make the final decision on entry/no entry, corrective actions, and safety checks of respiratory and personal protective clothing, monitoring and sampling equipment and withdrawal and evacuation procedures.

F. Insure that proper decontamination procedures are in place prior to entry.

G. Readiness of back-up teams.

H. Entry, exit and on-air time of all entry personnel.

THE SAFETY OFFICER RETAINS THE AUTHORITY TO CEASE ALL OPERATIONS AND ORDER PERSONNEL BACK TO THE WARM ZONE WHEN UNSAFE CONDITIONS ARE DETECTED.

3. SAFETY RESOURCES

—Haz Mat Safety Sector Checklist
—Binoculars
—Clipboard/Pencil
—Portable Radio
—Watch/Stopwatch or Timer
—Appropriate Protective Clothing and SCBA

SAFETY OFFICER

DUTY CHECKLIST

The Safety Officer is responsible for coordinating and supervising entry operations (includes donning & doffing, but not deconning suits). His primary responsibility is monitoring the safety of the entry team. Special attention must be paid to signs of heat stress and fatigue. The safety officer has the authority to cancel entry operations at any time, if in his opinion, the situation has escalated or an entry person's physical condition has deteriorated, to a point of unacceptable risk.

THE SAFETY OFFICER SHOULD:

______ Report to the team leader for instructions, radio, checklist, and any necessary assistance (medical officer, etc.).

______ Assure backup team is available and prepared.

______ Keep a written record of all equipment and supplies used, or loaned out, and returned (give to team leader).

______ Supply suit donning area with necessary PPE (entry team should assist).

______ Supervise entry team suit donning (use entry checklist).

______ Supervise entry team, pre & post entry, medical monitoring using entry team exposure form (team leader will advise proper level).

______ Maintain radio and visual (when possible) contact with entry team while in hot zone, monitor safety.

______ Coordinate entry team rescue, if necessary (use rescue guidelines).

______ Assist entry team with doffing suit.

______ See that all equipment is accounted for before returning.

POST-INCIDENT RESPONSIBILITIES:

______ Perform Level A suit testing (file checklist). Update suit history log.

______ Perform SCBA turnaround maintenance (file checklist).

______ Give entry checklist & exposure form to team leader.

______ Assist with any remaining equipment decontamination.

SAFETY-ENTRY PERSONNEL CHECKLIST

NAME ____

DATE ______________________ TIME ______________________ AM/PM

LEVEL OF PROTECTION: **A B C D** SCBA CAPACITY: **30M 60M OTHER**

SUIT MATERIAL ______________________ SUIT ID NUMBER ______________________

☐ PERSONAL ITEMS REMOVED, TAGGED AND SECURED

☐ SUIT COMPATIBILITY VERIFIED

☐ PRE-ENTRY BRIEFING COMPLETED BY HAZ MAT OFFICER

☐ PRE-ENTRY MEDICAL EVALUATION COMPLETED

☐ SCBA PERFORMANCE CHECK **(POSITIVE PRESSURE MODE)**

  ☐ Air bottle full and turned on
  ☐ Straps secure
  ☐ Regulator checks performed
  ☐ Facepiece checks performed
  ☐ Warning devices operating

☐ ENTRY SUIT CHECK

  ☐ Visual check performed
  ☐ No obvious suit damage
  ☐ Proper underclothing in place
  ☐ Complete glove and footwear
  ☐ Zippers properly secured
  ☐ Auxiliary airlines/Ventilation lines operational

☐ COMMUNICATIONS EQUIPMENT TESTED AND OPERATIONAL (Channel __________)

☐ **SAFETY OFFICER NOTIFIED AND HAS GIVEN PERMISSION TO GO ON AIR**

SAFETY CHECKLIST

Date ____________ Time ________ AM/PM ______ Location ____

Nature of Incident ____

Site Safety Officer ______________________________ Haz Mat Officer _________________________________

A. SITE SAFETY

☐ Safety Officer Identification

☐ Evaluation of Positions of Companies and Personnel

☐ Control Zones Established

☐ Hot Zone _________ft.	Physically defined	Yes ☐	No ☐
☐ Warm Zone _______ft.	Physically defined	Yes ☐	No ☐
☐ Cold Zone ________ft.	Physically defined	Yes ☐	No ☐

☐ Communication of Control Zones to Command and all Operating Personnel
☐ Zoning Completed and Transmitted at __________ AM/PM

☐ Command Post in Safe Location
☐ Staging Areas in Safe Location
☐ Security in Place as Required

☐ Hazards have been identified and discussed
☐ Entry Objectives have been identified and discussed

☐ Proper Levels of Protective Clothing have been identified
☐ Proper Levels of Protective Clothing have been transmitted to all Operating Personnel

NOTES: ____

____

____

____

____

____

____

ENTRY PROCEDURES

A. INITIAL ENTRY

- ☐ Back-up Personnel assigned for all Entry Personnel
- ☐ Support Personnel assigned for Entry Personnel
- ☐ Support Personnel completing the Entry Team Safety Checklists

☐ Hazard and Procedures Briefing completed by ____

at _____________ AM/PM
  - ☐ Review Assignment
  - ☐ Review Emergency Hand/Audible Signals
  - ☐ Review Site Emergency Escape Plan
  - ☐ Review SCBA & Suit Failure Procedures
  - ☐ Identify Access Control Points
  - ☐ Identify Decontamination Area
  - ☐ Review Decontamination Set-up
  - ☐ Review Signs/Symptoms of Material Exposure
- ☐ Entry Operations coordinated with Decontamination Personnel
- ☐ EMERGENCY WARNING SIGNAL IDENTIFIED AND REVIEWED WITH ALL PERSONNEL

B. SECONDARY ENTRY

- ☐ Back-up Personnel assigned for all Entry Personnel
- ☐ Support Personnel assigned for Entry Personnel
- ☐ Support Personnel completing the Entry Team Safety Checklists

☐ Hazard and Procedures Briefing completed by ____

at _____________ AM/PM
  - ☐ Review Assignment
  - ☐ Review Emergency Hand/Audible Signals
  - ☐ Review Site Emergency Escape Plan
  - ☐ Review SCBA & Suit Failure Procedures
  - ☐ Identify Access Control Points
  - ☐ Identify Decontamination Area
  - ☐ Review Decontamination Set-up
  - ☐ Review Signs/Symptoms of Material Exposure
- ☐ Entry Operations coordinated with Decontamination Personnel
- ☐ EMERGENCY WARNING SIGNAL IDENTIFIED AND REVIEWED WITH ALL PERSONNEL

C. ADDITIONAL ENTRY

- ☐ Back-up Personnel assigned for all Entry Personnel
- ☐ Support Personnel assigned for Entry Personnel
- ☐ Support Personnel completing the Entry Team Safety Checklists

☐ Hazard and Procedures Briefing completed by ______________________________

at __________ AM/PM

- ☐ Review Assignment
- ☐ Review Emergency Hand/Audible Signals
- ☐ Review Site Emergency Escape Plan
- ☐ Review SCBA & Suit Failure Procedures
- ☐ Identify Access Control Points
- ☐ Identify Decontamination Area
- ☐ Review Decontamination Set-up
- ☐ Review Signs/Symptoms of Material Exposure

☐ Entry Operations coordinated with Decontamination Personnel

☐ EMERGENCY WARNING SIGNAL IDENTIFIED AND REVIEWED WITH ALL PERSONNEL

E. MATERIAL HAZARDS

☐ Explosive A B C
☐ Flamm. Liquid
☐ Oxidizer
☐ Radioactive
☐ Flammable Gas
☐ Combust. Liquid
☐ Organic Peroxide
☐ Acid
☐ Non-Flammable Gas
☐ Flamm. Solid
☐ Poison Liquid A
☐ Alkaline
☐ Poison Gas
☐ Air/Water Reac.
☐ Poison Liquid B
☐ Haz. Waste

F. SIGNS/SYMPTOMS OF EXPOSURE

____

____

____

____

NOTES: ______________________________

____

____

____

LEVEL A

ENTRY TEAM CHECKLIST

DATE____

REPORT NUMBER______________________________

ENTRY PERSON_______________________________

SUIT I.D. # ____________________________________

SAFETY OFFICER ____

SCBA I.D. #______________________________ ____________________________________

______ SUIT & GLOVES CHEMICAL COMPATIBILITY CHECKED WITH RESOURCE OFFICER

______ REMOVE CLOTHES & JEWELRY, DON NOMEX COVERALLS & HOOD

______ MEDICAL EVALUATION (USE EXPOSURE FORM)

______ DON RADIO & TEST, REVIEW EMERGENCY SIGNALS

______ DON SCBA EXCEPT FACE MASK (SAVE MAINTENANCE TAG)

______ DON SUIT & GLOVES (TWO LAYERS MINIMUM)

______ REVIEW ACTION PLAN WITH RESOURCE & SAFETY OFFICER

______ APPLY ANTI-FOG TO FACE MASK & SUIT FACE PIECE

______ DON FACE MASK (CHECK SEAL), HOOD, HELMET & EAR PROTECTION

______ ENTRY PERSONNEL HAVE ALL NECESSARY TOOLS & EQUIPMENT

______ TURN AIR ON (RECORD TIME BELOW), SUIT FULLY ZIPPED & SEALED

______ FINAL RADIO CHECK & VISUAL INSPECTION OF SUIT

TIME ON AIR ______________________ TIME OFF AIR ________________________________

NAME OF CHEMICAL(S) INVOLVED ____

____

SUIT ACCESSORIES USED____

____

COMMENTS ____

____

LEVEL B
ENTRY TEAM CHECKLIST

DATE____ REPORT NUMBER _______________

ENTRY PERSON ____________________________________ SUIT I.D. # ____________________

SAFETY OFFICER ___________________________________ SCBA I.D. # ___________________

______ SUIT & GLOVE CHEMICAL COMPATIBILITY CHECKED WITH RESOURCE OFFICER

______ REMOVE CLOTHES & JEWELRY, DON NOMEX COVERALLS & HOOD

______ MEDICAL EVALUATION (USE EXPOSURE FORM)

______ DON RADIO & TEST, REVIEW EMERGENCY SIGNALS

______ DON CHEMICAL SPLASH SUIT (POLY VINYL CHLORIDE, GRAYLITE, TYVEK)

______ DON SCBA EXCEPT FACE MASK (SAVE MAINTENANCE TAG)

______ DON GLOVES (TWO LAYERS MINIMUM) & BOOTS, SEAL WITH DUCT TAPE

______ REVIEW ACTION PLAN WITH RESOURCE & SAFETY OFFICER

______ APPLY ANTI-FOG TO FACE MASK

______ DON FACE MASK (CHECK SEAL) AND HOOD, SEAL WITH DUCT TAPE

______ DON HELMET & EAR PROTECTION

______ ENTRY PERSONNEL HAVE ALL NECESSARY TOOLS & EQUIPMENT

______ TURN AIR ON (RECORD TIME BELOW)

______ FINAL RADIO CHECK & VISUAL INSPECTION OF SUIT

TIME ON AIR ________________________ TIME OFF AIR ___________________________________

NAME OF CHEMICAL(S) INVOLVED ____

SUIT ACCESSORIES USED____

SAFETY OFFICER IS RESPONSIBLE FOR POST-INCIDENT SUIT TESTING (SEE CHECKLIST), SCBA TURNAROUND MAINTENANCE (SEE CHECKLIST), AND UPDATING SUIT HISTORY LOG (SEE HAZ MAT FILE). TEST AND MAINTENANCE CHECKLIST ARE TO BE PUT INTO THE APPROPRIATE HAZ MAT FILE.

THIS RECORD ALONG WITH THE EXPOSURE REPORT FORM IS TO BE FILED IN THE ENTRY PERSON’S EMPLOYEE FILE BY THE TEAM LEADER (COPY TO INCIDENT REPORT FILE).

INCIDENT EXPOSURE RECORD

INCIDENT EXPOSURE RECORD

IMPORTANT: **Maximum** working times for entry teams shall be determined by weather conditions and type breathing apparatus selected, as follows:

A. 30 min. SCBA—15 min.
B. 1 hour SCBA—30 min.
C. 4 hour SCBA—As determined by Team Leader

NAME/SUIT	TYPE/AIR SUPPLY	TIME IN	ESTIMATED TIME OUT	TIME OUT	TOTAL TIME IN SUIT

FORM #3574 (12/86)

ENTRY TEAM EXPOSURE FORM

DATE________________________________ INCIDENT REPORT # ____________

ENTRY PERSON ____________________________ MEDICAL OFFICER ____________

PRE-ENTRY MEDICAL EVALUATION TIME________________________________

WEIGHT ________ BP ________ PULSE ________ RESP ________ TEMP ________

Give entry personnel as much water as they can drink while taking vitals.

POST-ENTRY MEDICAL EVALUATION TIME________________________________

WEIGHT ________ BP ________ PULSE ________ RESP ________ TEMP ________

Give entry personnel as much water as they can drink while taking vitals.

POST-ENTRY MEDICAL EVALUATION + 30 MINUTES

WEIGHT ________ BP ________ PULSE ________ RESP ________ TEMP ________

☐ YES ☐ NO Personnel cleared to re-enter hot zone?

☐ YES ☐ NO Contamination of personnel suspected? (If yes, explain):

____

____

☐ YES ☐ NO Signs or symptoms?

☐ YES ☐ NO Action taken at scene?

☐ YES ☐ NO Hospital notified? MSDS available?

☐ YES ☐ NO Personnel decontaminated thoroughly?

☐ YES ☐ NO Personnel transported to

____

☐ YES ☐ NO Physician advisor notified?

☐ YES ☐ NO Follow-up tests necessary? (If yes, explain):

____

____

☐ YES ☐ NO Personnel debriefed?

HAZ MAT ACCESS CONTROL LOG DATA SHEET

NAME	TEAM	#	SUIT	TYPE BOTTLE	AIR AMOUNT	TIME IN	15 MIN. AIR CHECK	START 2 MIN. INTERVAL	TIME OUT	REASON
		1								
		2								
		3								
		4								
		5								
		6								

TEAM # CHECK OFF EACH TIME YOU CALL IN A TIME CHECK

TIME																			
AIRTIME	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53

TEAM # CHECK OFF EACH TIME YOU CALL IN A TIME CHECK

TIME																			
AIRTIME	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53

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TEAM # CHECK OFF EACH TIME YOU CALL IN A TIME CHECK

TIME																			
AIRTIME	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53

TEAM # CHECK OFF EACH TIME YOU CALL IN A TIME CHECK

CHEMICALS

____

____

____

____

____

____

____

____

____

DECON OFFICER ____________________
OFFICER IN CHARGE ____________________
SAFETY OFFICER ____________________

HAZ MAT

CHECKLIST

HAZ MAT GROUP

HAZ MAT OFFICER

HAZ MAT OFFICER CHECKLIST

Date ____ Time ________ AM/PM ________
Location

Type of Incident: ☐ Fixed Facility ☐ Storage Facility ☐ Highway
☐ Rail ☐ Waterway ☐ Air

Nature of Incident: ☐ Air Release ☐ Leak ☐ Spill ☐ Other

Name of Material ____
Material Hazards:

- ☐ Explosive A B C
- ☐ Flamm. Liquid
- ☐ Oxidizer
- ☐ Radioactive
- ☐ Flammable Gas
- ☐ Combust. Liquid
- ☐ Organic Peroxide
- ☐ Acid
- ☐ Non-Flammable Gas
- ☐ Flamm. Solid
- ☐ Poison Liquid A
- ☐ Alkaline
- ☐ Poison Gas
- ☐ Air/Water Reac.
- ☐ Poison Liquid B
- ☐ Haz. Waste

A. ASSIGNMENTS

☐ Haz Mat Officer Identification

☐ Personnel Assignments
Team Leader ____
Haz Mat Safety Officer ____
Recon Officer ____
Decon Officer ____
Information Officer ____
Resource Officer ____
Other ____

B. AREA ISOLATION & SECURITY

FIXED FACILITY

- ☐ Access to Facility Blocked ☐ Access to Building Controlled
- ☐ Hazard Area Isolated: ☐ Room ☐ Floor ☐ Floors (   ) ☐ Building
- ☐ Control Zones Established ☐ Evacuation of Exposures Required
- ☐ HVAC ☐ Operating ☐ Shut Down
- ☐ Haz Mat Staging Area Established

TRANSPORTATION

- ☐ Access Roadways & Ramps Blocked
- ☐ Hazard Area Isolated
- ☐ Hot Zone Established
- ☐ Haz Mat Staging Area Established
- ☐ Access to Area Controlled
- ☐ Evacuation Required
- ☐ Warm Zone Established

B. CONTACTS

- ☐ Facility Representative____
- ☐ On-Scene Representative ____
- ☐ Shipper Representative ____
- ☐ Manufacturer ____
- ☐ Technical Advisor ____
- ☐ CHEMTREC
  - ☐ MSDS Obtained ☐ Shipping Papers Obtained
  - ☐ Research Information Obtained

C. HAZARD & RISK ASSESSMENT

- ☐ Container Integrity Checked
- ☐ Hazards Identified
- ☐ Hazards Evaluated:

HEALTH	0	1	2	3	4
FLAMM.	0	1	2	3	4
REACT.	0	1	2	3	4

- ☐ Physical and Chemical Properties Obtained

- ☐ Events Analysis
  - ☐ What has Happened ☐ What is Happening ☐ What is Likely to Happen
- ☐ Likely Harm Without Intervention
- ☐ Is a Full Evacuation Required?
- ☐ Decontamination Information Researched

D. PROTECTIVE CLOTHING & EQUIPMENT

- ☐ Level of Protective Clothing Determined A B C D
- ☐ Air Supply on site
- ☐ Entry checklists completed
- ☐ Decontamination Area planned

E. RECON OPERATIONS

- ☐ Permission for Recon Entry
- ☐ Monitor Recon Team
- ☐ Debrief Recon Team and retrieve data

F. ENTRY OBJECTIVES

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

G. TACTICAL OPTIONS

- ☐ Team meeting conducted
- ☐ Tactical Options reviewed

1. ____________________
____
____

2. ____________________
____
____

3. ____________________
____
____

- ☐ Incident Commander advised of Tactical Options and recommendations
- ☐ Full briefing of Command staff
- ☐ Full briefing of Haz Mat Team
- ☐ Full briefing of outside contractors and representatives

NOTES: ____________________
____
____

H. CONTROL OPERATIONS

- ☐ Haz Mat Personnel are prepared for Operations
- ☐ Permission received to begin Operations
- ☐ Safety Officer has approved the Entry
- ☐ Entry team is being monitored
- ☐ Personnel Rotation Schedule has been established

I. DECONTAMINATION PROCEDURES

- ☐ Decon Team has been briefed and is in the proper Level of Protective Clothing
- ☐ Decon is prepared to accept personnel
- ☐ Resources have been made available in the Decon Area

J. TERMINATION

- ☐ Team debriefing has been completed
- ☐ All personnel and equipment have been decontaminated
- ☐ The incident requires no further action
- ☐ The site has been turned over to another agency
  - ☐ Federal EPA ☐ State DEP ☐ County Health ☐ Local Health
- ☐ A private spill contractor has been engaged ☐ Yes ☐ No
- ☐ Termination has been declared on ____________________ at __________ AM/PM

TEAM LEADER

DUTY CHECKLIST

The team leader will act as haz mat group officer, with responsibility for coordinating all Haz Mat Team operations. Only the team leader and liaison officer should communicate with command. The team leader should use the radio designation “Haz Mat” when communicating with command. Team member should don coveralls and remain at the van until assigned. The team leader should remain at the van when practical, to reduce and monitor operations radio traffic.

