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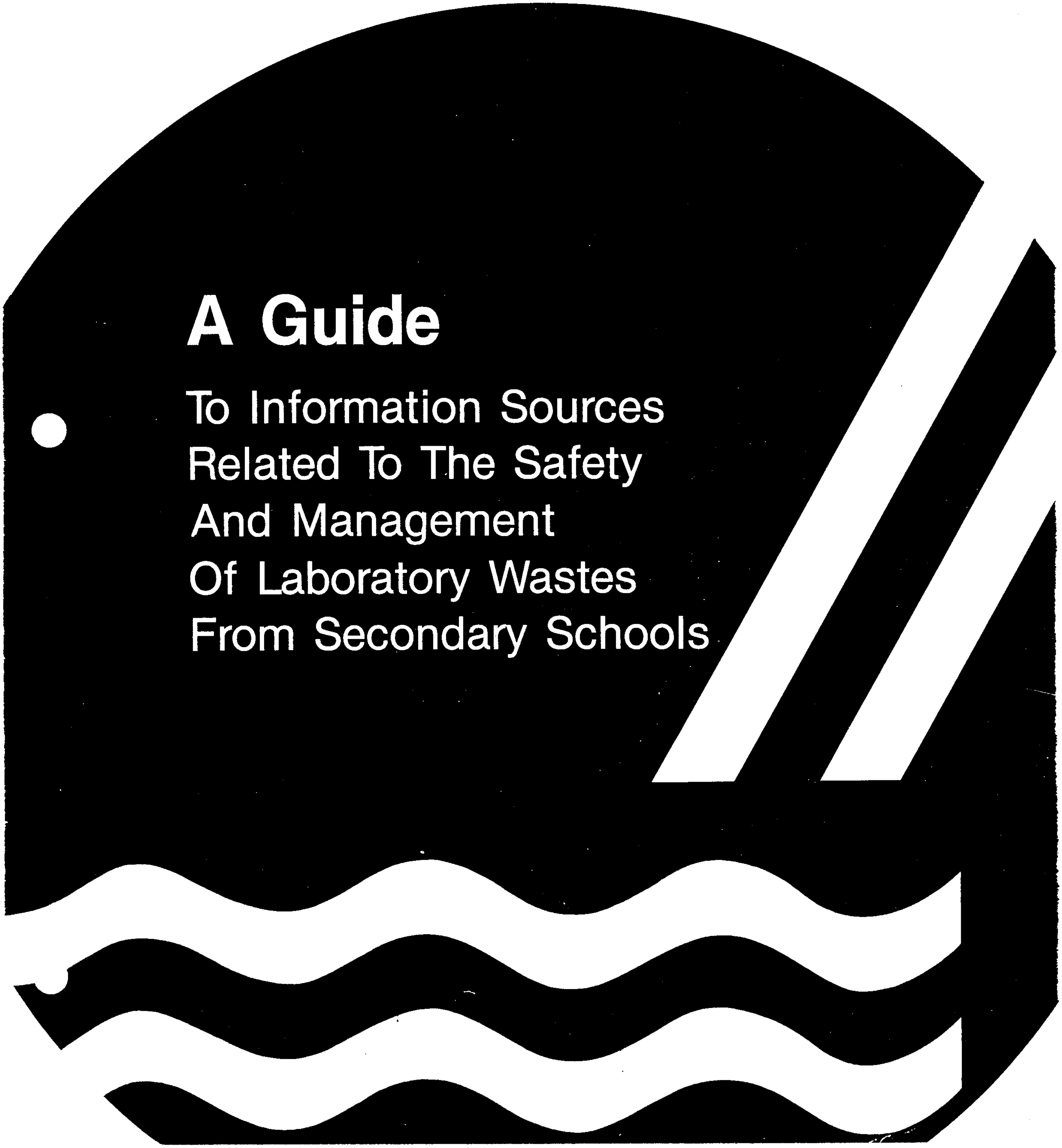

A Guide

To Information Sources Related To The Safety And Management Of Laboratory Wastes From Secondary Schools

A GUIDE TO INFORMATION SOURCES RELATED TO THE SAFETY AND MANAGEMENT OF LABORATORY WASTES FROM SECONDARY SCHOOLS IN NEW YORK STATE

NEW YORK STATE ENVIRONMENTAL FACILITIES CORPORATION
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JAN 1985

A GUIDE TO INFORMATION SOURCES RELATED TO THE SAFETY AND MANAGEMENT OF LABORATORY WASTES FROM SECONDARY SCHOOLS IN NEW YORK STATE

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AMBULANCE/RESCUE SQUAD ____________________

POLICE ____________________

POISON HOTLINE ____________________

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*The Chemical Manufacturers Association 24 hour a day hotline for information about spills, leaks, fire, exposure or accidents.

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DISCLAIMER

This guide is intended to provide secondary schools in New York State with sources of information about laboratory chemical management and safety. It does not contain every applicable warning or precautionary measure. Additional information or measures may be required. Users of this guide should refer to pertinent local, state and federal regulations for waste transport, storage, and disposal as well as any other regulations that may apply in the handling of such chemicals.(Examples: Federal Environmental Protection Agency regulations, OSHA requirements, State Department of Environmental Conservation regulations, Department of Transportation regulations, and state and local building and fire codes.) Legal counsel should be consulted prior to the initiation of a laboratory chemical management and safety program.

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ACKNOWLEDGEMENTS

The Corporation wishes to acknowledge the cooperation of the New York State Education Department's Bureaus of Educational Management Services and Science Education, the New York State Science Supervisors Association, the staff of Rennselaer Polytechnic Insitute's Writing Center, and those individuals and companies who contributed additional information and insight into this issue of wide concern.

INTRODUCTION

Science educators are faced with managing within a tight budget the safe storage, use and disposal of laboratory chemicals. The New York State Environmental Facilities Corporation (EFC) compiled this guide to provide assistance.

The guide has been designed to serve as a desk-top reference to sources of information about pertinent areas of laboratory chemical waste management. EFC identified the need for such a guide after receiving direct requests from both schools and universities for assistance in managing laboratory wastes. Once the need was recognized, EFC conducted a survey to determine the nature and scope of the reuse and/or disposal problem of laboratory chemicals in secondary schools. (See Appendix A.)

Because there are over 700 secondary school districts in New York State and each district is comprised of numerous schools, it was not possible for EFC to contact individual schools within these districts.

For these reasons, EFC limited the survey to New York State science supervisors who participated in the annual Science Supervisors Conference. The supervisors each represent staff in the fields of biology, chemistry, physics and general science. EFC assumed, therefore, that the supervisors would respond to the survey with their staffs' problems and needs in mind. In this way, a larger number of the targeted group of science educators could be represented indirectly by a smaller, more manageable number of science supervisors.

Forty surveys were distributed and forty-five percent of these were returned. Although the survey sample size was small, the survey responses represented fourteen different counties. The information contained within the eighteen completed forms, supplemented by information gained through many discussions with educators in the science field, enabled EFC to better assess the situation of management and disposal of laboratory chemicals in secondary schools.

NATURE OF THE PROBLEM

Chemicals play an integral role in approved science curricula. They are used in classroom demonstrations and laboratory sessions and range in type from relatively harmless substances to highly toxic materials. All must be stored, used and disposed of safely within the typically constrained budgets of science departments.

Coordinators of school science laboratories face four main problems in the management of chemical supplies and chemical wastes:

- Improper chemical storage
- Chemical stockpiles
- Waste disposal strategies
- Need for additional information

This guide will discuss each of these problems in turn.

Improper Chemical Storage

In chemical storage areas, teachers frequently shelve reagents alphabetically. This results in incompatible chemicals being stored near one another and, consequently, creates a potentially reactive situation. Instead, chemicals should be stored by categories of compatible types and these, in turn, should be arranged in a particular way on the storeroom shelves. Acids and bases, specifically, should be stored on the lower shelves to reduce the dangers associated with potential spills.

For safety reasons, storage room doors as well as specific cabinet doors within this room should be locked at all times. This prevents the unauthorized entry of students. Even students with permission to assist in laboratory preparations should never be allowed to work alone and unsupervised.

Many sources are available on laboratory storage procedures and room design and should be consulted for more information (refer to Appendices B and C). In particular, **School Science Laboratories, A Guide to Some Hazardous Substances,** 1984, A Supplement to the Manual of Safety and Health Hazards in the School Science Laboratory (NIOSH), offers a comprehensive section on chemical and biological storage rooms which suggests chemical storage patterns.

Chemical Stockpiles

Chemical stockpiles, excess chemicals that have been accumulated, pose the following problems to laboratory safety: 1) changed reactivity, 2) difficulty of identification and 3) chance of contamination.

1) Changed Reactivity. Many unused chemicals, especially reagents with short shelf lives break down after a relatively brief period of time, becoming unstable. Unexpected chemical reactions may occur as a result of this changed reactivity.

2) Difficulty of Identification. In addition, bottles and jars left to accumulate on the supply room shelves (some have been known to be stored for as long as twenty years) can be difficult to identify. Their labels may have become illegible over the years by staining or yellowing, or in extreme cases, crumbling with age. Materials unable to be identified require special analysis to determine use, proper treatment or disposal.

3) Chance of Contamination. The longer a chemical is stored on the shelf, the greater the chance of its becoming accidentally contaminated. If used in this condition, unexpected results could occur. These may simply waste the time and efforts of both the instructor and students who must rerun a laboratory exercise which did not yield the expected results. Or, more seriously, such unexpected results may threaten their personal safety.

Stockpiles develop over time as a result of one or a combination of the following reasons: infrequent inventorying of stock, frequent staff turnover, and use by a school district of a purchasing system that allows the purchase of supplies only once or twice a year.

Teachers who conduct infrequent inventories of chemical supplies cannot specifically know the variety or quantities of chemicals stored on the supply room shelves. As a result, each year they may needlessly order more of the same reagents.

This ordering of unnecessary supplies is further complicated when new faculty join the science staff and are not left with a complete inventory of stored chemicals. Unsure that the amounts of reagents are adequate for the coming school year's activities, and concerned about the possible contamination or age of existing chemical stocks, new science staff members may, in turn, order reagents which are already on the supply room shelf.

The quantity of chemicals ordered is also affected by the type of purchasing system used by a school district to buy supplies. School districts usually allocate money for purchasing supplies at one or two specific times during the year. Under this type of purchasing system it is difficult to buy supplies during other times of the year should there be an unexpected need for a chemical. The restricted ability to order laboratory chemicals and supplies causes issues of concern to the teacher and the chemical company.

Many instructors are concerned about running short of needed supplies during the school year. To avoid the risk of depleting supplies, instructors buy chemicals in amounts greater than those suggested by the teacher's guide to the textbook and laboratory manual. This contributes further to the practice of stockpiling.

Chemical companies are concerned about pleasing their school customers. In the past they have contributed to the development of a school district's stockpiles by establishing minimum purchase limits or by selling chemicals in large package sizes. However, responding to complaints about this practice, a number of chemical supply houses now make available small quantities of chemicals--many packaged in specially designed safety containers. Also, some such as Flinn Scientific, Inc. offer a delayed shipment option under which a school's order for potentially hazardous chemicals would be acknowledged, stock set aside, and shipment deferred until further notification from the school was received. In this way, a school's storage time of such chemicals is reduced, yet price and stock are guaranteed with the initial order.

Teachers revealed in both conversation and survey responses that there is a growing awareness in many school districts of the associated dangers of storing excess chemicals. As safety awareness increases, chemical stockpiling as a practice, and its associated problems, will continue to diminish.

Waste Disposal Strategies

Chemical wastes produced by school laboratories are of three main types:

1) Non-hazardous, disposable on site.

2) Hazardous, treated on site by methods such as neutralization or detoxification.

3) Hazardous, must be treated off site at commercial treatment, storage or disposal (TSD) facilities. See Appendix I.

For most schools, the necessity of disposing off site a portion of lab wastes generated creates expensive transportation problems. Because school laboratory wastes are both varied in type and produced in relatively small amounts, off-site disposal is expensive. Transporters permitted to haul wastes to TSDs operate cost-effectively only when traveling at or near capacity loads. (See Appendix D.) When the amount of wastes to be shipped is less-than-truckload, quantity price breaks to the generator are not possible.

For economic reasons, therefore, schools have expressed interest in developing transportation networks, cooperative arrangements which are mutually beneficial to both hauler and generator. Many small volume industrial waste generators already have arranged such networks.

In this system, a permitted hauler makes a series of waste pickups ("milk-run") from schools or other small volume generators of waste within a geographic area. In this way, a hauler accumulates a large enough quantity of wastes to economically justify transporting it to a TSD facility. Instead of paying the full cost of hiring a truck to deliver a small quantity of wastes to a TSD facility, each school pays only a proportionate amount of the hauling expense.

It is generally not advisable for either schools or BOCES (Board of Cooperative Education Services) to arrange a district-wide clean-up of chemical wastes with the wastes deposited at a designated centralized pick-up point.

A centralized collection of wastes is more hazardous than a milk-run collection of wastes for the following four reasons: 1) non-specialists may pack waste for shipping without regard to chemical compatibility, 2) wastes may be transported in private vehicles, thereby increasing the risk of jarring and spilling associated with a greater amount of handling, 3) the probability of a spill, fire or explosion occurring is increased by accumulating chemicals at one site, and 4) federal or state regulations may be violated depending on the types and amounts of materials accumulated at the centralized pick-up point.

In addition to saving money by reducing transportation costs through networking, more money could be saved by reducing the total volume of wastes destined for off-site disposal. This may be accomplished by redesigning key experiments and revising scheduled laboratory activity to substitute non-hazardous or less hazardous reactants for hazardous materials specified in experiments and demonstrations wherever possible. Instead of an experiment for students to do during a laboratory session, the lesson becomes a demonstration, reducing the exposure to such materials as well as reducing the volume of hazardous wastes produced.

Need for Additional Information

Science curricula require the use of a diversity of chemicals. Each chemical has characteristic properties as well as associated potential hazards. Because science educators are responsible for the proper use of these substances, instructors need specific and concise information about the chemicals used in their particular curriculum.

Teachers interviewed, however, frequently expressed a need for additional information about the chemicals used in school laboratory programs. There has been a response to this need. For example, reagent supply companies, the Chemical Manufacturers Association and the State, as well as many books (see Appendix B) provide pertinent, readily available information about the safe use of specific chemicals.

Reagent supply companies (see Appendix F) have become increasingly responsive to the demands of their customers for more product information. Supply catalogs now contain more than just product and price listings. Many have become reference manuals about chemical safety and management practices (refer to Appendix G) and may provide any or all of the following services:

- Hazard alerts for particular listed chemicals.
- Chemical handling and storage tips.
- Reagent bottles with dated labels.
- Chemicals shipped in metal or plastic containers rather than glass according to degree of chemical hazard.
- Inventory procedures and suggestions about chemical storage shelf arrangements.

- Suggested clean-up and disposal procedures.

- Telephone number for specific assistance.

- No minimum quantity purchase stipulation.

- Deferred purchase plan.

A number of sources including the Chemical Manufacturers Association (see Appendix C) and reagent supply houses provide Chemical Material Safety Data Sheets, which supply detailed information about specific chemicals and their properties, as well as safety and disposal suggestions. These sheets should be requested for each chemical at the time of purchase.

Under the New York State Toxic Substance Law, commonly referred to as the "Right-to-Know Law", the state has prepared toxic substance information and data training sheets about such substances used in schools. These were prepared by the Employee Health and Safety Management Unit, Bureau of Educational Management Services, Science Education Department (see Appendix C). A complete set of training sheets has been sent to each school districts' BOCES center within New York State. For further information, contact your area BOCES center.

LABORATORY SAFETY AND MANAGEMENT PROGRAM DEVELOPMENT

Once a science department has assessed the nature of any problems it may face in the management of laboratory wastes, it may be helpful for staff to read the following section about developing a laboratory chemical safety and management program.

A laboratory safety and management program that has been developed by a school district but has not been implemented is of no practical use. To engage the complete cooperation of science staff members in the implementation of any successful lab chemical safety and management program, it is necessary that the program be discussed and agreed upon by the entire staff. The process of such program development also helps to increase the level of safety awareness among them.

Once the program is developed, it must be established as policy and implemented after initial staff training. Monitoring and enforcement must occur periodically in order to maintain a consistent level of policy application.

In order for a district's science department to initiate a hazardous waste management program, four basic steps should be followed:

1) Inventory chemicals stored and waste produced.