UPON ARRIVING AT THE SCENE, THE TEAM LEADERS SHOULD:

_____ Don the team leader’s vest, tape recorder, and radio.

_____ Report to the incident commander: (liaison officer should attend also).

- Remind command that we are not assuming command of the incident. We are here to advise and/or operate at his request.
- Write down size-up information, use Chemtrec checklist.
- Has Chemtrec been called?
- Correct obvious safety hazard at this time.
- Tell command he will be kept informed and no action will be taken without his approval.
- Return to van.

_____ Perform a secondary size-up of the situation:

- SLOW DOWN! Is this a true emergency?
- What is a risk—Life, property, environment?
- Has the First Responder Checklist been followed?
- Is the *initial* hot zone appropriate? (use DOT book)
- Is entry really needed at this time?
- Is your information reliable?

_____ Should additional resources be called?

- Use emergency telephone directory
- Technical advisor list
- ALS unit, hospital ER, Decon personnel
- Chemtrec, shipper, manufacturer, consignee
- Lime, haz mat foam, absorbent

_____ Determine objective (decontamination, containment, rescue, evacuate, wait for help, etc.)

_____ Advise command of recommended action (use liaison officer if available) wait for instructions.

_____ Make the following assignments:

Resource officer ____________________

Safety officer ____________________

Decontamination officer ____________________

Entry team ____________________

____

Backup entry team ____________________

____

IF ENTRY IS NECESSARY, USE RESOURCE OFFICER, TECHNICAL ADVISORS, AND CHEMTREC RECOMMENDATIONS TO:

_____ Designate incident control zones, draw map (copy to command).

_____ Select safe location for haz mat van, upwind & uphill.

_____ Designate proper level of PPE for entry personnel.

_____ Determine level of medical monitoring and evaluation.

_____ Select location of the decon area.

_____ Select necessary decon stations and their layout.

_____ Select appropriate decon solutions to be used, if any.

_____ Designate proper level of PPE for decon personnel.

_____ Determine and write down or draw entry team action plan.

_____ Conduct entry team briefing, include:

- Safety, resource, and decon officers.
- Limitations of PPE.
- Product, physical, and environmental hazards.
- Action plan (mission).
- Avoid contact with product if possible.
- Review emergency signals and plan.
- Review decon procedure.

_____ Size-up must be reevaluated as time and conditions change.

_____ Advise command of appropriate local, state, and federal notifications.

_____ Determine methods for dealing with clothing or equipment that cannot be completely decontaminated at the scene.

_____ Provide for the disposal or recovery of decon equipment.

_____ Assist command in supervising recovery and cleanup operations.

_____ Record necessary report and billing information.

POST-INCIDENT RESPONSIBILITIES

_____ Supervise returning equipment to in-service status.

_____ Complete incident file, including all necessary reports, forms, logs, checklist, etc.

_____ See that all disposable, lost, or damaged equipment is replaced, repaired, or recovered.

HAZ MAT

CHECKLIST

HAZ MAT GROUP

HAZ MAT OFFICER

STANDARD OPERATING PROCEDURES

A. GENERAL INFORMATION

1. The information officer shall be assigned by the Haz-Mat Officer.
2. INFORMATION shall assume the responsibility for developing, documenting, and coordinating all data relevant to the incident.
3. The data gained will be used in hazard and risk assessment, evacuation recommendations, selection of protective clothing and equipment, and development of incident management.

B. INFORMATION FUNCTIONS

1. A minimum of three (3) reference sources shall be utilized.
2. All data gathering shall be coordinated with the Team Leader, Safety, Decon, Resource and EMS.
3. Information shall complete the necessary checklists.

C. INFORMATION RESOURCES

1. Reference Library
2. Computer Software
3. Maps of the Area
4. Evacuation Overlays
5. Photographs
6. Maps of Critical Systems
7. Governmental Agencies
8. Technical Advisors
9. Pre-plans
10. Chemical Manufacturers

INFORMATION CHECKLIST

Date:______________________ Time:______________________AM/PM

Location: ____

Haz-Mat Officer:______________________ Site Safety Officer:______________________

Haz-Mat Safety Officer: ______________________ Information Officer: ______________________

Information Personnel: ______________________ ______________________

______________________ ______________________

REFERENCE WORKSHEET

UN# ____________________ EPA# ____________

Chemical Name: ____________________

Trade Name: ____________________

Synonyms: ____________________

Chemical Symbol: ____________________

DESCRIPTION
Physical State: ____________________
Type of Container: ____________________
Appearance/Odor: ____________________

PROPERTIES
Flash Point: ____________________ Ignition Temp: ____________
Boiling Point: ____________________
Flammable Limits: __________ to __________
Specific Gravity: (H20 = 1) ____________________
Vapor Density (AIR = 1) ____________________
Water Soluble: no yes Percent: ____________

Health/Safety
Life Hazard Notes: ____________________

Recommended Protective Clothing: ____________________

REACTIVITY
Incompatible With: ____________________

RECOMMENDED FIRE FIGHTING METHODS/AGENTS
Extinguishment Methods: ____________________

Decon Methods: ____________________

Stabilization Methods: ____________________

EVACUATION DISTANCE
Initial: ____________________ Downwind: ____________________
Crosswind: ____________________

INFORMATION NEEDED BY CHEMTREC

800-424-9300

WHAT HAS HAPPENED? ______

WHERE? ______

WHEN? ______

CHEMICAL(S) NAME______

TYPE & CONDITION OF CONTAINER ______

SHIPPER & SHIPPING POINT ______

CARRIER ______

CONSIGNEE & DESTINATION______

EXTENT OF INJURIES ______

EXTENT OF PROPERTY DAMAGE______

PREVAILING WEATHER ______

COMPOSITION OF SURROUNDING AREA ______

CALLER'S NAME & LOCATION ______

CALL BACK NUMBER AND INSTRUCTIONS ______

WHAT CHEMTREC SHOULD TELL YOU

PRODUCT ____________________

COMMON NAME ____________________

SYNONYMS ____________________

PHYSICAL FORM & APPEARANCE ____________________

ODOR ____________________

EFFECT WITH WATER ____________________

SHIPPING OR BILL OF LADING DESCRIPTION (DOT CLASS) ____________________

NATURE OF PRODUCT ____________________

SHIPPER OR MANUFACTURER ____________________

FIRE HAZARD ____________________

EXPOSURE HAZARD ____________________

IN CASE OF ACCIDENT

SPILL OR LEAK ____________________

FIRE: FLASH POINT ____________________

IGNITION TEMPERATURE ____________________

SPECIFIC GRAVITY ____________________ VAPOR DENSITY ____________________

FLAMMABLE LIMITS: UPPER ________% LOWER ________%

EXPOSURE ____________________

POLLUTION HAZARD ____________________

OTHER INFORMATION ____________________

HAZ MAT

CHECKLIST

RECON GROUP

RECON OFFICER

STANDARD OPERATING PROCEDURES

A. GENERAL INFORMATION

1. Recon Officer shall be assigned by the Haz-Mat Officer.
2. RECON shall assume responsibility for developing information on the physical layout of the incident site in addition to other factors influencing the emergency. The intent is to obtain necessary information to utilize events analysis.

B. RECON FUNCTIONS

1. Recon shall not enter the Hot Zone unless approved by the Haz-Mat Officer.
2. Every attempt should be made to view the incident from all sides.
3. All data gathered shall be coordinated with Information Sector.
4. Recon shall complete the necessary checklists.

C. RECON RESOURCES

1. Clipboard & Writing Implements
2. Binoculars
3. Camera
4. Protective Clothing & SCBA
5. Portable Radios
6. Monitoring Instruments

RECON CHECKLIST

Date:______________________________ Time:__________________________AM/PM

Location: ____

Nature of Incident: ____

Haz-Mat Officer:__________________________ Site Safety Officer:_____________________

Haz-Mat Safety Officer: ___________________ Recon Officer:_________________________

Recon Personnel: ______________________ ____________________________

______________________ ____________________________

______________________ ____________________________

A. CONTAINERS

Number of Containers: ____________________

Type of Containers: 1 ________________ 2 ________________ 3 ________________

4 ________________ 5 ________________ 6 ________________

Condition of Containers: 1 ________________ 2 ________________ 3 ________________

4 ________________ 5 ________________ 6 ________________

B. SITUATION STATUS

☐ Air Release ☐ Leak ☐ Spill ☐ Other

C. EXPOSURES

☐ Life ☐ Property ☐ Environmental ☐ Other

D. TOPOGRAPHY

☐ Level ☐ Slight Grade ☐ Steep Grade ☐ Other

☐ Concrete ☐ Dirt ☐ Pavement ☐ Other

E. OTHER CONSIDERATIONS

☐ Wind direction
☐ Identification of access and egress routes
☐ Possible sources of ignition
☐ Identification of water supplies
☐ Identification of critical systems
☐ Useful equipment located in immediate area
☐ Identification of immediate problems and possible solutions

☐ **ALL ENTRY PERSONNEL HAVE COMPLETED A SAFETY-ENTRY TEAM CHECKLIST**

CONTAINMENT/STABILIZATION

GUIDELINES

_____ Perform with full awareness of hazards and limitations of protective clothing.

_____ Wear proper protective clothing and SCBA.

_____ Minimum 2 personnel in hot zone as briefly as possible.

_____ Avoid contact with product, approach upwind.

_____ BLEVE potential (use worksheet).

_____ Extinguish fire if appropriate.

_____ Protect exposures: (life, property, environment)
- Public-evacuate or shelter-in-place and secure area
- Emergency personnel-use incident control zones, decon, & PPE
- Property-contain or control spilled products
- Environment-streams, lakes, water table, sewer system

_____ Control flammable and/or toxic vapors:
- Vapor suppression-water fog (when soluble foam)
- Vapor dispersion-smoke ejector, house system, water fog
- Sorbents-commercial or natural
- Dilution or neutralizing techniques
- Controlled burn off

_____ Contain spill to as small an area as possible:
- Plug, patch, off load, or overpack container
- Cover spill with plastic (solids), sorbents (liquids)
- Close valve or rotate container
- Dike, dam, boom, ditch runoff

_____ Additional Resources:
- Emergency telephone directory
- Chemtrec
- D.S.A. for county, state, and federal aid
- Shipper, carrier, manufacturer, or consignee
- Others

HAZ MAT

CHECKLIST

DECONTAMINATION GROUP

DECONTAMINATION OFFICER

STANDARD OPERATING PROCEDURES

A. GENERAL INFORMATION

1. The Decon Officer shall be assigned by the Haz Mat Officer.
2. DECON shall assume the responsibility for the establishment of the Decon Site and the personnel and equipment passing through it.

B. DECON FUNCTION

1. Coordinate with the Haz Mat Officer and Safety Officer to determine the type of Decon Site to be set up.
2. Obtain the properties of the material from the Information Officer and research for proper methods and decon solutions to be used.
3. Log all personnel and equipment passing through the Decon Site.
4. Coordinate with EMS personnel to obtain proper medical monitoring at the end of Decon.
5. Coordinate with Resource to identify all contaminated tools and equipment.

C. DECON RESOURCES

1. Complete Decon kit
2. Proper Decon Solution
3. Adequate Water Supply

DECONTAMINATION CHECKLIST

Date:____________________ Time:____________________AM/PM

Location: ____

Nature of Incident: ____

Haz-Mat Officer:____________________ Site Safety Officer:____________________

Haz-Mat Safety Officer: ____________________ Decon Officer:____________________

Decon Personnel: ____

EMS Officer: ____________________ EMS Personnel: ____________________

A. SITE SELECTION

- ☐ Accessible by hard road surface
- ☐ Adequate water supply available
- ☐ Away from environmentally sensitive areas
- ☐ Upwind and in the Cold Zone
- ☐ Control Zones have been established and physically defined
- ☐ Decon Officer has been identified
- ☐ Runoff can be controlled

B. INFORMATION

☐ Material has been identified ______________________________

☐ Hazardous Properties ______________________________

____

☐ Signs & Symptoms of exposure ______________________________

____

☐ Effects on material and equipment ______________________________

____

		YES	NO
1.	Are any of the materials water reactive?	☐	☐
2.	Are any of the materials reactive with other substances?	☐	☐
3.	Are any of these substances present in the equipment in use?	☐	☐
4.	Are any of these materials reactive with the decon solutions?	☐	☐

5. Remarks: ______________________________

____

		YES	NO
6.	Will runoff contaminate the ground water?	☐	☐
7.	Will runoff contaminate surface areas (soil/pavement)?	☐	☐
8.	Will runoff damage plant life?	☐	☐

9. Remarks: ______________________________

____

C. PRE-ENTRY

☐ Proper Levels of Protective Clothing have been selected and announced
☐ Decon personnel are in the required level of Protective Clothing
☐ SCBA and spare bottles are available in the decon site
☐ The Decon site has been completed prior to any entry and is a ____ step site
☐ The Medical Sector Officer and EMS personnel are in place
☐ EMS personnel have been briefed on the health hazards involved
☐ The proper solution and the water supply is in place
☐ The site has been physically defined and the Access Control Point established
☐ Entry and back-up personnel have been briefed on decon procedures
☐ Entry and back-up personnel have observed the decon layout

D. DECON STATIONS

MANNED & READY

Station #1—__________________________ ☐ YES ☐ NO
Station #2—__________________________ ☐ ☐
Station #3—__________________________ ☐ ☐
Station #4—__________________________ ☐ ☐
Station #5—__________________________ ☐ ☐
Station #6—__________________________ ☐ ☐
Station #7—__________________________ ☐ ☐
Additional—__________________________ ☐ ☐
☐ ☐
☐ ☐

(Use back for added stations)

E. POST ENTRY

NAME	DECONNED	NAME	DECONNED

F. CLEAN-UP

☐ All disposable materials have been isolated, bagged and placed inside containers

☐ Containers have been secured and properly labeled

☐ All equipment has been identified for inspection

☐ Repairable equipment has been tagged and isolated

☐ The Decon Team has been decontaminated

☐ The Decon Site has been ☐ taken up ☐ left for private contractor

Section 4—Medical Monitoring of Entry Personnel

1. Haz Mat Checklist—Medical Group
2. Medical Monitoring and Treatment Report
3. New Jersey State Police Incident/Exposure Report
4. OEM Medical Surveillance Report

To define medical monitoring procedures for entry personnel.

All entry personnel in Level A or Level B protection shall comply with the medical monitoring procedures as detailed.

Prior to donning protective gear, personnel to be monitored will have the following physical assessment and hydration performed by the EMS Specialist or designee.

- Vital Signs: Temperature, respiratory rate, pulse and blood pressure

  Entry will be denied to personnel with an oral temperature of greater than 99.2°F, pulse greater than 110 or irregular without prior history, respiratory rate greater than 24, or blood pressure greater than 150/90.

  Personnel exhibiting an irregular pulse with no prior history must have a rhythm strip obtained.

- Body weight.
- Assess cognitive skills.

  Personnel shall count backwards from 100 by sevens.
- Hydrate.

  Personnel shall consume 16 ounces of cold water or diluted (4:1) electrolyte solution.

During the time in protective gear the entry personnel shall be monitored by the EMS Specialist or designee.

- Observed changes in gait, speech, or behavior requires “entry” person to undergo immediate decontamination, undressing, and assessment.
- Complaints of chest pain, dizziness, shortness of breath, weakness, or headache requires personnel to undergo immediate decontamination, undressing, and assessment.
- The time on SCBA and in protective gear will be monitored to ensure at least a fifteen (15) minute reserve air supply to undergo decontamination. Working time allowed on SCBA and in protective gear varies with the ambient temperature and humidity (humiture).

After decontamination and removal of protective gear, monitored personnel will have the following physical assessment and hydration performed by the EMS Specialist.

- Vital Signs: temperature, respiratory rate, pulse, blood pressure.

  If a respiratory rate, pulse or blood pressure exceed 10% of the pre-exposure values, personnel shall be kept at rest and reassessed every ten (10) minutes until return to normal and acceptable limits.

  If temperature is greater than 100(F, keep in a cool environment, apply cool, moist towels to trunk, head, neck, underarms, and groin areas. Establish medical control to determine if transport to medical facility is necessary.
- Weight

  If weight loss is less than 5%, and no signs of heat illness or dehydration, administer cool fluids by mouth (P.O.) in eight-ounce increments until satiation occurs.

  If weight loss is greater than 5%, or signs of dehydration are apparent, administer oxygen 50-100%, establish IV of Lactated Ringers solution KVO and titrate to a systolic blood pressure of 100 mmHg and as directed by the consulting physician. Avoid P.O. fluids if the patient is nauseous.
- Reassess cognitive skills.
- Further assessment of heart, lungs, mentation, and muscle tone will be performed as indicated by the toxicity of substances and exposure.