2) Analyze inventory results.

3) Establish waste handling procedures.

4) Develop a system for recordkeeping.

An inventory is initially conducted to determine the types and volumes of chemicals stored and wastes generated by a school system. After each school unit within a particular district has completed an inventory, a chemical management plan for the entire district can be developed.

Once the staff has identified what chemicals are in stock and what wastes are generated, they must further identify the chemical wastes as either hazardous or non-hazardous according to federal and state criteria.

Waste handling procedures should be established by the staff once they have identified the wastes and their degree of hazard. There are three levels of waste handling procedures: categorization, collection, and treatment and disposal. If laboratory managers assign compatible wastes to broad categories, the treatment and handling of wastes are simplified. In this way, the various small quantity laboratory wastes are consolidated. Appropriate treatment strategies for these categories can then be determined. Once the wastes are identified, categorized, and treatment strategies are determined, acceptable handling procedures can be established for each category of waste specifying what wastes can go into the sewer and under what conditions. Clearly marked collection containers should be provided for non-sewerable wastes.

Next, a system for collecting wastes from each laboratory should be devised. Greater control is maintained if wastes are picked up from individual laboratories rather than having the wastes brought to a central collection place. In this way, substances can be more closely monitored and, if necessary, questions about labelling, categorizing and packing can be answered immediately by each lab director. If possible, wastes should be treated or disposed of on site to reduce the volume of wastes to be shipped off site for treatment. Not all wastes, however, can be safely treated on site. Some types must still be transferred by a permitted hauler to a permitted TSD facility.

A Note of Caution: Consult reliable and comprehensive incompatibility tables before storing, using, disposing and transporting chemicals. Such tables may be found in laboratory safety manuals or in supply catalogs for laboratory chemicals.

Lastly, a system for recordkeeping should be developed and maintained which documents that acceptable waste handling procedures have been followed.

For further information about managing laboratory chemicals, turn to Appendix E for a summary of the book, Prudent Practices for Handling Hazardous Chemicals in Laboratories.

Teachers should emphasize to students the possible hazards and the appropriate emergency procedures associated with the safe use of all chemicals used in the lab. This information should be especially reviewed prior to any lab activity. Mock accident response drills such as "spill drills" should be conducted for practice purposes.

Laboratory staff should be cautioned against associating odor with degree of hazard as is frequently done. This results in greater concern for those substances having high levels of odor but low levels of toxicity, and less concern for odorless yet highly toxic substances.

SUMMARY

As a result of increasing awareness of the possible dangers and liability associated with the management of chemical wastes, secondary schools are developing and implementing comprehensive programs to store, use, and dispose of laboratory chemicals. Such programs will bring them into compliance with existing state and federal regulations.

The practice of stockpiling chemicals is declining due to better stockroom control practices such as more frequent inventorying and improved purchasing of chemicals only in the required quantities.

A problem that continues to face many schools is the lack of available funds for off-site disposal of hazardous materials. Establishment of transportation networks may help offset the fees assessed small volume generators.

Many science educators require more accessible information about the properties and potential hazards of chemicals used in school science curricula. This concern is addressed not only by the sources referenced in this guide but also by Material Safety Data Sheets supplied to each school district's BOCES by the New York State Bureau of Educational Management Services.

APPENDIX A

This appendix includes information about EFC's survey, Reuse/Disposal of Laboratory Chemicals in Secondary Schools, specifically:

- The cover letter distributed with the survey
- A copy of the questionnaire
- A summary of the results

New York State Environmental Facilities Corporation
50 Wolf Road, Albany, N.Y. 12205 / (518) 457-4100

Henry G. Williams
Chairman

Terence P. Curran, P.E.
Executive Director

To: Members of the New York State Science Supervisors' Association

The New York State Environmental Facilities Corporation (EFC), under the Industrial Materials Recycling Act (IMRA) of 1981, is currently involved in an effort to determine the nature and extent of the problems facing the majority of science laboratories, primarily biology, chemistry or physics, associated with secondary and post-secondary educational systems with the management of their non-radioactive chemical stockpiles or wastes.

Informal discussions reveal that many instructors are not satisfied with the prevalent method of disposing the unused or outdated chemicals or laboratory wastes via the lab sink drain, "flushed with water", and are searching for alternatives.

The data you provide in this survey is an important preliminary step towards the assessment of the problem. Thank you for your time and effort.

REUSE/DISPOSAL OF LABORATORY CHEMICALS
IN SECONDARY SCHOOLS

General Information:

Your responses to the questions of this survey will help EFC assess the nature and scope of the reuse/disposal of laboratory chemicals in secondary schools. Your cooperation is appreciated.

Name ______________________
Position/Title ______________________
School Address ______________________
____
Telephone ( ) ______________________
Name of School District ______________________
County ______________________

Instructions:

Please indicate your answers by placing a check in the box of your choice. Where applicable, more than one box may be checked.

1. Type of Lab: ☐ Biology ☐ Physics ☐ Chemistry ☐ General Science

2. Do you consider the disposal of school laboratory waste chemicals a problem?

   ☐ Yes ☐ No

3. If so, what is the primary nature of the problem?
   ☐ Method of disposal
   ☐ Disposal of stockpiled (excess chemicals)
   ☐ Cost of disposal

Chemical Waste Disposal

NOTE: Do not handle or dispose of chemicals unless knowledgeable about their specific handling or disposal procedures.

4. Common method of disposing of laboratory chemical wastes:
   ☐ Dumped down the drain
   ☐ Transported to a landfill
   ☐ Shipped to a secure treatment, storage, disposal (TSD) facility

5. Estimated total amount of laboratory chemical waste disposed of per semester (combine class volumes for total estimate).
   a. Solids disposed of (kilograms)
      ☐ 0 ☐ ≥1, <25 ☐ ≥25, <100 ☐ ≥100 ☐ Other__________
   b. Liquids disposed of (liters)
      ☐ 0 ☐ ≥1, <25 ☐ ≥25, <100 ☐ ≥100,<500 ☐ Other______
   ☐ Estimate not possible. Please explain ______________________

6. Are you interested in the organization of district collection points from which chemicals could be transferred to landfills, if approved, or to TSD facilities?

   ☐ Yes ☐ No

7a. Is additional information needed about acceptable disposal methods of solid/liquid chemical waste to properly manage your laboratory's waste? ☐ Yes ☐ No

b. If applicable, please list specific waste type(s) causing concern:

____

____

Excess (Stockpiled) Chemical Inventory

8. Some major chemical supply houses will buy back their own brand provided the container hasn't been opened and the expiration date has not yet passed.
a. Are your laboratory's excess chemicals stored in:
☐ Opened (unsealed) original containers
☐ Unopened (sealed) original containers
☐ No longer in original container
b. Name of primary chemical supplier______________________________

9. Estimated amount (in kilograms or liters) and types of excess chemicals currently stockpiled:

______________________________ ______________________________
______________________________ ______________________________
______________________________ ______________________________

☐ Inventory not available

10. Your laboratory's common method for disposing of excess chemical inventory:
☐ Returned to the chemical dealer
☐ Disposed of on-site
☐ Disposed of commercially
☐ Stored indefinitely
☐ Exchange for other school laboratory's excess chemicals that are useful to your lab

11a. Would you like to see the development of an exchange of excess chemicals with other schools? ☐ Yes ☐ No
b. If no, are you concerned about:
☐ Possible contamination
☐ Liability
☐ Other, please specify______________________________

12. Are you interested in further contact concerning information about the reuse/disposal of laboratory chemicals? ☐ Yes ☐ No

Summary of Results

14 New York State counties represented by completed questionnaires:

Chenango
Erie (2)
Fulton
Green
Monroe
Nassau
Otsego
Queens
Rockland (2)
Schenectady
Scoharie
Suffolk
Wayne (2)
Westchester (2)

Responses have been tabulated, but because more than one response could be given per question, response totals will not, in most cases, equal 18.

Question 1 Type of Lab Represented:

Biology -	11
Physics -	9
Chemistry -	15
General Science-	11

Question 2 Disposal of school laboratory waste chemicals:

Considered a Problem -	15
Not Considered a Problem -	2
No Response -	1

Question 3 Primary nature of the chemical problem in school labs:

Method of Disposal -	10
Disposal of Stockpiled (excess) Chemicals -	11
Cost of Disposal -	4
No Response -	2

Question 4 Common method schools used to dispose of chemical wastes:

Dumped Down the Drain -	14
Transported to a Landfill -	3
Shipped to a TSD Facility -	4

Question 5 Estimated total amount of laboratory waste disposed of per semester (combining class volumes):

a. unit: kilogram

0 --	1
≥ 1, <25 --	12
≥ 25, <100 --	2

b. unit: liter

0 --	0
≥ 1, <25 --	9
≥ 25, <100 --	4
≥ 100, <500 --	1
no response --	1

Three teachers were not able to provide an estimate but explained that "each teacher has taken care of it on their own" and "chemicals have accumulated for 25 years".

Question 6 Interest in the organization of district collection points (transfer stations):

Yes -	16	
No -	1	(no disposal problem in school district)
No Response -	1	

Question 7a Need for additional information about acceptable disposal methods for better management of lab chemicals:

Yes -	15
No -	2
No Response -	1

Question 7b Waste types causing concern for those surveyed:

- List of pertinent hazardous chemicals.
- Organic solvents
  - Formaldehyde (HCHO - formic aldehyde)
  - Benzene (C_6H_6)
  - Class A and other suspected carcinogens
- Mercury (Hg)
- Lead (Pb)
- Acids, example: Hydrofluoric acid (HF - hydrogen fluoride in aqueous solution)
- Sodium (Na)
- Sodium dioxide (NaO_2)
- Titanium Tetrachloride ($TiCl_4$ - titanic chloride, used as a basic chloride precipitant)
- Excess chemicals, in general - including non-carcinogenic and non-explosive types.
- Waste disposal information, particularly disposal of solid wastes.
- Information about disposers.

Seven respondents were also concerned about excess chemicals but cited no specific waste types.

Question 8a Excess laboratory chemicals are stored in:

Opened (unsealed) original containers -	15
Unopened (sealed) original containers -	9
Chemicals no longer stored in original containers -	3
No Response -	1

Question 8b Name of primary chemical supplier:

6 - Specified their supplier:

Merrell Scientific (2)

Fisher

Silver-Burdett

Sargent-Welch

J.T. Baker

5 - Choice of supplier primarily depended upon the "bid process" in which the lowest bidder is selected.

7- No response.

NOTE: Survey results indicated, that, in many cases, a district's use of a "low bid" contract system precluded their purchasing from reagent supply companies which offered high levels of safety service. In this type of system, the lowest bidder, not necessarily the company that could supply the quality of service required, gets the contract. This type of purchasing practice is not conducive to the best possible safety management goals of science departments. School systems' bid policies for scientific supplies should consider both safety services and economic specifications.

Question 9 Estimated amount and types of excess chemicals stockpiled:

Inventory not available -	12	(Most had this information in their labs at school and offered to provide it at a later date, if requested.)
"Very Little" to "No" Excess -	3	(1 district didn't order excess amounts of chemicals, another recently spent one month inventorying and disposing of its excess via private disposer.)

Of those detailing their excess lab chemicals:

1 - 100-500 g solids, various kinds

1 - 5 kg miscellaneous

1 - 1-4 liters, solvents

1 - 10 liters: formaldehyde, nitric acid and mercury

Question 10 Excess chemicals were disposed of in the following ways:

0 - returned to the chemical supplier

4 - disposed of on site

3 - disposed of commercially

14 - stored indefinitely

2 - exchanged in other schools' labs

1 - no response

Question 11a Interest in the development of an exchange of chemicals with other schools:

Yes - 10

No - 7

Question 11b If no, concern about:

6 - Possible contamination, liability and logistics

1 - No opinion

Question 12 Interest in desired further contact concerning information about the reuse/disposal of lab chemicals:

Yes - 16

No - 1 (no disposal problem at that district)

No Response - 1

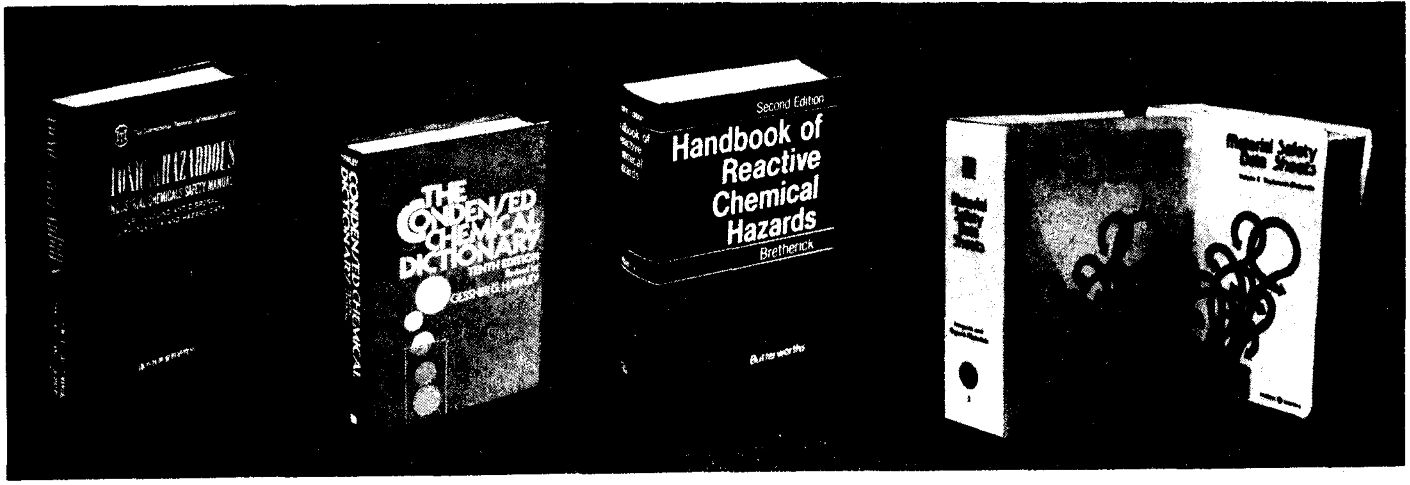
APPENDIX B

Lab Safety Supply, a company specializing in chemical health and safety, has granted EFC permission to reprint **The Safety Books** section of its catalog entitled, Safety Equipment. The entire catalog is available from Lab Safety Supply at the following address:

Lab Safety Supply
A Division of Science Related Materials, Inc.
P.O. Box 1368
Janesville, WI 53547-1368
(800) 356-0783

Safety Book Index

Safety Books



Toxic and Hazardous

Here is one of the most comprehensive chemical safety manuals ever published. It is filled with detailed safety information for personnel handling and disposing of dangerous chemicals. This is an important reference book for anyone who must work with chemicals and for those who are concerned with health and safety. Toxicity and hazard data is given for over 700 chemicals. The hazard data supplied for each chemical includes relevant data on flammability and reactivity to aid in preventing fire and explosions. The proper fire extinguishing agent is identified for each chemical. Detailed symptoms of exposure, first aid treatment and antidote information are described. Handling and storage instructions are provided for those who are responsible for small or large amounts of these chemicals. Spill and leakage instructions for small or large amounts of chemicals are provided to minimize accidents and further losses. Specific detailed disposal and waste treatment instructions are also listed. In addition to listing data for over 700 chemicals, toxicity data is provided for an additional 1,000 chemicals. The data is presented in an easy-to-read paragraph manner. Hardcover 8½" × 11" × 2½". 696 pp., 1982, revised edition.

J1419 . . . . 86.50

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In WI 1-800-362-7207
In AK, HI, 1-608-754-2345

The Merck Index

The Merck Index is a comprehensive, exhaustive encyclopedia of virtually all generally known chemical and drug entities. Offers illustrated chemical descriptions and a wealth of reference information for chemists, pharmacists, toxicologists, physicians, biologists, chemical engineers, botanists, veterinarians, physicists, students—anyone interested in chemical compounds for any reason. 6⅞" × 9⅞", thumb-indexed, over 2000 pp., 1983, 10th edition.

J1853 . . . . 36.50

The Condensed Chemical Dictionary

A compendium of technical data and descriptive information covering thousands of chemicals and chemical terms—organized for fast information retrieval. Information includes: technical description of chemicals, raw materials and processes, expanded definitions of chemical entities, phenomena and terminology; and description or identification of trademarked products used in the chemical industry. In addition, hazard information (toxicity, flammability, explosion risks), storage, uses and shipping information are included. Latest TLV values for workroom environment, FDA regulations on banned or restricted products and much, much more. Includes temperature conversion table, terms on latest alternative energy sources and appendix for the derivation of chemical terms. Gessner Hawley, 1472 pp., 1981, 10th edition.