HAZ MAT

CHECKLIST

MEDICAL GROUP

MEDICAL OFFICER

STANDARD OPERATING PROCEDURES

A. GENERAL INFORMATION

1. The Medical Officer shall be assigned by the Haz Mat Officer.
2. MEDICAL shall assume the responsibility for treatment of the sick and injured, medical monitoring, and evaluation of entry team members.

B. MEDICAL FUNCTION

1. Gather all pertinent data on signs and symptoms of chemical exposure through the Haz Mat Officer and Information Sector.
2. Treat all victims for any illness or injury.
3. Monitor emergency workers for exposure, heat stress and other medical problems.
4. Perform medical evaluations on all entry team members prior to and after entry and dispatch those requiring additional attention to the planned medical facility.
5. Provide aid to the Rest & Rehabilitation Area.

C. MEDICAL RESOURCES

1. Appropriate reference material
2. Appropriate protective clothing
3. Medical supplies

MEDICAL CHECKLIST

Date:____________________ Time:____________________AM/PM

Location: ____

Haz-Mat Officer:____________________ Site Safety Officer:____________________

Haz-Mat Safety Officer: ____________________ Medical Officer: ____________________

Medical Personnel: ____________________ ____________________

____________________ ____________________

____________________ ____________________

A. SIGNS & SYMPTOMS OF EXPOSURE

1. Reference Sources: 1) ____________________
2) ____________________
3) ____________________

CHEMICAL #1: ____________________

Signs/Symptoms ____________________

CHEMICAL #2: ____________________

Signs/Symptoms ____________________

CHEMICAL #3: ____________________

Signs/Symptoms ____________________

CHEMICAL #4: ____________________

Signs/Symptoms ____________________

CHEMICAL #5: ____________________

Signs/Symptoms ____________________

HAZARDOUS MATERIALS RESPONSE

MEDICAL MONITORING AND TREATMENT REPORT

NAME: ______________________________ REPORT #: __________

AGE: ______ SEX: ______________________ TRIAGE #: __________

AGENCY: ______________________________ DATE: ______________

INCIDENT HISTORY, INCLUDING POTENTIAL/CONFIRMED AGENT(S) OF EXPOSURE:

MSDS ATTACHED? YES ☐ NO ☐ Specify:

CURRENT MEDICAL HISTORY:

Current or Recent Ailments: Colds, Flu, Infections, Open Wounds, Rashes, Etc.

Current Medications: (Include Over-the-Counter)

LOCATION AND CONTRACT FOR MEDICAL RECORDS:

VITAL SIGNS, WEIGHT, AND COGNITIVE TEST LOG

TIME	ENTRY/ EXIT	TEMP	PULSE	RESP	BLD/PRES	LEAD 2 ECG	WGT	TEST

HYDRATION LOG

TIME	ENTRY/ EXIT	AMOUNT (cc)	FLUID DESCRIPTION	NOTES:

Signature: ____________________ Title: ________________ Agency: ______________

Page 1 of 2

HAZARDOUS MATERIALS RESPONSE

MEDICAL MONITORING AND TREATMENT REPORT

NAME: ______________________________ REPORT #: __________

CHIEF COMPLAINT:

SIGNS **SYMPTOMS**

CNS/Senses:

Head/Neck/Back:

Chest/Abdomen:

Extremities:

VITAL SIGNS

TIME	TEMP	PULSE	RESP	BLD/PRES	LEAD 2 ECG	WGT	TEST P/F

TREATMENT RECORD

TIME	TEMP	PULSE	RESP	BLD/PRES	LEAD 2 ECG	TREATMENT

TREATMENT NARRATIVE

TRANSPORTED TO: **BY:** **TIME:**

ADMIT DIAGNOSIS: **DISCHARGE DIAGNOSIS:**

Signature: ____________________ Title: ________________ Agency: ______________

Distribution: White—Hospital/Yellow—Medical Director/Pink—EMS Agency

Attach to Standard Ambulance Report

Page 2 of 2

NEW JERSEY STATE POLICE INCIDENT/EXPOSURE REPORT

☐ INCIDENT ☐ EXPOSURE

Station/Unit	Code	Phone No. and Ext.	Division Case Number	Other Report Numbers

No. of Incident/Exposure	Time A.M. ☐ P.M. ☐	Location of Incident (Bldg/Street/Highway)

Municipality	Mun. Code	County	Exact Product Spelling (List additional products in narrative)

Materials I.D. Number	Response Guide Number	Time Arrived at Scene ☐ A.M. ☐ P.M.	Time Departed from Scene ☐ A.M. ☐ P.M.

Narrative: (Include: type of incident, cause of incident/spill, known hazardous materials, your activity at scene, exposure symptoms, vehicle transporting product—make/year, reg./state, owner/address, etc.)

Agencies at Scene	State Police Personnel at Scene	Badge No.

Continue Additional Information on Plain Bond Paper

Rank/Name/Badge No. (Print or Type) Signature	Page ____ of ____	Date	Reviewed By:

White Copy: C.J.R.B. Yellow Copy: Hazardous Materials Emergency Response Planning Unit Pink Copy: Station/Unit Gold Copy: Medical Unit

S.P. 81 (Rev. 7-88) S.O.P. JB

Section 5—Post-Incident

National Fire Incident Reporting System (NFIRS)
Hazardous Material Incident Report

The New Jersey Department of Community Affairs, Bureau of Fire Safety, has recognized the National Fire Incident Reporting System (NFIRS) hazardous material incident report. A copy of this report and a brief explanation of its intent and use is given to you. For further information, contact the Bureau of Fire Safety, Fire Incident Reporting Section at (609) 633-6324.

State of New Jersey
Department of Community Affairs
Division of Housing and Development
Bureau of Fire Safety

HAZARDOUS MATERIALS INCIDENT REPORT

HA	FDID	INCIDENT NO.	EXP	MO	DAY	YEAR	DELETE 1 ☐ CHANGE 2 ☐

HB	SPECIAL HAZMAT RESPONSE ACTIONS TAKEN 1.	SPECIAL HAZMAT RESPONSE ACTIONS TAKEN 2.			
HC	SPECIAL HAZMAT RESPONSE ACTIONS TAKEN 3.	SPECIAL HAZMAT RESPOSNE ACTIONS TAKEN 4.			
HD	GENERAL PROPERTY USE	AREA OF RELEASE	LEVEL OF RELEASE		
HE	RELEASE FACTORS	PRIMARY	SECONDARY	TERTIARY	
HF	EQUIPMENT INVOLVED IN RELEASE	TYPE WEATHER	TEMPERATURE _ _ _ _ °F		
HG	ESTIMATED NUMBER OF CHEMICAL/HAZMAT	DISPOSITION OF INCIDENT			
HH	PERSONNEL IDENTIFYING HAZMAT 1.	PERSONNEL IDENTIFYING HAZMAT 2.			
HI	REFERENCE MATERIAL USED TO IDENTIFY HAZMAT 1.	REFERENCE MATERIAL USED TO IDENTIFY HAZMAT 2.			
HJ	NUMBER OF INJURIES FIRE SERVICE	OTHER	NUMBER OF FATALITIES FIRE SERVICE	OTHER	
HK	CHEMICAL/HAZMAT TRADE NAME	DOT I.D. NO.	DOT HAZARD CLASS	C.A.S. NO.	
HL	PHYSICAL STATE STORED	EXTENT OF RELEASE	PHYSICAL STATE RELEASED		
HM	QUANTITY RELEASED	UNIT OF MEASURE	SUSPECTED ENVIRON CONTAMINATION		
HN	CONTAINER USE	SPECIAL CONTAINER FEATURES	CONTAINER TYPE		
HO	CONTAINER MATERIAL	CONTAINER CAPACITY	UNIT OF MEASURE		
HK	CHEMICAL/HAZMAT TRADE NAME	DOT I.D. NO.	DOT HAZARD CLASS	C.A.S. NO.	
HL	PHYSICAL STATE STORED	EXTENT OF RELEASE	PHYSICAL STATE RELEASED		
HM	QUANTITY RELEASED	UNIT OF MEASURE	SUSPECTED ENVIRON CONTAMINATION		
HN	CONTAINER USE	SPECIAL CONTAINER FEATURES	CONTAINER TYPE		
HO	CONTAINER MATERIAL	CONTAINER CAPACITY	UNIT OF MEASURE		
HP	TRANSPORT TYPE	YEAR MAKE	MODEL	VEHICLE LICENSE NO.	STATE
HQ	VEHICLE IDENTIFICATION NO.	ICC/DOT NO.			
HR	DRIVER'S LICENSE NO.	STATE			
HS	COMMENTS				

☐ CHECK IF COMMENTS ON REVERSE SIDE

HT	SPECIAL STUDIES	1 a b c d	2 a b c d	3 a b c d	4 a b c d	5 a b c d	6 a b c d
HU	MEMBER MAKING REPORT	DATE OF REPORT					

The National Fire Information Council (NFIC) in cooperation with the United States Fire Administration (USFA) has been collecting and processing Fire Incident Data for the past several years. This data collection effort is known as the National Fire Incident Reporting System (NFIRS). In February of 1987, NFIC began discussions focused on expanding the National Fire Incident Reporting System to include data on incidents involving hazardous materials.

From the beginning, NFIC has sought to develop a HAZARDOUS MATERIALS INCIDENT REPORTING SYSTEM that focuses on the informational needs of fire service management in their efforts to prevent such incidents and to be fully prepared to mitigate those that do occur.

The importance placed on management needs and practical constraints has also prompted a definition of a REPORTABLE Haz Mat Incident that is unique in scope and character. In the definition that follows, the utilization of specialized resources has been included along with the nature of the material and the hazard presumed to be present. Broadening the definition to include an element addressing specialized resources (1) excludes those incidents that are so commonplace that they are handled by conventional response units, and (2) focuses on the fire service's concern for the optimum utilization of special resources.

The Hazardous Materials Incident Report form and the accompanying codes where developed from a pilot test conducted by NFIC. A total of 875 hazardous materials incidents from over 125 fire departments were included in the test. The analysis of these incidents resulted in the final form included in this Handbook and in important revisions to the codes for hazardous materials incidents. NFIC would like to thank the fire departments that participated in the pilot study for their diligence and cooperation.

When a reportable hazardous material incident occurs in your jurisdiction, you, as the officer in charge, should complete the NFIRS-1 and HMI (and if appropriate, NFIRS-2 and NFIRS-3) reports for the incident. If aid or assistance is received from outside your department, you are still responsible for completing the full report, regardless of which agency or unit mitigates the incident. This is the same procedure you have used in completing NFIRS-1 reports for fires when mutual aid is received.

If you have any comments or requests for changes to the Hazardous Materials Incident Reporting System, please forward those comments to your State Project Manager.

NFIRS DEFINITION OF A REPORTABLE HAZ MAT INCIDENT

Brief Definition

A REPORTABLE Haz Mat Incident is an incident at which ALL THREE of the following conditions apply:

1. A material is present that is suspected to be other than ordinary combustible materials or combustible material by-products,

   AND

2. The material is in such a state, quantity, or circumstance that, if left unattended, it is presumed to pose a threat to life, health, property, or the environment,

   AND

3. Specialized Haz Mat resources were dispatched or used, or should have been dispatched or used, for assessing, mitigating, or managing the situation.

Description By Positive Example

A REPORTABLE Haz Mat Incident is an incident to which specialized resources such as Haz Mat vehicles, special sensing equipment, chemical entry suits, special protective equipment, chemical analysis kits, absorbents, neutralizing agents, and/or specially trained personnel were used or dispatched. Specialized resources from other agencies, private industry, and specially-trained Fire Service personnel normally utilized in other ways are specifically included.

Description By Negative Example

Occurrences that need not be reported as a Haz Mat incident include releases from 42 gallon or smaller vehicular fuel tanks; releases from low pressure fuel lines smaller than 2 inches in diameter serving residential properties with natural gas, LPG, and heating oil; ordinary sewage spills that do not include industrial waste.

Supportive Assumptions

The following assumptions support this definition and its use: (1) nothing in this definition, or these procedures, are meant to preclude the use of good judgment at the scene in the determination of whether the incident is a REPORTABLE Haz Mat incident; (2) nothing in this definition is meant to alter the execution of local, state, or federal mandates regarding Haz Mat incidents.

Purposes

The purposes of this definition are: (1) to guide the collection of data that will ultimately make a difference in the decisions made by fire service management; (2) to instruct fire ground commanders as to when it is appropriate to complete a Haz Mat Incident Supplement to the existing NFIRS Fire Incident Report; (3) to produce information that will ultimately guide prevention and control efforts and assist in the development of new codes, regulations, and laws; (4) to provide the basis for uniform quality of reporting and the resultant information.

IMPORTANT: An NFIRS-1 Incident Report must be completed for all reportable Haz Mat incidents. In addition, Civilian Casualty Reports (NFIRS-2) and Fire Service Casualty Reports (NFIRS-3) should also be completed, as appropriate.

NOTE: The data classification structure for use with the Hazardous Materials Incident Report (NFIRS-HMI) is from NFPA 901, Uniform Coding for Fire Protection—1990. Permission is granted for the publication, translation, reproduction, delivery and use of this copyrighted material by any Federal, State or local jurisdiction or fire service organization in connection with the use of the NFIRS system.

APPENDIX B

TERMINATION

Outline

—Introduction

—Phase-Down

—Incident Follow-up

APPENDIX B

TERMINATION

Objectives

The Student Will Be Able To:

1. List Three Considerations Associated With Phase-Down Activities
2. List Three Phases Associated With Incident Follow-up

INTRODUCTION

Termination of an incident can only be conducted when the hazard has been contained. The threat to public health, safety, welfare and the environment must be evaluated and controlled prior to closing out the incident.

Termination of the emergency requires securing of the site from further compromise or threat to the public health and the environment, and release of liability from the responders back to the responsible party or property owner. Under conditions of non-declared ownership or government receivership, the site is turned over to the NJDEP or other authority having jurisdiction to supervise a final clean-up and removal operation. These operations may run from hours to months in length, dependent on the extent of environmental impact.

Incident termination is the final step in a Haz Mat operation. Now that the immediacy of the emergency situation has been satisfied and the hazardous material no longer poses a threat, the technician can now begin incident termination procedures.

Incident termination procedures basically fall into two categories (1) Phase-Down Activities and (2) Incident Follow-up.

1. PHASE-DOWN ACTIVITIES

The following is a list of considerations the technician should employ when securing the emergency situation:

______ Haz Mat team personnel should not actively participate in the recovery/cleanup stage of an incident.

______ Contaminated tools, turnouts, personnel, etc., should not be returned to service or removed from the scene until they have been properly decontaminated or bagged.

______ No recovered hazardous material should be taken to any fire station for disposal or storage.

______ Hazardous material recovery, cleanup, and disposal is the responsibility of the discharger. If the discharger is unable to perform the cleanup operation, he/she is required to contact a responsible private contractor to perform this function. The discharger is the party responsible for the product at the time of the discharge.

______ If the discharger cannot be identified, or is unable to recover and dispose of the product in a reasonable time period, the incident Commander should contact the appropriate agency for assistance.

______ The source of funding must be clearly identified before a private contractor is called. Refer to the hazardous waste management company directory.

______ Incident records such as technical worksheets, checklists, logs and photos should be consolidated.

______ Final medical monitoring performed.

______ Safety officer evaluation of personnel for signs of post-incident stress or medical symptoms.

______ Follow-up disposition of all reported injuries as a result of the Haz Mat incident.

______ Samples or evidence seized during the incident has been properly turned over to an authorized agency and a chain of custody is maintained.

______ Finally, termination notification should be made to all on-scene emergency response personnel.

2. INCIDENT FOLLOW-UP

Defined: The cessation of emergency tactical operations to include documentation, debriefing, and the eventual post-incident analysis, and critiquing.

Incident Follow-up activities are divided into three phases: (1) debriefing the incident, (2) post-incident analysis, and (3) critiquing the incident.

1. An effective debriefing should:
   a. Inform responders exactly what Haz Mats they were exposed to.
   b. Identify equipment damage and unsafe conditions requiring attention.
   c. Assign information, gathering responsibilities for post-incident analysis and critique.
   d. Summarize the activities performed.
   e. Reinforce the positive aspects of the response.
2. Post-incident analysis is conducted to:
   a. Determine the level of financial responsibility.
   b. Establish a clear picture of the emergency response for further study.

   The post-incident analysis should focus on four key topics:

   Command and control
   Tactical operations
   Resources
   Support services
3. Critiques

   Many injuries and fatalities have been prevented as a result of critique sessions. A commitment to critique all Haz Mat responses will improve emergency responder performance by improving efficiency and pinpointing weaknesses.