J1705 . . . . 48.00

The Handbook of Reactive Chemical Hazards

Covers reactive chemical hazards and the relationship between structure and hazard. Also offers documentation of specific hazards and describes conditions under which accidents have occurred. Resource literature for more detailed readings about specific chemical reactions is cited as well as properties of highly flammable gases and liquids. Four levels of cross-reference facilitiate access to information.

Comprehensive coverage of how the chemicals you work with . . . or plan to work with react:

- under impact or pressure
- at different temperatures
- when combined with other chemical structures
- during preparation
- in air, water, vacuum
- under long-term storage

L. Bretherick, 1281 pp., 1979, 2nd edition.

J939 Hardcover 165.00

Material Safety Data Sheets

A collection of 690 Material Safety Data Sheets to provide information to help you protect your employees. Serves as a reference source of vital information on inorganic, organic and trade name materials. It will also aid your compliance with government regulations and help you prepare your own material safety data sheets (OSHA 20 forms).

Volume 1, Inorganic and Organic Materials. Volume II, Trade Name Materials. Designed to be a "one-step" reference source that can help keep you and your employees informed of the hazards and necessary precautions involved in the use of materials in your workplace. Compiled by General Electric for in house use to cover materials GE uses, (not manufacturers). Updating service available from GE. Each safety data sheet gives the following types of data in the OSHA 20 and includes two loose leaf binders with 8½" × 11", 2 sided sheets.

- Material Identification
- Ingredients and Hazards
- Physical Data
- Fire and Explosion Data
- Reactivity Data
- Health Hazard Information
- Spill, Leak and Disposal Procedures
- Special Protection Information
- Special Precautions and Comments
- Indexed: Materials, Terms, Abbreviations, Suppliers, Referenced Sources

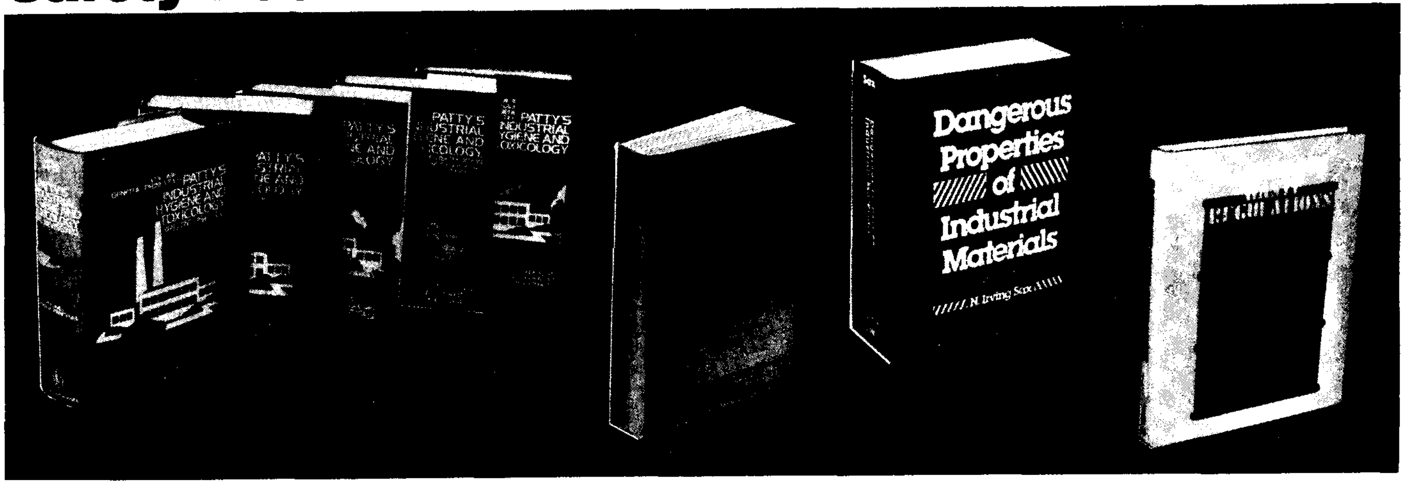
J2030 . . . . 325.00

NIOSH OSHA Pocket Guide To Chemical Hazards

A tabulation of critical data for over 370 compounds. Gives the following data for each compound: critical chemical and physical properties; permissible exposure limits and the "immediately dangerous to life and health" levels; chemical incompatibilities and suggested methods of measurement. Also listed for each compound are recommendations for personal protection, a respirator selection guide and a tabulation of health hazards. An indispensable working manual. 1980.

J2011 . . . . 10.00

Safety Books



Patty's Industrial Hygiene and Toxicology

Volume 1—General Principles. 3rd edition reflects every aspect of industrial hygiene: air pollution, legislation, reports and records, sampling and analysis and calibration. G.D. and F.E. Clayton, ed., 1466 pp., 1978. **Volume II—Toxicology, 3rd edition, Part A** includes chapters on phenols, esters, aldehydes and acetals, epoxies and more. G.D. and F.E. Clayton, ed., 1430 pp., 1980. **Part B** reviews occupational carcinogenesis, N-nitrosamines, aliphatic and aromatic hydrocarbons, fluorine-containing organic compounds and more. G.D. and F.E. Clayton, ed., 955 pp., 1981. **Part C** gives updated information on the toxicology of glycols, nitrites, polymers, ketones, cyanides and many more. G.D. and F.E. Clayton, ed., 1312 pp., 1982. **Volume III—Theory and Rationale of Industrial Hygiene Practice** includes radiation exposure, chemical and biological agents, sampling theory, job safety, health law and much more. L.V. and L.J. Cralley, ed., 752 pp., 1979.

No.	Description	Each
J1726	Volume I	156.40
J1726-2	Volume II, Part A	148.00
J1726-3	Volume II, Part B	105.00
J1726-4	Volume II, Part C	134.00
J1726-5	Volume III	95.00
J1726-6	Complete 5 Volume Set	510.75

RCRA Inspection Manual

This volume informs you of compliance requirements and what can be done to enforce the hazardous waste regulations.

J5012 . . . . 36.50

Resources Recovery Guide

Data you need on municipal waste recycling theory, procedure and practice. Investigates glass, paper, steel, plastics, rubber and aluminum recycling and energy recovery through direct combustion of unprocessed and processed waste, pyrolysis and other recycling techniques. Provides details on DOE planning documents and national commission reports. James G. Abert, Ph.D., 593 pp., 1983.

J5041 . . . . 51.00

Handling Chemicals Safely

Information on the hazards of chemicals is a necessity wherever they are used. This book provides detailed information on 874 chemicals in data page format including: physical properties, characteristics, hazards/symptoms, prevention, fire extinguishing agents/first aid, spillage, storage, packaging/labelling and other notes. Comprehensive introduction gives much useful information about protection against chemical exposure. Thoroughly indexed. Blue plastic cover helps protect book against liquids. Published by Dutch Association of Safety Experts, Dutch Chemical Industry Association of Safety Experts, Dutch Chemical Industry Association and the Dutch Safety Institute. 6" × 8⅜", 1013 pp., 1980 English edition.

J2873 . . . . 75.00
J2873-2 . . . . Lot of 10, Each 67.50

Managing Hazardous Substances Accidents

This book shows how to develop a management system to best coordinate activities at the scene of a spill. Topics include contingency planning, how to use tools and techniques now available, where to get technology, the latest clean up technology, training and education and more. The book also describes various types of chemical accidents and selected illustrations show examples of accident response teams. Relevant laws and governmental levels of interest in hazardous substances accidents are outlined. Also included is a special section covering the steps to take to prevent hazardous substances accidents. Al J. Smith, Jr., 188 pp., 1981.

J2693 . . . . 31.50

Spill Prevention and Fail-Safe Engineering for Petroleum and Related Products

Spill prevention procedures and practices plus presentation of automation techniques that can reduce spills caused by human error are presented in this manual. From transportation to processing petroleum and related products, the manual outlines safe practices for handling as well as containment procedures. Historic spills are briefly described. J.L. Goodier, R.J. Siclari, P.A. Garrity, 329 pp., 1983.

J5064 . . . . 41.25

Dangerous Properties of Industrial Material

A complete, updated, expanded and revised edition of a standard reference of dangerous materials. All areas of hazards are covered with maximum accuracy and dependability. Provides general information, hazard analysis, and explanation of countermeasures. The manufacturer, user, handler, storer, and shipper of hazardous materials will find this book an encyclopedia guide to handling all materials safely. N. Irving Sax, 3136 pp., 1984, 6th edition.

J1704 . . . . 198.00

Hazardous Wastes Handbook

A practical, easy-to-read book which provides an analysis of EPA regulations. Get clear and concise answers which take you step-by-step through the maze of EPA regulations. Chapters include identification of hazardous wastes, EPA notification, generators, transporters, permit regulations, Superfund legislation, common law, civil liability and more. Section two covers the RCRA and Superfund statutes. Section three contains the EPA regulations from the Code of Federal Regulations and list of Federal Registers published under RCRA. Government Institutes, 656 pp., Nov. 1983, 4th edition.

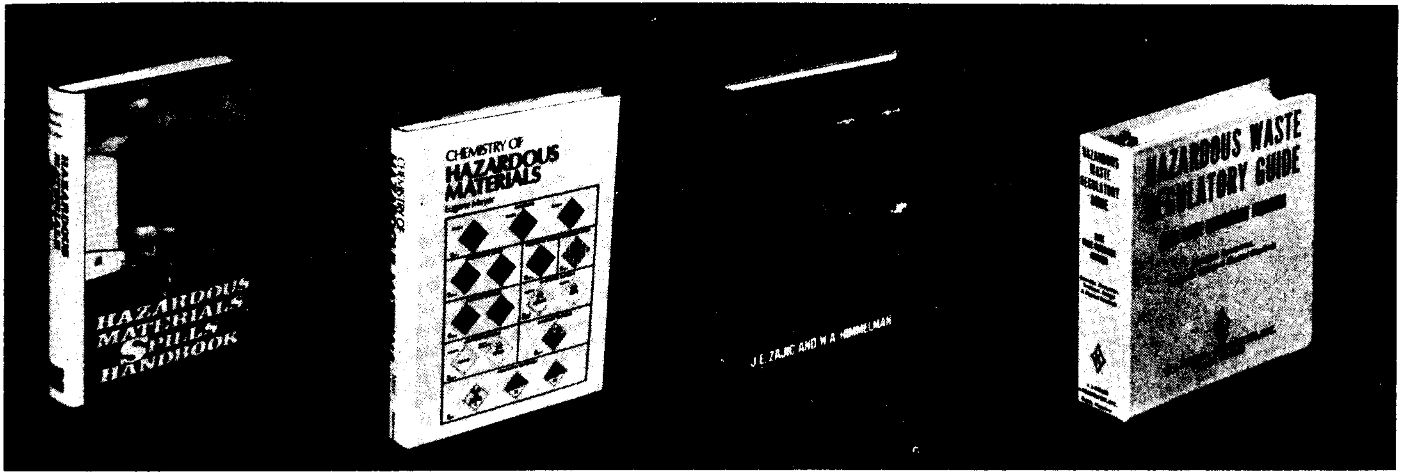
J5011 . . . . 129.00

Hazardous Waste Regulations

An Interpretive Guide

Disposal of hazardous waste has been complicated by new EPA regulations which are often time consuming. This book analyzes and reorganizes the 150 pages of 3 column regulations, clarifying all aspects of the requirements. The volume begins with a concise overview of the law and regulations and an identification and listing of hazardous wastes. A checklist format is included to give a practical approach to analyzing their unique requirements. An essential volume for anyone involved with implementation, regulation or management of hazardous waste. Alex Mallow, 395 pp., 1981.

J2690 . . . . 50.20



Hazardous Materials Spills Handbook

This comprehensive handbook treats all aspects of hazardous materials spills, from regulations surrounding a spill to the actual organization of a cleanup. Fifty world-wide contributors, each an expert in his own right, make this theoretical and practical handbook completely authoritative. Special features include: response plans, spills in water, spill clean-up, personnel safety, case histories, volatile materials and ultimate disposal. G.F. Bennett, F.S. Feates and I. Wilder, ed., 704 pp., 1982.

J2871 . . . . .62.00

Handbook of Toxic and Hazardous Chemicals

This handbook presents concise chemical, health and safety information on about 600 toxic and hazardous chemicals including name, where most commonly encountered, tolerance levels, measurement methods, harmful effects and personal protection. Includes substances in ACGIH handbook, all of the priority water pollutants classified by EPA and most of the chemicals classified as EPA "hazardous substances and hazardous wastes." Chemicals are listed alphabetically. Also includes an Index of Carcinogens. Marshall Sitting, ed., 729 pp., 1981.

J2687 . . . . .73.50

Emergency Manual for All Users and Makers of Industrial Chemicals

Ideal for plant safety and pollution managers, this guide contains a 2000 item checklist to safeguard your plant. The checklists included are for emission of toxic and hazardous substances, fire and explosion, personal injuries, power failure and waste disposal. Indispensable not only in an emergency, but also for control of daily pollution and safety problems. Includes disposal instructions for 400 toxic and hazardous substances, and the effects on the environment for 600 toxic and hazardous substances. Published and sold worldwide by the International Technical Information Institute, 442 pp., 1978.

J1723 . . . . .86.50

Chemistry of Hazardous Materials

A textbook that provides the chemical basics of hazardous materials and their reactions. Eugene Meyer, 370 pp., 1977.

J1420 . . . . .33.00

Highly Hazardous Material Spills and Emergency Planning

The first in a series of books on hazardous and toxic substances. Special emphasis on emergency planning for communities affected by chemical spills or disasters. Provides an extensive classification list of highly hazardous materials and a rating system. Also included are discussions of environmental effects of spills on water, land and air as well as containment and treatment techniques for spills. J.E. Zajic, W.A. Himmelman, 225 pp., 1978.

J1721 . . . . .39.00

Organic Chemicals Manufacturing Hazards

This book provides industrial background information plus descriptions of manufacturing processes in the formation of such compounds as polyvinyl chloride, acetic acid and vinyl acetate. Also included is a discussion of the flammability and toxicity hazards associated with those substances and processes studied. A.S. Goldfarb and Associates, 430 pp., 1981.

J5082 . . . . .72.20

Oil Spill Cleanup and Protection Techniques for Shorelines and Marshlands

Provides systematic methodologies used to assess the threat or extent of contamination of inland shorelines and marshlands from oil spills. Guidelines are given to determine which protection, cleanup and restoration techniques would be most effective in many spill situations. It gives information intended to minimize damage and speed recovery of the system. This book is directly applicable during prior planning and spill operations. A cost survey and bibliography are included. A. Breuel, ed., 404 pp., 1981.

J5096 . . . . .50.00

Hazardous Chemical Spill Clean-Up

This book is intended to serve as a practical guide and manual for the handling and control of hazardous material spills. Includes discussions of mechanical cleanup methods, such as dispersion, containment, dredging, burial, barriers, etc. and chemical methods, such as neutralization, precipitation, chelation, redox, biodegration. Also discusses sorbents, gels, foams, and available mobile units for spill control. Also includes sections on procedures leading to cleanup, various response techniques for different types of materials, planning for hazardous material spills and an overview of legislative aspects and procedures. Thoroughly referenced. J.S. Robinson, ed. 406 pp., 1979.

J2028 . . . . .56.95

Protective Barriers for Containment of Toxic Materials

An excellent reference for the selection of protective, impermeable barriers in lagoons or landfills to prevent the escape of toxic pollutants from disposal sites. Liner materials are discussed in detail which range from natural in-place soils to artificial membranes. Lists of suppliers and existing installations are included, plus chemical compatibility guidelines, testing of liners for hazardous wastes and actual liner installation techniques. R. Fung, ed., 228 pp., 1980.