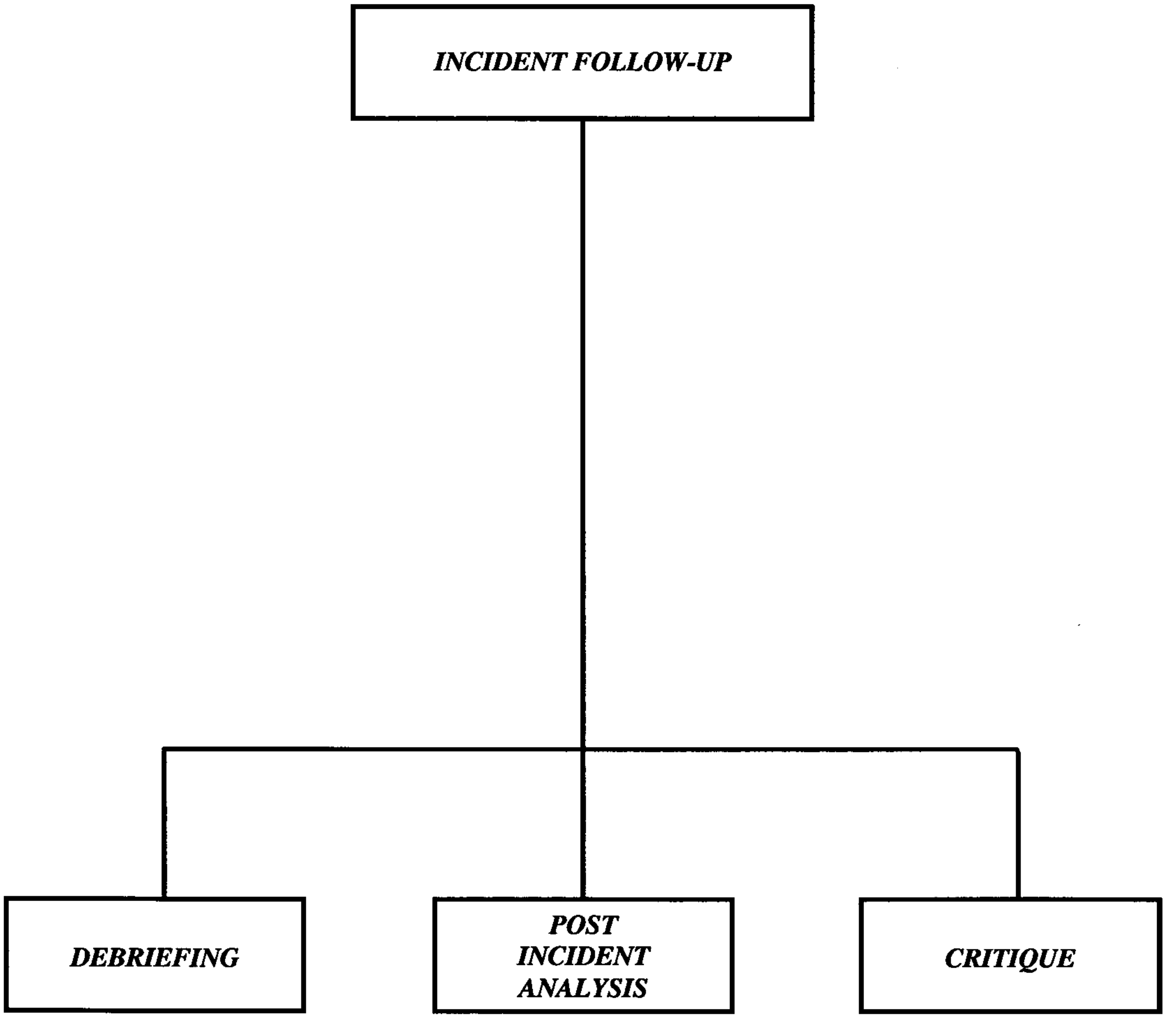
   The crucial person to a good critique is the critique leader; the critique leader should:

   1. Control the critique
   2. Ensure that direct questions receive direct answers
   3. Ensure that participants play by the critique rules.
   4. Ensure that each operational group presents their observations.
   5. Keep notes of important points.
   6. Sum up the lessons learned.

SUMMARY

The termination process enjoys incredibly clear hindsight.

Hazardous materials incidents should be formally terminated to ensure emergency responder safety, to establish a record of events, and to document the lessons learned from the entire incident. The recommendations in this module should be used to enhance your organization's SOP's.



SUMMARY

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Hazardous materials incidents should be formally terminated to ensure emergency responder safety, to establish a record of events, and to document the lessons learned from the entire incident. The recommendations in this module should be used to enhance your organization's SOP's.

APPENDIX C

HAZARDOUS MATERIAL RELEASES IN NEW JERSEY (1995)

There were approximately 20,000 reported hazardous material releases in New Jersey in 1995. This is a 64% increase in reported releases since 1991. The largest number of reported releases still involve petroleum fuels and oils. Oil now makes up 40% of the total releases as opposed to 60% in 1991.

There were about 8400 petroleum product releases including:

Oil
Fuel Oil
Motor Oil
Hydraulic Oil
Transformer Oil
Transformer Oil (with PCB)
Transmission Oil
Diesel Fuel
Jet Fuel
Gasoline
Asphalt
Mineral Spirits (Naptha)
Kerosene
Tar
Odors

Frequently released products (20 or more reported releases):

PRODUCT:	RELEASES:	PRODUCT:	RELEASES:
UNKNOWN	3200	Solvents	55
Sewage	1020	Ash & Fly Ash	55
Natural Gas	790	Asbestos	70
Antifreeze (& Ethylene Glycol)	840	Ammonia	70
Smoke	610	Freon	50
Carbon Monoxide	225	Propane	45
Contaminated Soil	165	Sulfuric Acid	40
Paint (Oil or Water Base)	120	Pesticides	30
NOX	95	Hydrogen Sulfide	30
Sulfur Dioxide	90	Hydrochloric Acid	20
Chlorine	85	Lead	20
Medical Waste	85		

Infrequently released products (10 to 20 reported releases):

Acetone
Benzene
Dye
Herbicide
Nitrates
Nitric Acid
Nitrogen
Radioactives
Soap
Sodium hydroxide
Sodium hypochlorite
Tetrachloroethylene
Toluene
VOC
Wastewater
Xylene

NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK ID AND GUIDE NUMBERS, & NFPA HAZARD CLASSIFICATIONS OF COMMON HAZARDOUS MATERIALS

Substance:	DOT ID #	DOT Guide #	Health Hazard:	Flammability:	Reactivity:
Acetone	1090	127	1	3	0
Ammonia	1005	125	3	1	0
Asphalt	1999	130	0	1	0
Benzene	1114	130	2	3	0
Chlorine	1017	124	3	0	0
Ethylene Glycol	1153	127	—	—	—
Fuel Oil	1993	128	—	—	—
Gasoline	1203	128	1	3	0
Hydrochloric Acid	1789	157	3	0	0
Hydrofluoric Acid	1790	157	4	0	0
Hydrogen Chloride	1050	125	3	0	0
Hydrogen Chloride	2186	125	3	0	0
Hydrogen Fluoride	1052	125	4	0	0
Hydrogen Sulfide	1053	117	3	4	0
Kerosene	1223	128	0	2	0
Mercury	2809	172	—	—	—
Naphtha	1255	128	0	2	0
Naphtha	1256	128	0	2	0
Naphtha	2553	128	0	2	0
Nitric acid	1760	154	3	0	0
Nitric acid	2031	157	3	0	0
Nitric acid	2032	157	3	0	0
Oil	1270	128	0-2	1-3	0
Oxygen	1072	122	3	0	0
Oxygen	1073	122	3	0	0
PCB	2315	171	—	—	—
Pesticides	2210	135	—	—	—
Pesticides	2588	151	—	—	—
Pesticides	2902	151	—	—	—
Pesticides	2903	131	—	—	—
Pesticides	3021	131	—	—	—
Propane	1075	115	1	4	0
Propane	1978	115	1	4	0
Sodium Hydroxide	1823	154	3	0	1
Sodium Hydroxide	1824	154	3	0	1
Sodium Hypochlorite	1791	154	-	-	-
Sulfur Dioxide	1079	125	2	0	0
Sulfuric acid	1830	137	3	0	2
Sulfuric acid	1831	137	3	0	2
Sulfuric acid	1832	137	3	0	2
Toluene	1294	130	2	3	0
1,1,1-Trichloroethane	2831	160	2	1	0
Trichloroethylene	1710	160	2	1	0
Turpentine	1299	128	1	3	0
Xylene	1307	130	2	3	0

NOTE: A “—” means that there is no NFPA classification available at this time.

SELECTED EXPOSURE LIMITS

Compound	TLV ppm	Odor ppm	IDLH ppm	REL ppm
acetaldehyde	100	0.21	10000	—
acetic anhydride	5C	81.2	1000	—
acetone	750	100	20000	—
acrylonitrile	(A2) 2 sk	21.4	4000	Ca
ammonia	25	46.8	500	50
arsine	0.05	<1	6	Ca
asbestos	(A1a)	none	—	Ca
benzene	10 (A2)	4.68	2000	Ca
benzidine	(A1b) sk	—	—	Ca
benzyl chloride	1	0.047	10	—
bromine	0.1	0.047	10	—
2-butanone (MEK)	200	10	3000	200
carbon dioxide	5000	none	50000	10000
carbon disulfide	10 sk	0.21	500	1
carbon monoxide	50	none	1500	35
chlorine	1	0.314	30	—
fluorine	1	<3	25	—
hydrogen cyanide	10 C sk	0.00027	50	—
isopropyl alcohol	400	<1	12000	400
LPG	1000	—	19000	—
methane	E	—	—	—
naphthalene	10	<0.3	500	—
phosgene	0.1	1	2	0.1
propane	E	1000-20000	20000	—
toluene	100	2.14	2000	100

NOTES:

A1a—human carcinogen with assigned TLV
A1b—human carcinogen without assigned TLV
A2 —suspected human carcinogen
C —ceiling TLV
Ca —carcinogen, no exposure recommended
E —simple asphyxiant
REL—Recommended Exposure Limit—NIOSH
Sk —skin notation
TLV —Threshold Limit Value—ACGIH

11 HIGHEST VOLUME CHEMICALS PRODUCED IN THE U.S. IN 1992 (CHEMICAL AND ENGINEERING NEWS, APRIL, 1993)

<table>
<tr><th>NAME</th><th>FORMULA</th><th>BILLIONS OF LBS</th><th>PEL</th><th>IDLH</th><th>UN #</th><th>ERG GUIDE</th></tr>
<tr><td>Sulfuric acid</td><td>H_2SO_4</td><td>88.8</td><td>1 mg/m3</td><td>80 mg/m3</td><td>1830</td><td>137</td></tr>
<tr><td colspan="7">NFPA 3,0,2,W
USES: Fertilizers, chemicals, dyes; petroleum refining, electroplating baths; iron & steel industry; explosives.
HAZARDS: Corrosive; water reactive (exothermic).</td></tr>
<tr><td>Nitrogen</td><td>N_2</td><td>58.7</td><td></td><td></td><td>1977</td><td>120</td></tr>
<tr><td colspan="7">NFPA 3,0,0
USES: Ammonia production, acrylonitrile, nitrates, cyanamide, cyanides, nitrides, explosives; inerting gas, food refrigeration and freeze drying; cryogenic preservation.
HAZARDS: Cryogenic liquified gas, asphyxiant.</td></tr>
<tr><td>Oxygen</td><td>O_2</td><td>42.4</td><td></td><td></td><td>1073</td><td>122</td></tr>
<tr><td colspan="7">NFPA 3,0,0,OXY
USES: Steel production; oxidizer for rocket propellants; resuscitation; coal gasification; anti-eutrophication for lakes and reservoirs . . .
HAZARDS: Cryogenic liquified gas, oxidier. Liquid readily absorbed into clothing, etc.</td></tr>
<tr><td>Ethylene</td><td>C_2H_4</td><td>40.4</td><td></td><td></td><td>1962</td><td>116P</td></tr>
<tr><td colspan="7">NFPA 1,4,2
USES: Polyethylene, polypropylene, ethylene oxide, ethylene glycol, vinyl chloride, polystyrene, styrene, polyvinyl chloride, polyester resins, fruit ripening, etc.
HAZARDS: Flammable gas (FR 2.7%-36%); Possible polymerization if container is involved in fire.</td></tr>
<tr><td>Ammonia</td><td>NH_3</td><td>36</td><td>35ppm (STEL)</td><td>500ppm</td><td>1005</td><td>125</td></tr>
<tr><td colspan="7">NFPA 3,1,0
USES: Fertilizers, refrigerant; synthetic fibers; latex preservative; nitrocellulose; rocket fuel, etc.
HAZARDS: Liquified, compressed gas; corrosive, hygroscopic . . .</td></tr>
<tr><td>Lime</td><td>CaO; $Ca(OH)_2$</td><td>34.7</td><td>5 mg/m3</td><td></td><td>1910</td><td>157</td></tr>
<tr><td colspan="7">NFPA 1,0,1
USES: Refractory brick; calcium carbide mfg.; remove sulfur dioxide from stack gases; sewage treatment; poultry feeds; insecticides, fungicides . . .
HAZARDS: Mildly corrosive, irritant, exothermic reaction with water (up to 800°F).</td></tr>
<tr><td>Phosphoric acid</td><td>H_3PO_4</td><td>25.4</td><td>1 mg/m3</td><td>10,000 mg/m3</td><td>2835</td><td>138</td></tr>
<tr><td colspan="7">NFPA 2,0,0
USES: Fertilizers; soaps & detergents; inorganic phosphate; pickling and rust proofing; pharmaceuticals; sugar refining; water treatment; gasoline additive, etc. . . .
HAZARDS: Moderately strong acid, somewhat corrosive, irritant.</td></tr>
</table>

<table>
<tr><th>NAME</th><th>FORMULA</th><th>BILLIONS OF LBS</th><th>PEL</th><th>IDLH</th><th>UN #</th><th>ERG GUIDE</th></tr>
<tr><td>Sulfuric acid</td><td>H_2SO_4</td><td>88.8</td><td>1 mg/m3</td><td>80 mg/m3</td><td>1830</td><td>137</td></tr>
<tr><td>Sodium hydroxide</td><td>NaOH</td><td>24</td><td>2 mg/m3</td><td>250 mg/3</td><td>1823</td><td>154</td></tr>
<tr><td colspan="7">NFPA 3,0,1
USES: Chemical manufacture, rayon and cellophane; detergents; soap; textile processing; reclaiming rubber; vegetable oil refining; etching & electroplating, etc. . . .
HAZARDS: Very corrosive, CAUSTIC. Toxic. Severe eye hazard.</td></tr>
<tr><td>Propylene</td><td>C_3H_6</td><td>22.6</td><td></td><td></td><td>1077</td><td>115</td></tr>
<tr><td colspan="7">NFPA 1,4,1
USES: Isopropyl alcohol, polypropylene, acrylonitrile, vinyl resins, propylene oxide, acrylic acid, cumene, etc. . . .
HAZARDS: Highly flammable gas (FR 2%-11%).</td></tr>
<tr><td>Chlorine</td><td>CL_2</td><td>22.3</td><td>0.5ppm</td><td>30ppm</td><td>1017</td><td>124</td></tr>
<tr><td colspan="7">NFPA 3,0,0
USES: Chlorinated hydrocarbons, polychloroprene (neoprene), PVC, HCL; water purification; shrink proofing wool; etc. . . .
HAZARDS: Compressed gas. Strong oxidizer, corrosive, irritant, toxic.</td></tr>
<tr><td>Nitric acid</td><td>HNO_3</td><td>16.1</td><td>2ppm</td><td>100ppm</td><td>2032</td><td>157</td></tr>
<tr><td colspan="7">NFPA 3,0,0,OXY
USES: Manufacture of ammonium nitrate for fertilizers and explosives; organic synthesis; metallurgy; etching steel; urethanes; rubber chemicals; reprocessing spent nuclear fuel.
HAZARDS: Strong acid. Very corrosive. Strong oxidizer. May cause fire when mixed with organic materials.</td></tr>
</table>

OBSOLETE CHEMICAL NAMES AND CURRENT EQUIVALENTS:

NOTE: This chart may contain errors. Use it with caution.

Old:	**Current:**
Acid Potassium Sulfate	Potassium Bisulfate
Acid of sugar	Oxalic Acid
Alcali Volatil	Ammonium Hydroxide
Alcohol Sulfuris	Carbon Disulfide
Alumina	Aluminum Hydroxide
Ammonia	Ammonium Hydroxide
Antimony Black	Antimony Trisulfide
Antimony Bloom	Antimony Trioxide
Antimony Glance	Antimony Trisulfide
Antimony Red	Antimony Oxysulfide
Antimony Vermilion	Antimony Oxysulfide
Aqua Fortis	Nitric Acid
Aqua Regia	Nitro Hydrochloric Acid
Bitter salt	Magnesium Sulfate
Blue Copperas	Copper Sulfate
Blue salts	Nickel Sulfate
Blue Stone	Copper Sulfate
Blue Vitriol	Copper Sulfate
Bone Ash	Impure Calcium Carbonate
Bone Black	Animal Charcoal
Brimstone	Sulfur
Butter of Antimony	Antimony Trichloride
Butter of Tin	Tin (IV) Chloride Hydrated
Butter of Zinc	Zinc Chloride
Calomel	Mercury (I) Chloride
Caustic Soda	Sodium Hydroxide
Chile Nitre	Sodium Nitrate
Chile Saltpeter	Sodium Nitrate
Chromic Acid	Chromium Trioxide
Copperas	Iron (II) Sulfate
Corrosive Sublimate	Mercury (II) Chloride
Corundum	Aluminum Oxide
Ferric Chloride	Iron (III) Chloride
Ferric Nitrate	Iron (III) Nitrate
Ferric Sulfate	Iron (III) Sulfate
Fero Prussiate	Potassium Ferricyanide
Ferrous Chloride	Iron (II) Chloride
Ferrous Sulfate	Iron (II) Sulfate
Flores Martis	Anhydrous Iron (III) Chloride
Flowers of Sulfur	Sulfur
Fustic	Dried,Pulverized, Sumac Leaves
Purple Crystals	Potassium Permanganate
Quicksilver	Mercury
Red Prussiate of Potash	Potassium Ferricyanide
Sal Ammoniac	Ammonium Chloride
Salts of Lemon	Potassium Acid Oxylate (5% solution)
Salts of Sorrol	Potassium Acid Oxylate (5% solution)

Old:	**Current:**
Gallic Acid	3,4,5-Trihydrobenzoic Acid
Grain Alcohol	Ethyl Alcohol
Grain Vitriol	Iron (II) Sulfate
Green Vitriol	Iron (II) Sulfate
Hard Oil	Boiled Linseed Oil
Iron Perchloride	Iron (III) Chloride
Iron Pernitrate	Iron (III) Nitrate
Iron Protochloride	Iron (II) Chloride
Iron Persulfate	Iron (III) Sulfate
Iron Sulfate	Iron (II) Sulfate
Jeweler's Etchant (mixture)	3g Silver Nitrate +3g Nitric Acid +3g Mercury (I) Nitrate +100cc Water
Killed Spirits	Zinc Chloride
K.N.S.Solution (mixture)	10g Ammonium Carbonate +20g Ammonium Peroxydisulfide +200cc Ammonium Hydroxide
Lime	Calcium Oxide
Liver of Sulfur (mixture)	Melted Potassium Carbonate +Sulfur
Logwood	Haematoxylin
Lunar Caustic	Silver Nitrate
Mercuric Chloride	Mercury (II) Chloride
Mercurous Chloride	Mercury (I) Chloride
Muriate of Mercury	Mercury (II) Chloride
Muriatic Acid	Hydrochloric Acid
Nitre	Potassium Nitrate
Nitre	Sodium Nitrate
Nitrate of Silver	Silver Nitrate
Nordhausen Acid	Fuming Sulfuric Acid
Oil of Mars	Deliquescent Anhydrous Iron (III) Chloride
Oil of Vitriol	Sulfuric Acid
Orthophosphoric Acid	Phosphoric Acid
Oxymuriate of Mercury	Mercury (II) Chloride
Oxymuriate of Potassium	Potassium Chlorate
Pearl Ash	Potassium Carbonate
Plumgabo	Graphite
Potash	Potassium Carbonate
Prussic Acid	Hydrocyanic Acid
Spirits of Salt	Hydrochloric Acid
Spirit of Nitrous ether	Ethyl Nitrate
Spirits of Wine	Ethyl Alcohol
Stannic Chloride	Tin (IV) Chloride
Stannous Chloride	Tin (II) Chloride
Sugar of Lead	Lead Acetate
Sulfuric Ether	Ethyl Ether
Sweet Spirits of Nitre	Ethyl Nitrate Spirit

Old:	**Current:**	**Old:**	**Current:**
Salt of Tartar	Potassium Carbonate	Tetrachloromethane	Carbon Tetrachloride
Salt of Vitriol	Zinc Sulfate	Tincture Ferric Chloride	Iron (III) Chloride +Ethyl Alcohol
Salt of Wormwood	Potassium Carbonate		
Saltpeter	Potassium Nitrate	Tincture of Steel	Iron (III) Chloride +Ethyl Alcohol
Sal Volatile	Ammonium Carbonate		
Slaked Lime	Calcium Hydroxide	Tin Salt	Tin (II) Chloride
Salts of Hartshorn	Ammonium Carbonate	Verdigris	Copper Acetate
Soda	Sodium Carbonate	Vitriol	Sulfuric Acid
Soot	Carbon	Water Glass	Sodium Silic

CHARACTERISTICS OF SOME COMMON MATERIALS THAT EXPLODE

OXYGEN

ETHERS	C-0-C
PEROXIDES	C-O-O-C

BONDING

AS THE BONDING GOES FROM SATURATED TO UNSATURATED, THE FIRE HAZARD INCREASES

ETHANE	C - C
ETHENE	C = C
ACETYLENE	C ≡ C

NITROGEN

NITRATES	NO_2
AMMONIA/AMMONIUM	NH_3 NH_4

REACTIVE METALS

WATER REACTIVE -

CLASS D FIRES

AIR REACTIVE -

PYROPHORIC SPONTANEOUS IN AIR

SLOWER BURN

WATER REACTIVE -

HYGROSCOPIC TAKE ON WATER

HYDROLYSIS BREAK UP WATER

REACTIVE METAL + WATER > METAL HYDROXIDE + H_2 GAS

MOST ALKALI METALS ARE FLAMMABLE SOLIDS

LITHIUM, SODIUM, POTASSIUM

LITHIUM

SOFT, SILVERY

LIGHTEST OF ALL SOLID ELEMENTS

FLOATS ON PETROLEUM PRODUCTS

EXPENSIVE

USED IN THE PRODUCTION OF PLASTICS, MEDICINE,

CERAMICS, GREASE AND FUNGICIDES

WATER REACTION:

$2Li + 2\,H_2O \text{ -----> } 2\,LiOH + H_2$

AIR (NITROGEN) REACTION:

$2Li + N_2 + 3\,O_2 \text{ -----> } 2Li\,NO_3$

FIRES INVOLVING LITHIUM METAL ARE NOT EXTINGUISHED WHEN

THEY ARE BLANKETED WITH NITROGEN

SODIUM

SOFT, SHINY BRIGHT
CRUST ON SURFACE (HYDROXIDE OR PEROXIDE)
USED AS REDUCING AGENT IN ORGANIC REACTION

2 FORMS:
- AMALGAM OF MERCURY, SOLID SOLUTION
- POTASSIUM ALLOY (“NAK”) HEAT EXCHANGER IN NUCLEAR SUBS

VIOLENT REACTION WITH WATER

$2\ Na + 2\ H_2O$ -----> $2\ NaOH + H_2$

BURNS IN AIR WITH YELLOW FLAME TO FORM:
SODIUM OXIDE Na_2O AND SODIUM PEROXIDE Na_2O_2

POTASSIUM

SIMILAR CHARACTERISTICS OF SODIUM

MUCH MORE REACTIVE THAN OTHER ALKALI METALS

IGNITES IN AIR AT ROOM TEMPERATURE WITH PURPLE FLAME

WHEN EXPOSED TO PURE OXYGEN IT FORMS

SUPER OXIDE (KO_3)

THE SUPEROXIDE REACTS WITH ORGANICS

METALLIC POTASSIUM REACTS MORE VIOLENTLY

THAN SODIUM OR LITHIUM WITH WATER.

THE REACTION SPATTERS

$2K + 2\ H_2O$ ----> $2\ KOH + H_2$

WARNING PLACARD

DANGEROUS CHEMICAL — KEEP FIRE AWAY

ORGANIC PEROXIDES

1. No smoking permitted. Matches and cigarette lighters prohibited.
2. CAUTION — Flammable Material — Unstable — may Explode under certain conditions (Heat, Impact, Friction).
3. Store in a cool place — keep away from all sources of heat, open flames and sparks.
4. Handle Peroxides with care. Do not grind or subject the Peroxides to any type of friction or impact.
5. Keep Peroxides in original containers, prevent contamination.
6. Leaking containers should be removed. Spilled materials should be handled in accordance with emergency instructions.
7. Maximum and minimum temperatures should carefully be observed in storage and manufacturing areas (manufacturers will usually indicate optimum temperature).
8. Avoid all sources of ignition — use non-sparking tools.
9. Observe good personal hygiene. Do not breathe organic peroxide vapors or permit the Peroxides to contact skin. Work clothes without cuffs are recommended — use Goggles, Safety Shields and Gas or Dust Masks as needed.
10. In case of accidental contamination of clothing, skin or eyes, flush immediately with copious quantities of water. If contaminated clothing ignites, discard clothing, use water to control . . . a fire blanket is not effective.
11. Only trained personnel, and in the minimum number required, should be allowed in manufacturing and storage area.

EMERGENCY PROCEDURE PLACARD

1. IN CASE OF ACCIDENTAL SPILLAGE:

A. Remove spilled Organic Peroxide in accordance with instructions for each specific material.

B. Exercise care in removing the spilled material. Do not use any tool or implement that can strike a spark. Wet down and avoid friction when gathering or sweeping Solid Peroxides.

C. Destroy spilled Peroxides according to instructions. Don't try to salvage or return to broken containers.

2. IN CASE OF FIRE:

A. If the Organic Peroxide becomes involved evacuate building as quickly as possible and let the automatic sprinkler take over. Explosions are possible. Apply water from a safe distance.

B. If the Organic Peroxides are not involved in the fire, they should be wetted down and kept cool.

C. Do not try to use first aid fire extinguishing equipment on an organic peroxide fire.

D. Cleanup and salvage operations should not be attempted until the entire area is completely cooled down. Disposal of large quantities of peroxides involved in a fire should not be attempted without technical assistance of the Manufacturer.

STRENGTH

Amount of Gas and Heat it produces (6000° F)

BLASTING CAPS

MERCURY FULMINATE (MF) $Hg(ONC)_2$

LEAD AZIDE $Pb(N_3)_2$ CONTAINS NO OXYGEN

OTHER PRIMARY EXPLOSIVES

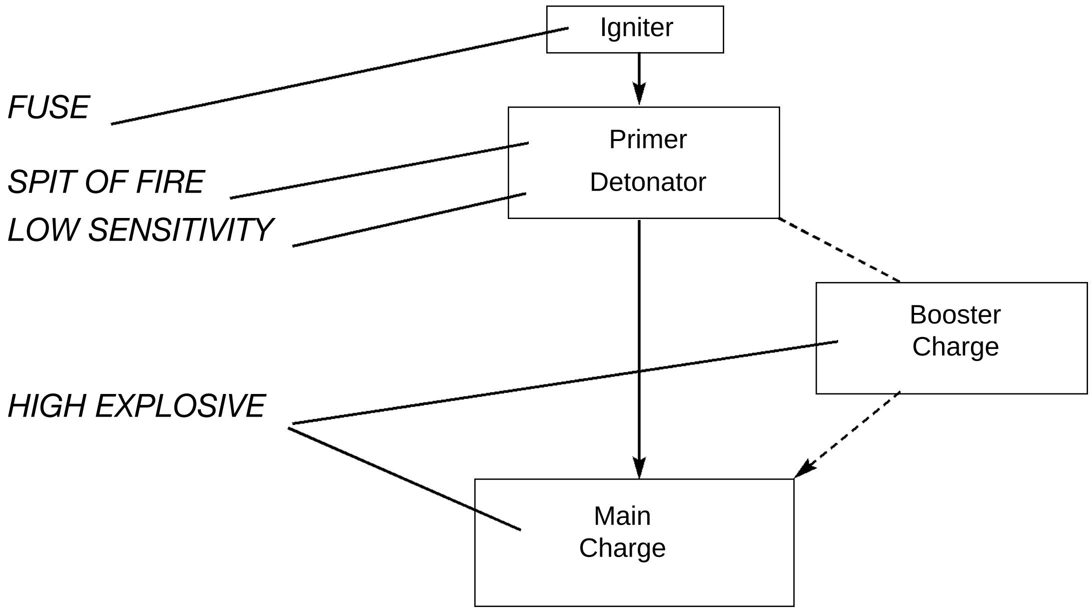
DDNP

PETNPENTAERYTHRITOLTETRANITRATE   “PETTIN”

PRIMACORD   100 Yd/Sec   3000 MILES/10 MIN

PENTOLITE

THE EXPLOSIVE TRAIN



High explosives vary widely in their susceptibility to detonation. Broadly, with some overlapping, they are divided into two major groups. A PRIMARY or INITIATING explosive (such as mercury fulminate or lead azide), is generally much more sensitive to heat, flames, or shock than a main charge such as dynamite or TNT.

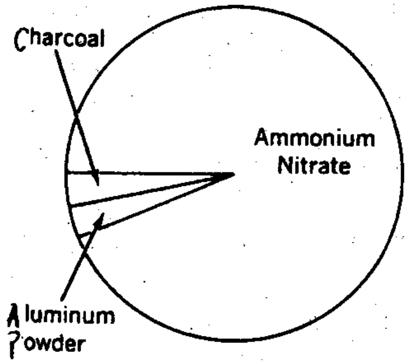
Primary explosives are also much more vulnerable to heat and to flame: a fire that will only ignite a high explosive, such as dynamite or TNT, will cause most primary explosives to explode immediately. Deliberate explosion of smaller and less dangerous amounts of a sensitive primary explosive supplies the jolt that detonates the main charges.

THE EXPLOSIVE COUSINS OF BENZENE

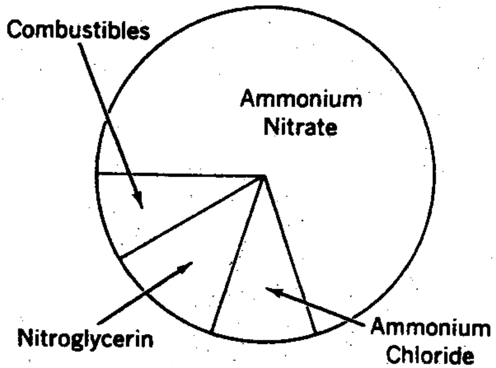
Tetranitroaniline (TNA)	Used in primers or as a booster. Explodes at 459°F.
Tetranitrol (Erythrityl Tetranitrate)	Crystals which explode upon shock or heating.
Tetranitronaphthalene	Crystals used in bursting charges. Less sensitive than TNT.
Trinitroacetonitrile	Solid which explodes below 400°F. Emits cyanides when heated.
Trinitroaniline (Picramide)	Shock and heat sensitive crystalline explosive.
Trinitroanisol (Methyl Picrate)	Shock and heat sensitive crystalline explosive sometimes used in boosters.
Trinitrobenzene (TNB)	More brisant and less sensitive than TNT, but difficult to manufacture.
Trinitrobenzoic Acid	Crystalline high explosive.
Trinitrochlorobenzene	Shock and heat sensitive explosive. Emits phosgene when heated.
Trinitro-n-Cresol (Cresolite)	Shock and heat sensitive yellow crystals. Not as powerful as TNT.
Trinitromethylenetriamine	Chemical name for cyclonite (RDX).
Trinitroglycerin	Chemical name for nitroglycerin.
Trinitrophenol	Chemical name for picric acid.
Trinitrophenylmethylnitramine	Chemical name for tetryl.
Trinitrophenylnitramine Ethyl Nitrate (Petryl)	Sensitive to shock and friction, used in detonators. More brisant than tetryl.
Trinitrorescorcinol (Styphnic Acid)	Shock and heat-sensitive yellow crystals used in primers.
Trinitrotoluene	Chemical name for TNT.
Trinitroxylene (TNX)	Shock and heat sensitive explosive used in mixtures. Not as brisant as TNT.

MIXTURES OF ALIPHATIC (CHAIN) HYDROCARBON EXPLOSIVES

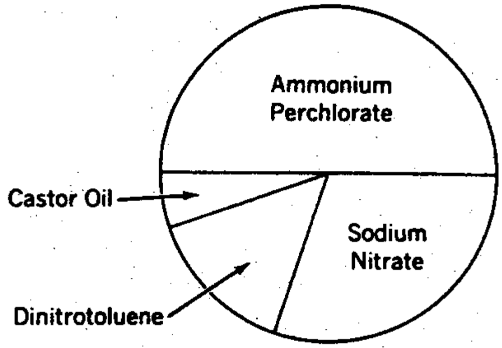
COMMERCIAL AMMONIUM EXPLOSIVES



Ammonal IV
(Permissible)

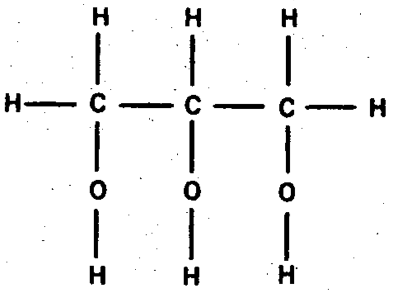


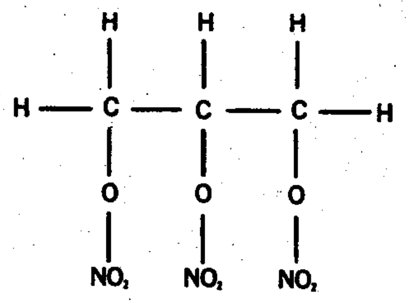
Monobel Dynamite
(Permissible)



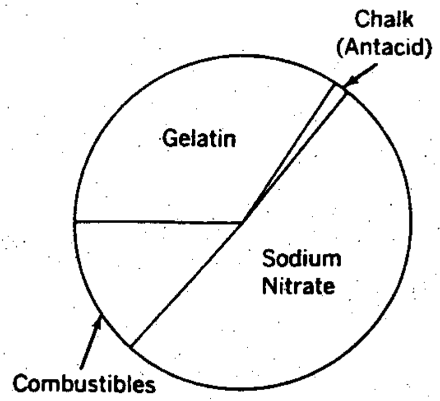
Perchlorate Explosive
(Cheddite)

NITROGLYCERINE

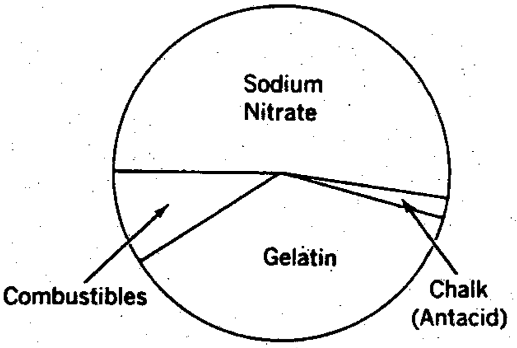




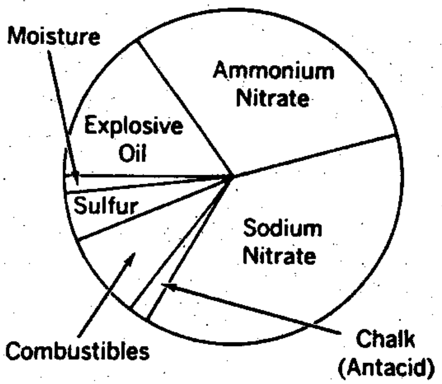
DYNAMITE MIXTURES



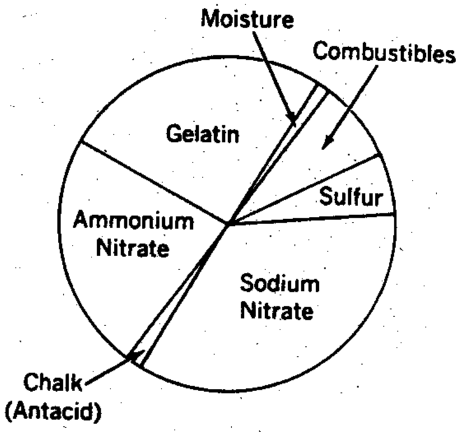
40% Gelatin



60% Gelatin



40% Ammonia



Ammonia-Gelatin

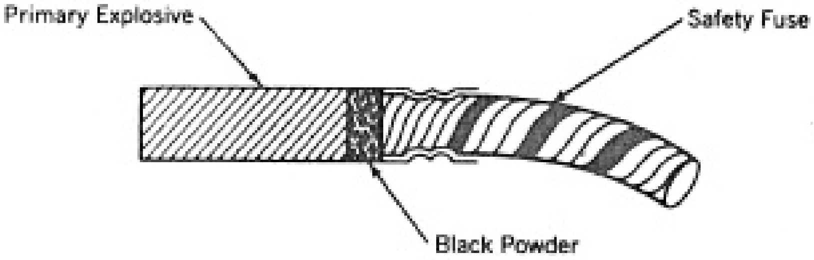
These components are wrapped in waxed paper. This not only provides moisture resistance, but also enters into the explosive reaction. Dynamites are also shipped in bags weighing a maximum of 50 pounds (DOT limitation).