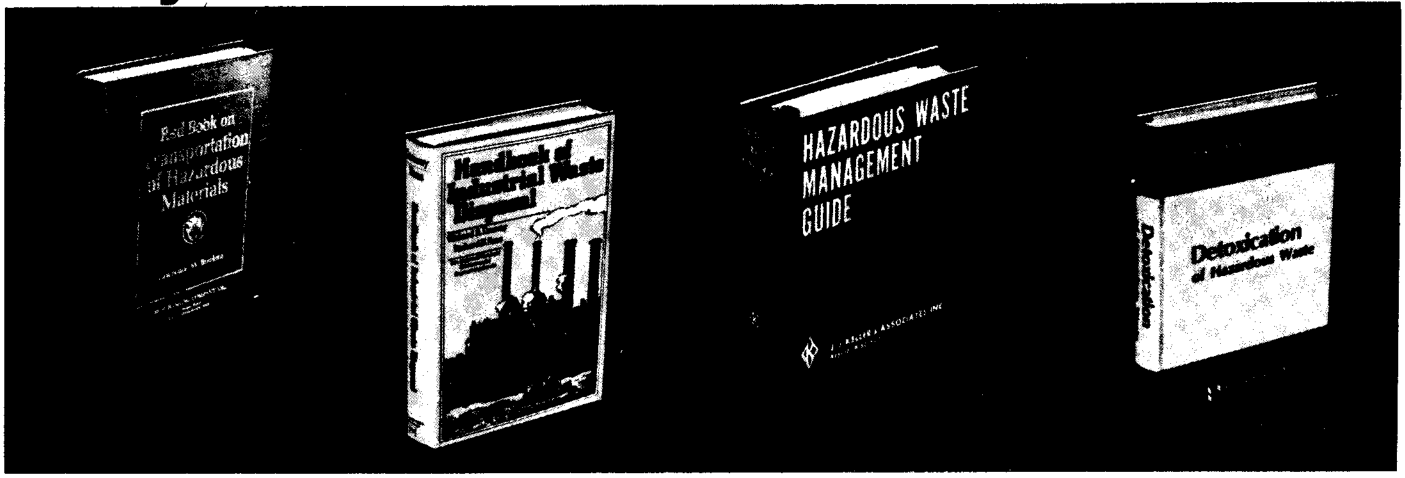
J5063 . . . . .44.50

Hazardous Waste Regulatory Guide

Up-to-date information on state hazardous waste regulations. All data is assembled in quick reference format for fast retrieval. Contents include general information; identification and listing; generator standards, transporter standards, treatment, storage and disposal standards; forms and permits. A valuable book for generators and disposers of hazardous waste.

J5003 . . . . .95.00

Safety Books



Handbooks on Transportation

Three basic reference texts for handling hazardous materials. Each test measures 4½" × 5½". **Hazardous Materials Handbook** provides rules and instructions for DOT's hazardous materials regulations. **Fundamentals of Transporting Hazardous Waste** is a self-study text covering EPA hazardous waste regulations. **Fundamentals of Transporting Hazardous Materials** is a training text designed to assist personnel in the shipment of hazardous materials. American Trucking Association, Inc.

No.	Description	Each
J5037	Hazardous Materials	8.00
J5036	Fundamentals of Transporting Hazardous Waste	8.00
J5035	Fundamentals of Transporting Hazardous Materials	8.00

Dense Gas Dispersion

Recent developments in the risk assessment of hazardous installations have highlighted the need for improved methods of estimating the possible consequences of releases of materials that may form dense gas mixtures with air such as liquefied natural and petroleum gas, chlorine and ammonia. Describes the recent developments in modeling and field testing in the laboratory, wind tunnels and large scale field tests. R.E. Britter, R.F. Griffiths, 247 pp., 1982.

J5075 . . . . 76.00

Red Book on Transportation of Hazardous Materials

This book is written as a guide for a wide range of people concerned with transportation of hazardous materials and aids in understanding federal DOT regulations. Broad coverage of the types of hazardous materials, description of packing materials and requirements for motor, rail, water and air carriers are included and cross-referenced to appropriate DOT regulations. Other chapters discuss hazardous materials accident and incident reporting, CHEMTREC, international regulatory bodies and the Hazardous Materials Transportation Act. Lawrence Bierlein, 880 pp., 1977.

J2229 . . . . 105.00

Handbook of Industrial Waste Disposal

A handbook for the selection and design of control processes for industrial wastewater and solid waste. The book will aid in identifying the real problems in pollution control, review alternatives, evaluate techniques and design criteria for each treatment or disposal approach. Subjects on wastewater treatment include equalization, neutralization and clarification; absorption by activated carbon; biological processes, etc. Discussion of solid waste includes subjects such as preparation, recovery, reuse, incineration, pyrolysis, land and ocean disposal, etc. Richard Conway, Richard Ross, 565 pp., 1980.

J2401 . . . . 46.00

Hazardous Waste Management Guide

A complete management program for complying with hazardous waste regulations. This book contains useful information for generators, transporters and disposers of hazardous waste. Special sections provide a synopsis of state regulations and reference materials. Helps to satisfy RCRA and CPA requirements.

J5002 . . . . 99.00

Risk Assessment at Hazardous Waste Sites

A collection of articles covering industrial guidelines for risk assessment, legislative problems on the national, state and county levels and health affects attributed to hazardous waste sites. Case studies are discussed including the Love Canal and others in Pennsylvania and Tennessee. F.A. Long and G.E. Schweitzer, 128 pp., 1982.

J5081 . . . . 25.50

Incineration of Industrial Hazardous Wastes and Sludges

This highly informative volume deals with incineration and related combustion processes such as pyrolysis. Designed to help in conforming with RCRA-based regulations. Discusses types of wastes which can be incinerated, waste disposal alternatives, regulatory requirements, incinerator design examples and much more. Marshall Sitting, 350 pp., 1979.

J5056 . . . . 56.00

Dangerous Goods Regulations

When transporting goods by air, a regulations manual is essential on how materials can be carried in accordance with national and international laws. Compliance with these regulations will ensure that all regulatory and airline requirements are met. Regulations include the essential Shipper's Declaration for dangerous goods, operator differences and full transitional packaging requirements. International Air Transport Association, effective January 1, 1985, 26th edition.

J5099 . . . . 60.00

Hazardous Waste Management for the 80's

This book provides practical information for improved management of hazardous wastes. It includes discussion of critical issues in toxic waste management, groundwater seepage, treatment, storage, disposal, site cleanup and legal considerations. T.L. Sweeney, H.G. Bhatt, R.M. Sykes, O.J. Sproul, ed., 553 pp., 1982.

J5027 . . . . 61.00

Detoxication of Hazardous Waste

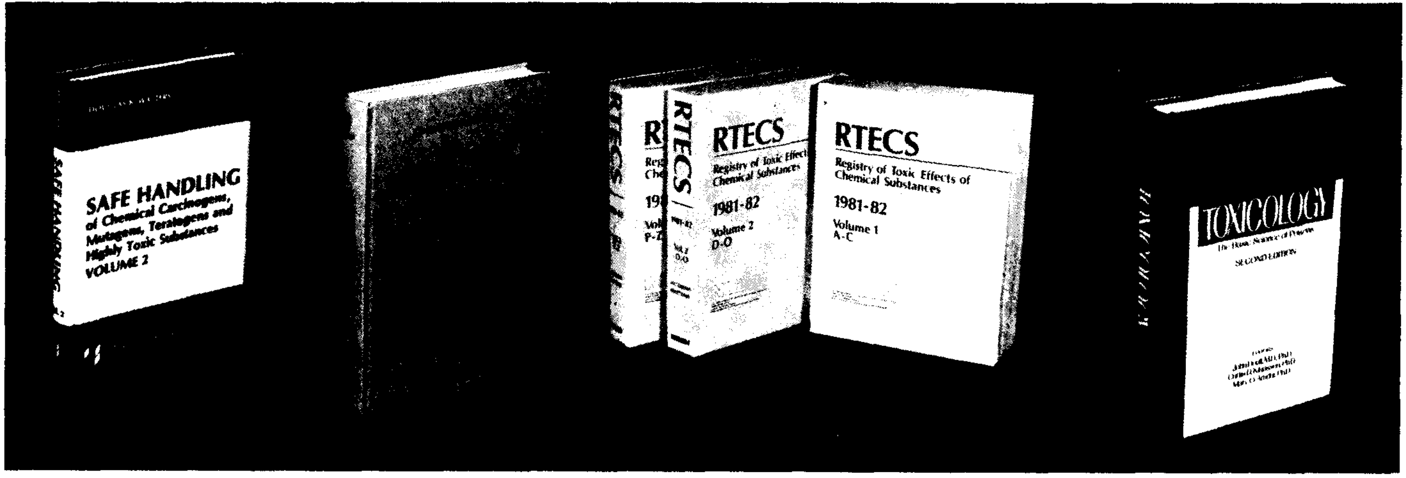
Increased legal liabilities and ground water contamination are forcing a shift from landfill to treatment or total destruction of hazardous wastes. This book focuses on diverse detoxication techniques and recovery of valuable chemicals in toxic wastes. 362 pp., 1982.