BLASTING CAPS

SAFETY FUSE TYPE

At the time of firing, the blaster is a comfortable distance away, usually at the end of a couple of hundred yards of electric wire that is attached to a plunger-type, battery-powered blasting machine. When electric caps are used, outside energy sources must be controlled. The use of radio transmitters may be banned and no blasting is permitted during storms.

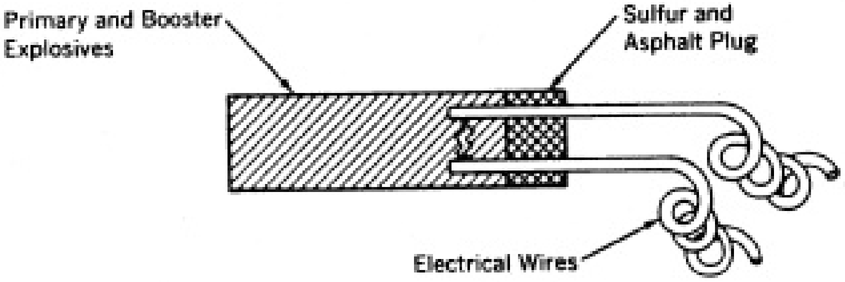
Safety fuse gives the blaster time to make his escape. In appearance, safety fuse is a waxy-looking textile cord that may be orange, white, black, or striped. It is filled with a black powder formulated to burn at a steady, predictable rate: 20 to 40 seconds per foot. The fuse extends a safe distance away from the charge. If a high explosive is to be detonated, the other end of the fuse has already been crimped into a blasting cap. Once lit, safety fuse will burn evenly into the blasting cap, ending its journey with a "spit" of flame which explodes the primary, leading to the detonation of the main charge.



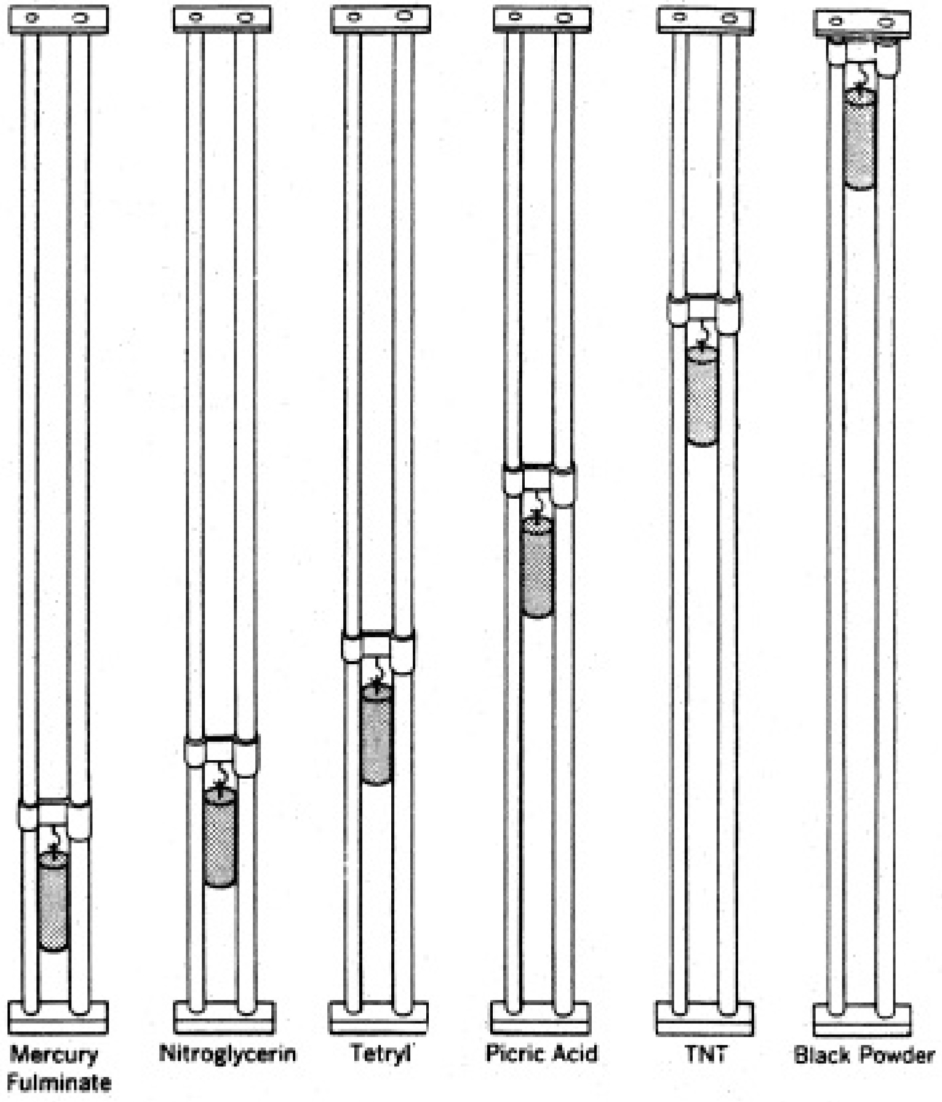
ELECTRIC FUSE CAP

When blasting caps are imbedded in an explosive, the shock of their detonation is enough to set off the entire mass. The more shock-sensitive the main charge, the weaker the cap that can be used. One of the definitions of a blasting agent is that it cannot be exploded by the strongest cap, a #8.

Blasting caps are generally set off by safety fuses or by electricity. Naturally, the method used to fire the charge should guarantee that the blaster will be around to do it again. An electrical blasting cap explodes because of the interior heating of an electric wire or the formation of an arc.

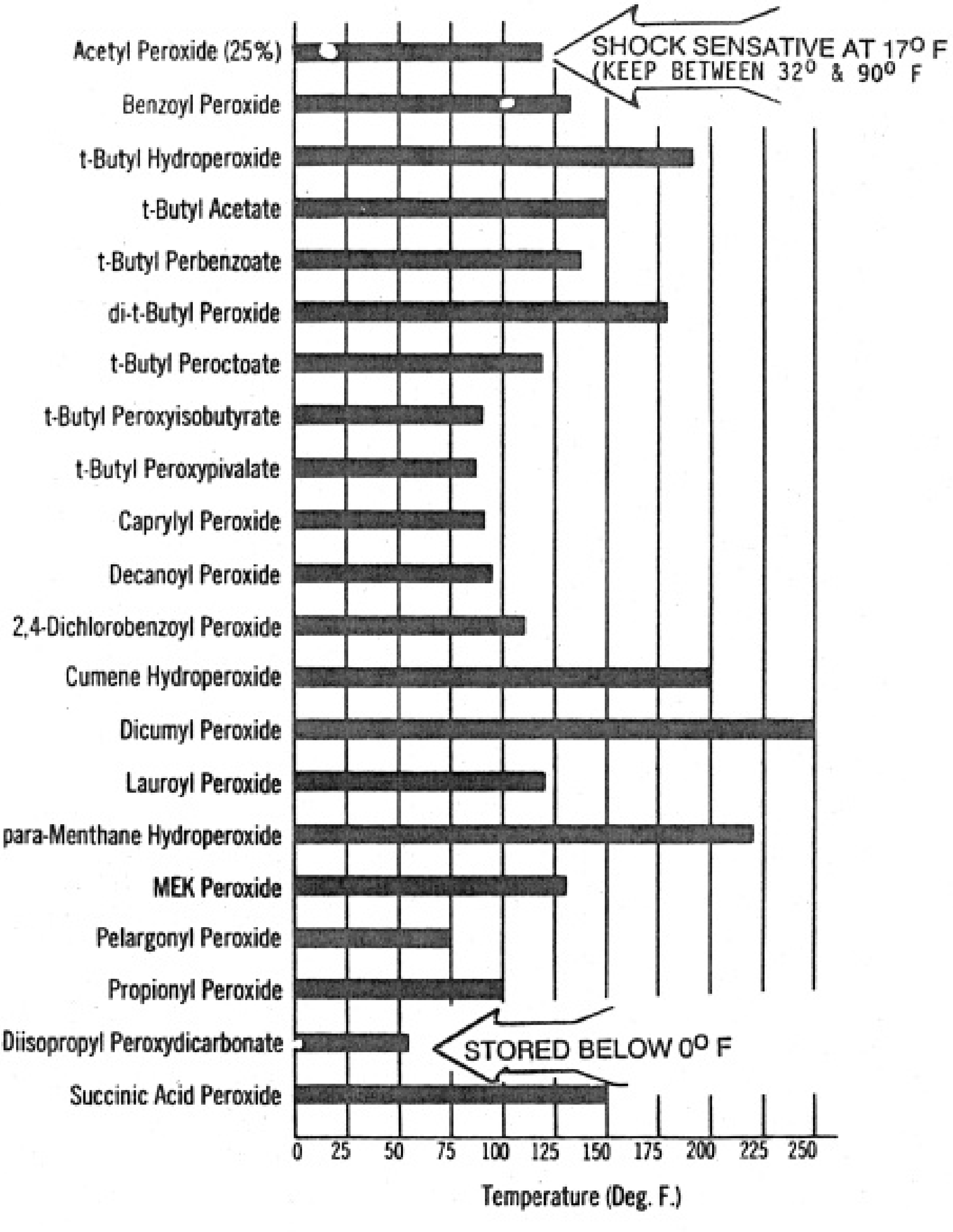


A COMPARISON OF THE FORCE NEEDED TO CAUSE AN EXPLOSION



The difference between these two types of explosives can be pointed up by a few more comparisons. All explosives can be ignited or detonated by a blow of some kind. Some explosives are so ticklish they will explode upon the slightest jostling — dry fulminate of silver, for instance, and impure or decomposing nitroglycerin. They are much too touchy to use safely. At the other end of the scale are explosives like *ammonium picrate* or TNT that require a healthy blow from a sledge hammer to set them off. (Once, during a talk on the shock-sensitivity of high explosives, an Army explosives expert became rather annoyed at an inattentive fire captain. By way of demonstration, the sergeant suddenly slammed down on the table, directly in front of the captain, a half-pound block of TNT he had been carrying. The captain became all eyes.) Somewhere between these extremes lie the primary explosives. A fairly gently rapping is sufficient to explode them, compare the distances a weight must drop to explode some test samples.

THE MAXIMUM SAFE STORAGE TEMPERATURES
OF
ORGANIC PEROXIDES

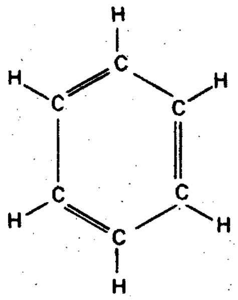


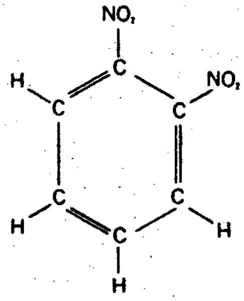
SHOCK SENSATIVE AT 17° F
(KEEP BETWEEN 32° & 90° F

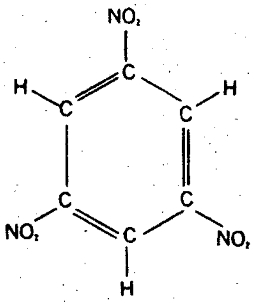
STORED BELOW 0° F

EXPLOSIVE AND TOXIC MATERIALS, J.E. MEIDEL, GLENCO PRESS, 1970

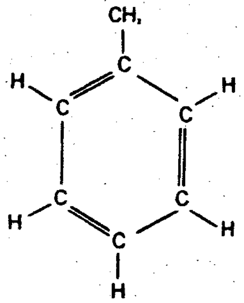
NITRATED BENZENE

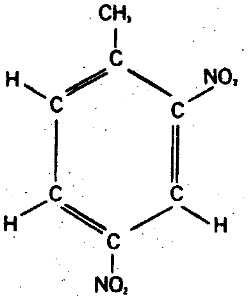

Benzene
C_6H_6

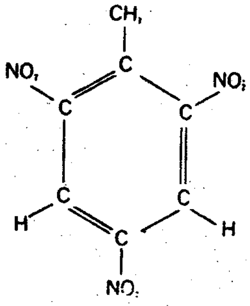

Dinitrobenzene
$C_6H_4(NO_2)_2$


Trinitrobenzene (TNB)
$C_6H_3(NO_2)_3$

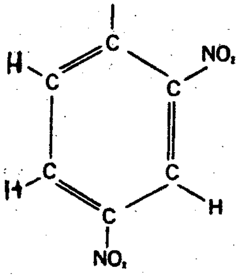
NITRATED TOLUENE

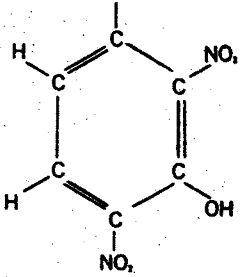

Toluene
$C_6H_5CH_3$

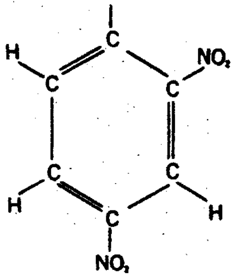

Dinitrotoluene
$C_6H_3(NO_2)_2CH_3$


Trinitrotoluene (TNT)
$C_6H_2(NO_2)_3CH_3$

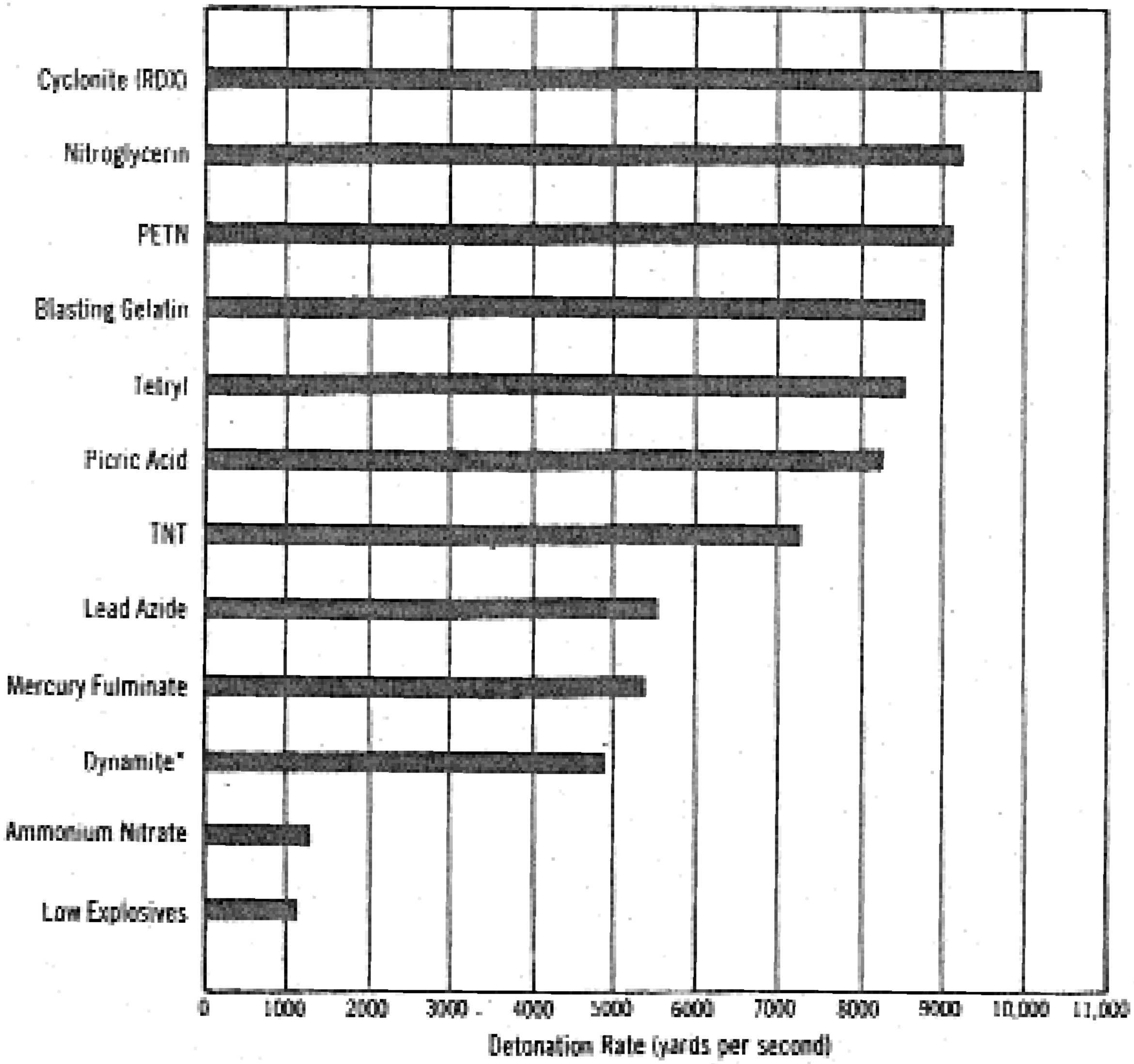
NITRATED AROMATICS


Picric Acid
$C_6H_2(NO_2)_3OH$


Dinitroresorcinol
(Styphnic Acid)
$C_6H(NO_2)_3(OH)_2$


Dinitrochlorobenzene
$C_6H_3(NO_2)_2Cl$

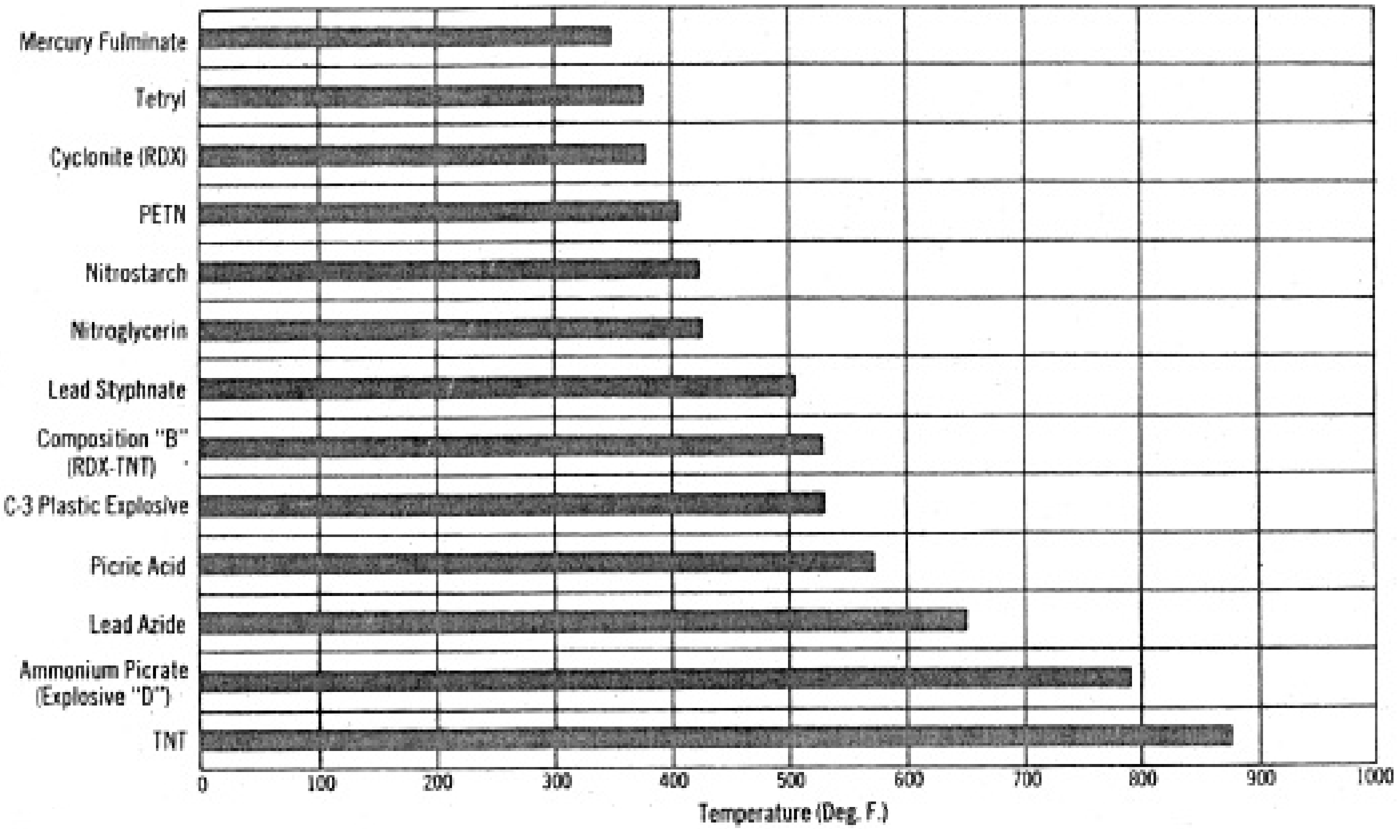
APPROXIMATE DETONATION RATES OF SOME EXPLOSIVES



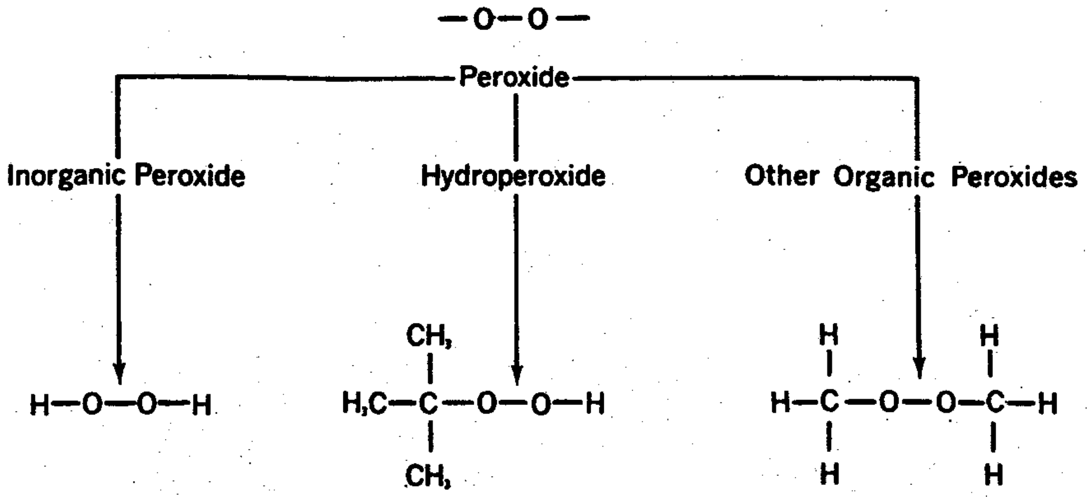
**The detonation rates of different types of dynamite vary widely. This figure is only representative.*

Gas pressures can soar to as high as 1 million pounds per square inch and to temperatures as high as 6,000°F. Remember, the speed of sound is 1,250 feet per second—below this speed it is a Deflagration

RELATIVE TEMPERATURES LIKELY TO CAUSE DETONATION OF COMMON EXPLOSIVES



ORGANIC PEROXIDES



Hydrogen Peroxide H_2O_2 | t-Butyl Hydroperoxide $(CH_3)_3COOH$ | Dimethyl Peroxide $(CH_3)_2O_2$

USES AND MANUFACTURERS

INITIATORS AND HARDENERS

FLAMMABILITY AND DILUTANTS

“DON’T LET THEM HEAT UP OR DRY OUT”

BENZOL

MEK

EXPLOSIVITY

SELF-ACCELERATING DECOMPOSITION TEMPERATURE (SADT)

OR

MAXIMUM SAFE STORAGE TEMPERATURE (MSST)

GLOSSARY

-A-

ABSOLUTE PRESSURE—(psia) Also; True pressure. Equal to (measured) gauge pressure plus atmospheric pressure (14.7 psi).

ABSORBANT MATERIAL—Loose or bagged material like commercial bagged clay, kitty litter, Zorbal, or "pigs" used to soak up liquid hazardous materials.

ABSORPTION—The penetration of one substance into the inner structure of another, as distinguished from adsorption in which one substance is attracted to and held on the surface of another.

ACARICIDE—Chemical compound lethally toxic to spiders, ticks and mites either by ingestion or body contact.

ACGIH—American Conference of Governmental Industrial Hygienists. Recommends upper limits (TLVs) for exposure to workplace chemicals.

ACIDS—Have a pH lower than 7.0 and may be inorganic, or organic. Most inorganic acids are also oxidizing agents. Organic acids contain carbon and most are also flammable. Strong acids react violently with water.

ACUTE TOXICITY—Any effects produced by a single dose or exposure to a substance.

ADHESION—A union of two surfaces that are normally separate.

ADSORPTION—Adherence of atoms, ions, or molecules of one substance to the surface of another (the adsorbent), as opposed to absorption.

AIR REACTIVE MATERIALS—Materials that will react with atmospheric moisture and rapidly decompose.

AFF (AQUEOUS FILM FORMING FOAM)—Extinguishing agent designed to flow on a burning liquid.

ALCOHOL FOAM—Extinguishing agent designed to blanket burning liquids that are soluble in water (like alcohol and acetone). Must be applied more carefully than regular foam because of the lesser strength of its bubbles.

ANESTHETIC—A chemical that causes a total or partial loss of sensation. Overexposure to anesthetics can cause impaired judgement, dizziness, drowsiness, headache, unconsciousness and death.

APR—Air Purifying Respirator. Breathing apparatus used with filter cartridges. For use **only** when the air is monitored and is found to have at least 19.5% oxygen.

AQUATIC TOXICITY—Adverse effects to marine life that result from exposure to a substance.

AQUIFER—A geologic formation, formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

ASPHYXIANT—A substance that can cause unconsciousness or death by lowering the concentration of oxygen in the air or by out competing oxygen metabolically in the body.

ATOM—The basic particles of which all matter is composed. Smallest possible unit of an element comprised of a nucleus containing one or more protons and (except hydrogen) two or more neutrons and one or more electrons which revolve around it.

AUTO-IGNITION TEMPERATURE—The temperature at which a substance will spontaneously ignite.

-B-

BACTERICIDE—A pesticide used to control bacteria.

BAFFLE—A partial bulkhead to reduce product surging in a partially filled tank.

BASES—Have a pH of higher than 7.0 and also known as alkalis or caustics. They react violently with acids.

BIOACCUMULATION—Absorption and storage of toxic chemicals from the environment in an organism (often due to the solubility of the chemical in body fat).

BIOLOGICAL HAZARDS or **ETIOLOGIC AGENTS**—Viable microorganisms or their toxins, which may cause human disease.

BIOTOXIN—Toxic substance of a biological nature.

BLOW DOWN VALVE—A manually operated valve to quickly reduce the pressure in a tank.

BOILING POINT (BP)—The temperature at which the vapor pressure of the material being heated equals the atmospheric pressure.

BREAKTHROUGH—The action of a chemical physically passing through a material.

BREAKTHROUGH TIME—The actual time it takes a chemical to pass from the exterior surface of a material to the interior surface by permeation.

BRITISH THERMAL UNIT—(BTU) The amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit.

BUDDY SYSTEM—A system of work group assignments made so that each worker in a group is designated to be observed by at least one other worker in the group. The purpose of the system is to provide rapid assistance to workers in the event of an emergency.

BULKHEAD—An upright partition separating compartments.

BULK PACKAGING—Packaging other than a vessel or barge in which materials are loaded with no intermediate form of containment. It includes transport vehicles and freight containers which have an internal volume greater than 450 Liters (118.9 gallons) for liquids, 400 Kilograms (881.8 pounds) for solids, or a water capacity greater than 453.6 Kilograms (1000 pounds) for gas.

BUNG—1) The cap or plug used to seal the small opening in the top of a drum or barrel. 2) The small opening in the top of a drum or barrel.

-C-

C—Celsius or Centigrade.

CAG—The Carcinogens Assessment Group of the federal EPA.

CARCINOGEN—A substance that causes cancer.

CARGO TANK—Bulk packaging which is a tank intended for carrying liquids or gases, is attached to a motor vehicle or not detached for unloading, and is not fabricated under other specifications (as for cylinders, portable tanks, tank cars, etc.).

CARGO TANK MOTOR VEHICLE—A motor vehicle with one or more permanently attached cargo tanks.

CATALYST—A substance which notably affects the rate of a chemical reaction without itself being consumed or undergoing chemical change.

CAUSTIC—As a noun, it usually refers to caustic soda (sodium hydroxide). As an adjective, it refers to any strongly alkaline (basic) material which has a corrosive or irritating effect on living tissue.

CEILING (C or TLV-C)—Exposure level to employees that shall not be exceeded during any part of the work day.

CELSIUS (syn. CENTIGRADE)—A system for measuring temperature that defines the freezing point of water as 0° and its boiling point as 100°.

CHEMICAL INCOMPATIBILITY—Chemicals incapable of coexisting harmoniously; gives a harmful reaction.

CHEMICAL RESISTANCE—The ability of a fiber, fabric, or material to resist the effects of direct chemical exposure/contact.

CHRONIC TOXICITY—A poisonous effect resulting from long-term exposure to low dosages of toxic substances. As a disease, long-lasting or frequently recurring.

COCARCINOGEN (or promoter)—Not a carcinogen by itself, but promotes the effects of a carcinogen.

COMBUSTIBLE SUBSTANCE—A solid, liquid, or gas that will burn.

COMPOUNDS—Groups of two, or more, different elements combined in the same molecule.

CONFINED AQUIFER—An aquifer bounded above and below by beds of distinctly lower permeability than that of the aquifer itself; an aquifer containing confined groundwater.

CONFINED SPACE—A space which, by design, has limited openings for entry and exit, unfavorable natural ventilation which could contain or produce dangerous air contaminants, could contain a hazardous atmosphere and which is not intended for continuous employee occupancy. A confined space includes (but is not limited to) a tank, vessel, pit, ventilation duct work, vat, boiler, sewer, or underground utility vault. (NJAC 12:100-9.2).

CONTAINMENT—The act of preventing or confining the spread, or further spread, of a hazardous material.

CONCENTRATION—The amount of a given substance in a stated unit of a mixture or solution.

CONSUMER COMMODITY—A material that is packaged and distributed in a form intended for sale through retail agencies for consumption by individuals for purposes of personal care or household use.

CORROSIVE—Materials that cause irreversible damage to containers or human tissue.

CORROSIVITY—The measure or extent of a material's being corrosive.

CRITICAL PRESSURE—(of a gas) The pressure above which a liquid cannot be turned into a gas by an increase in temperature.

CRITICAL TEMPERATURE—(of a gas) The temperature above which the gas cannot be liquified by an increase in pressure.

CRYOGENIC—Pertaining to materials at extreme low temperatures (below -90 degrees C or -130 degrees F).

CYLINDER—A pressure vessel designed for pressures above 40 psia and having a circular cross section.

-D-

DECOMPOSITION—The basic breakdown of a substance into different substances. Energy will be released by this reaction; in the case of highly reactive materials, the release may be sudden, i.e. explosive.

DECONTAMINATION—The process of removing hazardous substances to prevent adverse health, safety, or environmental effects. Takes place at three levels based on exposure:

Level 1: contamination is likely but unknown.

Level 2: contamination is known to have occurred but skin contact or irritation is not evident.

Level 3: contamination is known to have occurred and skin contact or irritation is evident.

DEFLAGRATION—Rapid or violent decomposition with flame and large amounts of heat. The speed of decomposition is less than 1,251 ft/sec (subsonic).

DEFOLIANT—A type of herbicide which is especially effective in dropping leaves from deciduous trees, shrubbery, etc.

DEGRADATION—(applied to protective clothing) Chemical decomposition brought about by exposure to heat, sunlight, solvents, or oxidation.

DELETERIOUS SUBSTANCE—Substances not normally harmful to people that may be harmful to the environment.

DENSITY—The weight of a material divided by its volume. Density is usually measured in grams per cubic centimeter (g/cc).

DEPE—The New Jersey Department of Environmental Protection and Energy.

DERMAL TOXICITY—The ability of a pesticide or toxic chemical to poison people or animals by contact with the skin.

DESORPTION—The recovery of an absorbed material by the opposite reaction; stripping.

DETONATION—Extremely rapid, violent decomposition producing a lethal shock front, heat and flame. The speed of decomposition is from 1,252 to 30,000 ft/sec (supersonic).

DISPERSANT—Chemical agent used to break up concentrations of organic materials such as spilled oil.

DISPERSION—To spread, scatter, or diffuse through air, soil, or surface or ground water.

DOT—The Department of Transportation. Federal agency that regulates transportation of hazardous materials.

DOWNWIND—The area directly in the path of the wind from the incident site.

DUMP—Site used to dispose of solid wastes without environmental controls.

-E-

EFFLUENT—Waste material (such as smoke, liquid industrial refuse, or sewage) discharge into the environment. It generally refers to water pollution.

ELEMENTS—Molecules which are made up of atoms of the same type.

ENDOTHERMIC—A process or chemical reaction which takes place with adsorption of heat and requires high temperature for initiation and maintenance.

EPA—Environmental Protection Agency. The federal agency responsible for regulating environmental hazards.

ETIOLOGIC AGENTS or BIOLOGICAL HAZARDS—Viable microorganisms or their toxins, which may cause human disease.

EVAPORATION RATE—The rate at which a material will vaporize in comparison to the rate of vaporization of a standard material. The designated standard material is usually n-butyl acetate (NBUAC or n-BuAc) with a vaporization rate designated as 1.0. Vaporization rates of other materials are classified as:

- Fast evaporating (>3.0)
- Medium evaporating (from 0.8 to 3.0)
- Slow evaporating (<0.9)

Some examples are:

Hexane	8.3
Acetone	5.6
Methyl Ethyl Ketone	3.8
MIBK	1.6
Ethyl Alcohol (95%)	1.4
Xylene	0.6
Isobutyl Alcohol	0.6
n-Butyl alcohol	0.5
Water	0.3
Mineral Spirits	0.1

EXOTHERMIC—A process or chemical reaction which is accompanied by the release of heat.

EXPLOSIVE LIMITS—The range of concentration of a gas or vapor (measured in percent by volume in air) that can explode upon ignition in a confined space. The highest and lowest concentration are called respectively, the Upper Explosive Limit **(UEL)** and the Lower Explosive Limit **(LEL)**. At concentrations lower than the LEL, there is not enough product in the air to explode; the mixture is "too lean." At concentrations above the UEL, there is not enough oxygen to sustain an explosion; the mixture is "too rich."

EXPLOSIVE RANGE—The number (as a percentage) that results from subtracting the LEL of a substance from its UEL.

-F-

F—Fahrenheit.

FAHRENHEIT—System for measuring temperature that defines the freezing point of water as 32° and its boiling point as 212°.

FETUS—Unborn human or animal.

FLAMMABLE LIMITS—The range of concentration of a gas or vapor (measured in percent by volume in air) that can burn upon ignition in a confined space. The highest and lowest concentrations are called, respectively, the Upper Flammable Limit **(UFL)** and the Lower Flammable Limit **(LFL)**. At concentrations lower than the LFL, there is not enough product in the air to burn; the mixture is "too lean." At concentrations above the UFL, there is not enough oxygen to sustain burning; the mixture is "too rich."

FLAMMABLE RANGE—The number (as a percentage) that results from subtracting the LFL of a substance from its UFL.

FLAMMABLE SUBSTANCE—A solid, liquid, vapor, or gas that will ignite easily and burn rapidly.

FLASH POINT (FP)—The lowest temperature at which the vapor given off by a liquid within a test vessel forms an ignitable mixture with air. This is **only** a flash, not a sustained fire.

FREEZING POINT—The freezing point or melting point of a substance is the temperature at which its crystal are at equilibrium with its liquid state. The terms melting point and freezing point are used interchangeably, depending on whether that temperature is approached by heating or cooling the substance.

FREIGHT CONTAINER—A reusable container having a volume of 64 cubic feet or more. It is designed and constructed to permit lifting with its contents intact.

FUMES—The particulate, smoke-like emanation from the surface of heated metals. Also, the vapor from concentrated acids, evaporating solvents, or as a result of combustion or other decomposition reaction.

FUNGICIDE—A substance that kills or inhibits the growth of spores and fungus.

-G-

GAS—A substance with perfect molecular mobility and the property of indefinite expansion.

GRADE D AIR—The minimum grade of breathing air used in supplied air respirators. The standards are established by CGA and adopted by OSHA 1010.134.

GRAM—The weight of one cubic centimeter (1cc) of water at 4°C.

GROSS WEIGHT—The combined weight of packaging and its contents.

GROUNDWATER—Water below the land surface in a zone of saturation.

GAUGE PRESSURE (psig)—The pressure registered on a gauge. It does not include the standard atmospheric pressure of 14.7 psi.

-H-

HAZARDOUS MATERIAL—Any substance that, when released from its container, is a potential or actual threat to the safety of life or property when it touches or impinges upon them.

HAZARDOUS MATERIAL INCIDENT—The unintentional or uncontrolled release of a hazardous material.

HAZARDOUS WASTE—Any substance that may pose an unreasonable risk to health, safety, or property when transported in commerce for the purpose of treatment, storage, or disposal as waste.

HEAT STRESS—Refers to a group of illnesses caused by a number of interacting factors including environmental conditions (temperature, humidity), clothing, work load, and the individual tolerance of the worker. Hazmat workers may experience six distinct types of heat stress:

> **Heat Edema**—A swelling of the feet and ankles during hot weather.
>
> **Heat Rash**—Symptom caused by continuous exposure to heat and humid air; it decreases the ability to tolerate heat.
>
> **Heat Syncope**—A sudden and brief loss of consciousness; normally related to standing upright for prolonged periods with little or no movement.
>
> **Heat Cramps**—Muscular spasms and pain resulting from loss of water and salt from the body.
>
> **Heat Exhaustion**—A form of shock caused by heavy work or exercise in extreme heat.
>
> **Heat Stroke**—A life-threatening condition in which the victim's body temperature control system stops working.

HERMETICALLY SEALED—Closed by fusion, gaskets, crimping, or equivalent means so that no gas or vapor can enter or escape.

HYPOTHERMIA—A general lowering of body temperature.

-I-

IARC—International Agency for Research on Cancer. A scientific group that classifies chemicals according to their cancer-causing potential.

IDLH—**I**mmediately **D**angerous to **L**ife and **H**ealth—maximum concentration of a contaminant from which one could escape within 30 minutes without any impairing symptoms or any irreversible health effect.

IGNITION TEMPERATURE (Ign. Temp.)—The minimum temperature required to initiate sustained self-combustion of a material or compound.

INITIATOR—An agent used to start the polymerization of a monomer. Similar to a catalyst except it is consumed in the reaction.

INHIBITOR—A compound (usually organic) that stops, reduces, or retards an undesired chemical reaction. The opposite action of a catalyst.

INORGANIC CHEMISTRY—A major branch of chemistry which includes the study of all substances except hydrocarbons and their derivatives.

INSECTICIDE—Chemical compound lethally toxic to insects either by ingestion or body contact.

INSTABILITY—The tendency of some compounds to readily, and often, violently, decompose.

IONIZING RADIATION—Any form of radiation sufficient to cause the removal of orbiting electrons from atoms when interacting with living matter.

-J-

JACKET—Sheet metal covering to protect tank insulation.

-L-

LAB PACK—Small secure containers placed in larger metal containers and divided by absorbant materials.

LC_{50} (Lethal Concentration 50%)—The quantity of a substance, administered by **inhalation** required to kill 50% of the exposed animals in a laboratory test in a specified time. This test applies to gases, vapors, fumes, dusts, and other particulates suspended in the air. (See LD_{50}).

LD_{50} (Lethal Dose 50%)—The quantity of a substance, administered either **orally or by skin contact,** required to kill 50% of the exposed animals in a laboratory test in a specified time. A substance having an LD_{50} of less than 50 mg/Kg of body weight is rated highly toxic. (See LC_{50}).

LEACHATE—Any liquid, including any suspended components in the liquid, that has percolated through or drained from hazardous waste.

LIMITED QUANTITY—The maximum amount of a hazardous material for which there is a specific labeling and packaging exception.

LIQUID—A substance whose molecules move freely among themselves but do not tend to separate like those of a gas. Any material having a vertical flow rate of more than 2 inches in three minutes or having one gram or more liquid separation as determined by procedures outlined in ASTM D 4359-84.

LIQUIFIED GAS—Under pressure, is partially a liquid at 21.1°C (70°F).

LYME DISEASE—Skin, joint, heart and nervous system disease transmitted by the deer tick.

-M-

MISCIBILITY—The ability of a liquid or gas to dissolve completely and evenly in another liquid or gas at any concentration.

MIXTURE—Combinations of different compounds which are **not** chemically linked together (e.g. sand and salt mixed in a bag).

mg/M^3—(see also “ppm”)—Milligrams of a chemical in a cubic meter of air. It is a measure of concentration (weight/volume).

MODE—Any of the following transportation methods: rail, highway, air or water.

MOLECULE—Groups of atoms that are chemically linked together.

MONOMER—A molecule (usually containing carbon) of low molecular weight and simple structure, which is capable of conversion to polymers, synthetic resins, or elastomers by combining with itself or other similar molecules (e.g. styrene is the monomer of polystyrene resin).

MSHA—Mine Safety and Health Administration. The federal agency that regulates mining. It also evaluates and approves respirators.

MUTAGEN—A substance that cause mutations. A mutation is a change in the genetic material in a body cell. Mutations can lead to birth defects, miscarriages, or cancer.

-N-

NCI—National Cancer Institute. A federal agency that determines the cancer-causing potential of chemicals.

NEMATICIDE—Chemical compound lethally toxic to nematodes (microscopic roundworms) either by ingestion or body contact.

NFPA—National Fire Protection Association. It classifies substances according to their fire and explosion hazard.

NIOSH—National Institute for Safety and Health. It tests equipment, evaluates and approves respirators, conducts studies of workplace hazards, and proposes standards to OSHA.

NOMEX (copyrighted name)—A synthetic, aramid fiber produced by E.I. Dupont Company that has inherent self-extinguishing characteristics. Used for garments where the potential for exposure to open flame is significant.

NON-BULK PACKAGING (see bulk packaging)—Packaging smaller than bulk packaging.

NON-IONIZING RADIATION—A form of radiation which can impart energy to biological molecules and thereby affect living systems.

NON-LIQUIFIED GAS—Under pressure, is entirely in the gaseous state at 21.1°C (70°F).

N.O.S.—Not Otherwise Specified.

NTP—National Toxicology Program. Tests chemicals and reviews evidence for cancer causing properties.

-O-

OEM—The New Jersey State Police Office of Emergency Management. Responsible for the coordination of all emergency management and response policy, planning, and training for New Jersey.

OSHA—Occupational Health and Safety Administration. Adopts and enforces health and safety standards.

ORGANIC CHEMISTRY—A major branch of chemistry dealing with all compounds of carbon except binary compounds (e.g. carbon oxides, carbides, carbon disulfides), ternary compounds (e.g. metallic cyanides, metallic carbonyls), and the metallic carbonates (e.g. calcium carbonate, sodium carbonate). Approximately 3,000,000 organic compounds have been identified and named.

ORM—Other Regulated Material.

OUTAGE (ULLAGE)—The amount by which a package falls short of being full of liquid. Usually expressed as a percent by volume.

OVERPACK—An enclosure used by a consignor to provide protection or convenience in handling a package or to consolidate two or more packages. It does not include a freight container.

OVERPRESSURE—The pressure above atmospheric pressure that is at the leading edge of a shock wave.

OXIDATION—The process in which oxygen combines chemically with another substance. It can be slow (rusting) or fast (fire).

OXYGEN DEFICIENCY—Normal air contains approximately 20.8% oxygen; for the purpose of respirator selection, an oxygen deficient atmosphere is defined as air with less than 19.5% oxygen.

-P-

PAPR—Powered air purifying respirator. The same use limitations apply to PAPR with a “tight fitting mask” as to an APR. A PAPR with a “loose fitting mask” can only be used for certain sand-blasting or welding operations. (NJAC 12:100)

PBI (trademark)—An aramid, organic fiber produced by Celanese Corporation that has inherent non-combustible properties in air. Used for garments where the potential for exposure to open flame is significant.

PEL—Permissible Exposure Limit—air concentration in the workplace which OSHA allows 8 hrs/day, 40 hrs/wk, over a working lifetime.

PENETRATION—1) Refers to chemicals physically passing through protective clothing by way of a tear, cut, or improperly sealed closure. 2) Introducing contaminants into the body by way of exposed cuts or injection by sharp materials (broken glass, metal shards, etc.).

PERMEATION—Refers to chemicals passing through protective clothing by absorption. **All** protective clothing is permeable to some extent.

PERSISTENCE—Long-term presence of a substance in the environment before chemical breakdown or biodegradation occurs.

pH—A measure of a substance's acidic or basic properties, it is the logarithm of the reciprocal of hydrogen ion concentration in gram atoms per liter. Neutral substances have a pH of 7; acids have a pH less than 7; bases have a pH greater than 7.

PILE—Any non-containerized accumulation of solid, nonflowing hazardous wastes that is used for treatment or storage.

PLUME—A vapor cloud formation which has shape and buoyancy.

POINT SOURCE—Any discernible, confined, and discrete conveyance (pipe, ditch, channel, conduit, well, etc.) from which pollutants are, or may be, discharged.

POISON—Any substance that is harmful to living tissue when applied in relatively small doses. (See toxin).

POLYMER—A large or "long chain" molecule (macromolecule) formed by the chemical union of five or more identical combining units (monomers).

POLYMERIZATION—A chemical reaction, usually carried out with a catalyst, in which large numbers of monomers combine to form a chain-like macromolecule.

POLAR SOLVENTS—A solvent whose positive and negative changes are permanently separated. Polar solvents (e.g. water, alcohol, sulfuric acid) are ionic and conduct electricity.

PORTABLE TANK—A bulk packaging designed to be loaded onto or temporarily attached to a transport vehicle or ship.

ppb—Parts of a substance per billion parts of air or water. It is a measure of concentration by volume 1 μg/Kg or 1 μg/L.

ppm—Parts of a substance per million parts of air or water. It is a measure of concentration by volume 1 mg/Kg or 1 mg/L.

PSI—Pounds per square inch.

PSIA—Pounds per square inch absolute (see absolute pressure).

PSIG—Pounds per square inch gauge (see gauge pressure).

PULMONARY EDEMA—The condition of having fluid in the lungs. The condition may be fatal.

PYROPHORIC MATERIAL—Any liquid or solid that will ignite spontaneously at temperatures below 130° Fahrenheit (54.4° Celsius).

-R-

RADIOACTIVITY—The spontaneous disintegration of unstable nuclei accompanied by the emission of nuclear radiation. Ionizing radiation is either particles, or pure energy, which produces changes in matter by creating ion-pairs.

> **ALPHA PARTICLES**—The largest of the radioactive particles (the same size as the nucleus of the helium atom), travel only 3 or 4 inches and can be stopped by a sheet of paper.

BETA PARTICLES—The same size as an electron and travel up to 100 feet. Can be stopped by a one millimeter thick piece of aluminum.

GAMMA RAYS—Weightless forms of pure energy which can travel great distances. Gamma rays can be attenuated (greatly lessened) by three inches of lead and stopped only by gold shielding.

REACTIVE SUBSTANCE—A solid, liquid, or gas that can cause an explosion under certain conditions or on contact with other specific substances.

RESIDUE—The hazardous material that remains in a packaging after its contents has been unloaded to the maximum extent practicable and before the packaging is refilled or cleaned and purged to remove any hazardous vapors.

-S-

SADT—The molecules of many compounds may be disassociated (decomposed) by the application of heat. Some compounds release heat (are exothermic) during this decomposition which speeds up the reaction. Such compounds are said to have reached their **S**elf-**A**ccelerating **D**ecomposition **T**emperature. Typically, chemical reactions accelerate by 50% for every 10°F their temperature is raised—chemicals at their SADT require no external source to raise their temperature.

SAR—**S**upplied **A**ir **R**espirator—A type of respirator that uses a hose to bring compressed air to the wearer's breathing mask. The air line is often connected to a small air tank on the wearer's harness which acts as an escape air supply and from there to the breathing mask.

SARANEX (copyrighted name)—Produced by Dow Chemical Company, it is a proprietary laminate of polyethylene, SARAN, and Tyvek.

SCBA—**S**elf **C**ontained **B**reathing **A**pparatus—A type of respirator that supplies air from a tank of compressed air that is carried by the wearer on a backpack-type harness. They can be demand or pressure-demand design but only the pressure-demand type may be used for working with hazardous materials.

SHIPPING PAPER—A shipping order, bill of lading, manifest or other document containing the information required by 172.202, 172.203 and 172.204.

SHOCK WAVE—The high pressure wave that radiates from the surface of an explosive that has detonated.

SOLID—The most concentrated form of matter with the lowest molecular mobility. The normal condition of the solid state is a crystalline structure (called a lattice). All solids can be melted and thus changed to a liquid form. Solids, as defined by ASTM D 4359-84, have a vertical flow rate of two inches or less in three minutes or a separation of one gram or less of a liquid.

SOLUBILITY—The ability or tendency of one substance to dissolve evenly in another.

SOLUTION—A homogeneous liquid mixture of two or more compounds or elements that will not undergo segregation under normal conditions.

SOLVENT—A substance capable of dissolving another substance (the solute) to form a uniformly dispersed mixture (the solution). Water, referred to as the "universal solvent," is a strongly polar solvent.

SPECIFIC GRAVITY (Sp. Gr. or SG)—The ratio of the density of a solid, or liquid, to the density of an equal volume of water. Relative Density.

SPONTANEOUSLY COMBUSTIBLE—The ignition of a substance from the rapid oxidation of its own constituents.

STEL—**S**hort **T**erm **E**xposure **L**imit—The exposure level of a hazardous material that is considered safe for employees to work in for only short periods of time (15-minutes), 4 times a day. The exposure periods should be separated by at least 60 minutes.

STLC—Short **T**erm **L**ethal **C**oncentration—The exposure level of a hazardous material that is considered to be lethal with 10 minutes of exposure time for employees.

STRENGTH—1) the degree to which a corrosive ionizes when it mixes with water; the greater the ionization the stronger (and more corrosive) the fluid. 2) concentration; the higher the concentration, the stronger the solution.

SUBLIMATION—The direct passage of a substance from the solid to the gaseous state without passing through the intermediate (liquid) state. An example is dry ice (solid carbon dioxide) which vaporizes at room temperature.

SUMP—Lowest point of a tank. The emergency valve or outlet valve is usually attached to a tank's sump.

SURFACE TENSION—An inward pull or internal pressure set up in a liquid by the attractive force exerted by the molecules below the surface on the molecules at the liquid's surface. Its strength varies with the nature of the liquid.

-T-

TARGET ORGAN (TISSUE)—The organ or tissue of the body that is susceptible to a given toxin.

TERATOGEN—A substance that causes birth defects by damaging a fetus.

TLV—Threshold **L**imit **V**alue—Recommended air concentration in which most persons can work for an 8-hour work day without ill effects. Set by the ACGIH.

TLV-C—Threshold **L**imit **V**alue-**C**eiling—Exposure level to employees that shall not be exceeded during any part of the work day.

TLV-STEL—See STEL.

TOXICITY—The state or degree of being poisonous; a harmful effect on biological mechanisms.

TOXIN—Anything harmful, destructive, or poisonous to the body (adj. Toxic). (See Poison.)

TTL—Threshold **T**oxic **L**imit—The estimated exposure value, below which no ill effects should occur to an individual.

TWA—Time **W**eighted **A**verage—The calculated average concentration for an 8-hour work day, 10-hour work day or 40-hour work week to which workers may be exposed over their working career without ill effects. Set by the ACGIH.

TYVEK (copyrighted name)—A proprietary non-woven fiber produced by E.I. DuPont Company.

-U-

ULLAGE—See “outage.”

UEL, LEL—See **E**xplosive **L**imits and **E**xplosive **R**ange.

UFL, LFL—See **F**lammable **L**imits and **F**lammable **R**ange.

UNIT LOAD DEVICE—Any type of freight container with a net or aircraft pallet with a net over an igloo.

UNSTABLE MATERIALS—Those which, in the pure state, will vigorously polymerize, decompose, condense, or become self reactive, and undergo other violent chemical changes.

UPWIND—The direction from which the wind is coming.

-V-

VALENCE—A whole number which represents the combining power of one element with another.

VAPOR—An air dispersion of molecules of a substance that is liquid or solid in its normal state (room temperature).

VAPOR DENSITY (V_{den})—Relative density of a vapor compared to the density of air.

VAPOR PRESSURE—A measure of how readily a liquid or solid mixes with air at its surface. A higher vapor pressure indicates a higher concentration of the substance in the air and therefore increases the likelihood of breathing it in.

VISCOMETER (also called viscosimeter)—A device to measure the viscosity of liquids. The most commonly used types are the Engler, Redwood and Saybolt. The viscosity is empirically measured by the flow rate of the test liquid through a standard size orifice or the sink rate of a metal ball through a column of the liquid.

VISCOSITY (see viscometer)—The internal resistance to flow exhibited by a liquid. Viscosity is measured in **poise**. The standard for viscosity is water with an accepted viscosity of 0.01002 poise (1.002 centipoise) at 20°C. Some hydrocarbon liquids, such as hexane, are less viscous than water and flow more readily. Materials like molasses are more viscous and resist flowing. Viscosity in centipoises, at a given temperature, divided by the liquid's density at the same temperature equals the liquid's kinematic viscosity in centistokes (cs).

VISCOUS LIQUID (see viscometer)—A liquid with a measured kinematic viscosity over 2500 cs (centistokes) at 25°C (77°F).

VITON (copyrighted name)—A proprietary synthetic elastomer (fluoroelastomer) with excellent chemical resistance to hydrocarbon based products and solvents.

VOLATILITY—The tendency of a solid or liquid to pass into the gaseous state at a given temperature.

-W-

WATER REACTIVE MATERIALS—Materials which will violently decompose and/or burn vigorously when they come in contact with water.

WATER SOLUBILITY—The degree to which a material, or its vapors, are soluble in water. Materials that are completely soluble in water are said to be **miscible**.