J5028 . . . . 61.00

Emerging Technologies for the Control of Hazardous Waste

This book reviews and assesses emerging technologies or variations of established technologies for hazardous waste control. Most of the hazardous waste considered in this study are organic substances such as PCB's, dioxins, pesticides, herbicides and chemical warfare agents.Three major technologies are covered in detail in the book which include molten salt combustion, fluidized bed incineration and ultraviolet/ozone destruction. B.H. Edwards, J.N. Paullin, K. Coghlan-Jordan. 146 pp., 1983.

J5076 . . . . 28.00



Safe Handling of Chemical Carcinogens, Mutagens, Teratogens and Highly Toxic Substances

Volume 1 includes a discussion of laboratory design for safe handling of chemical carcinogens, packaging, handling and transporting carcinogenic materials and chemical monitoring methods. **Volume II** covers methods of structure activity and toxicity prediction, application of these to models for toxicity estimation, metabolic activation, spill control, degradation and deactivation. D.B. Waters, ed., Vol. 1, 405 pp., 1980. Vol. II, 291 pp., 1980.

J2012	Vol. 1	72.00
J2013	Vol. II	72.00

Potential Industrial Carcinogens and Mutagens

This work provides detailed information on reported industrial carcinogens and mutagens and arranges them by structural categories in order to highlight their potential risks. Helps one to predict the hazards of new agents considered for introduction into the environment. A tabular summary of potential industrial carcinogens and mutagens is included. Lawrence Fishbein, 534 pp., 1979.

J2408 . . . . 106.00

Clinical Toxicology of Commercial Products

Provides a ready reference to more than 17,500 commercial chemical products containing potentially toxic ingredients. The information contained in its seven color-coded sections ranges from general to specific for diagnostic and treatment procedures. 5th edition.

J1421 . . . . *Available Jan. 1, 1985*

Handbook of Poisoning

Provides a concise summary of the diagnosis and treatment of poisoning. Poisons are organized as agricultural, industrial, household, medicinal and plant/animal hazards. Robert H. Dreisback, 578 pp., 1982, 11th edition.

J2027 . . . . 18.95

Registry of Toxic Effects of Chemical Substances

This three volume set is the tenth revision of toxicity data extracted from scientific literature by NIOSH. It contains over 218,000 listings of chemicals, 59,224 names of different chemicals and 159,522 synonyms. Other data includes CAS number, molecular formula, irritation, mutation and reproductive effects data, IARC reviews, TLV, federal standards, EPA status and more. 3057 pp., 1981-82.

J1424-2 . . . . 39.00

Cancer Causing Chemicals

Regulations relating to carcinogens, chemical carcinogenesis and their significance in the workplace and to the general population are discussed. A total of 2,400 basic carcinogens and 25,000 synonyms and cross-references are listed and described. N. Irving Sax, 466 pp., 1981.

J2411 . . . . 48.95

Catalog of Teratogenic Agents

This book contains over 1,000 listings of different chemical compounds and corresponding research data on their potential teratogenicity. The chemicals are listed in alphabetical order, with an abstract of test observations and findings as to the birth defects on animals. Each entry is referenced to the original research publication. Inside covers include time comparison chart for development of various species. Thomas H. Shepard, M.D., 410 pp., 1980, 4th edition.

J2400 . . . . 48.30

Reproductive Hazards of Industrial Chemicals

A detailed review of research covering reproductive toxicity of commonly used industrial chemicals. The first part presents reproductive hazards and appropriate tests in lab animals. In the second part, each compound is reviewed for relevant pharmacology and toxicology, fertility, pregnancy, mutagenicity and carcinogenicity. S.M. Barlow, F.M. Sullivan, 610 pp., 1982.

J5026 . . . . 90.00

Cassarett and Doull's Toxicology, The Basic Science of Poisons

The fundamental authoritative text describing the total aspects of toxicology. Unit sections include general principles, systemic toxicology; toxic agents; environmental toxicology and applications of toxicology. Each unit is broken down into chapters written by experts in the field. Chapters on teratogenesis, chemical carcinogenesis, genetic toxicology and more are included. J.V. Doull, C. Klassen, and M. Amdur, ed., 778 pp., 1980, 2nd edition.

J5000 . . . . 57.50

Disposition of Toxic Drugs and Chemicals in Man

An excellent toxicological reference on over 300 drugs and chemicals which gives essential information on the chemicals and drugs most frequently encountered in episodes of human poisoning. Data relates to body fluid concentrations in normal circumstances and in instances of toxicity. Specific analytical procedures for determining the substance and its active biological metabolites are mentioned. Information is of interest to toxicologists, pharmacologists and clinical chemists. Randall C. Baselt, 795 pp., 1982, 2nd edition.

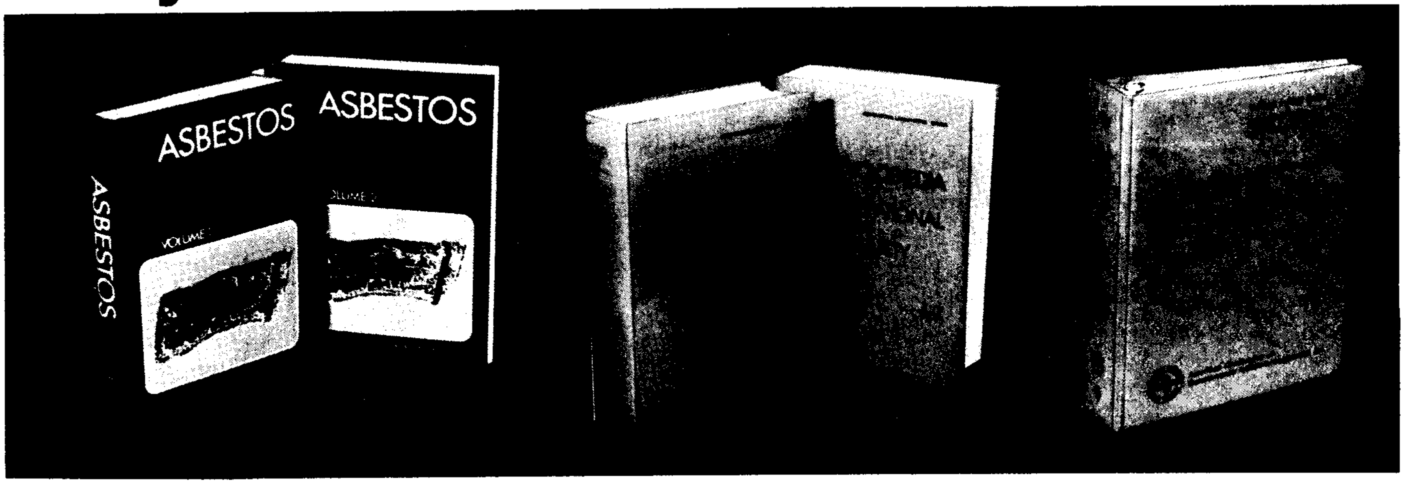
J5019 . . . . 51.50

Handbook Series in Analytical Toxicology

This handbook is a collection of physical, toxicological and chemical data on drugs, environmental hazards, economic poisons and industrial chemicals. The first three sections of the handbook are divided into units on drugs, economic poisons, industrial chemicals and air and waste pollutants. Within these units are presented an alphabetically arranged index describing physical, toxicological and analytical data followed by synonyms, chemical names, formulas and Chemical Abstract Registry Numbers. The fourth section presents a detailed index containing items from each unit and tabulated opposite the name of each product for convenience. Irving Sunshine, ed., 1081 pp., 1969. Section A: General Data, Vol. I.

J5070 . . . . 79.00

Safety Books



Asbestos - Properties, Applications and Hazards

A valuable two volume set which discusses in detail asbestos and its hazards. Volume 1 presents the basic science of asbestos including mineralogy, chemistry and physics and its effects on the health of people exposed to it. There are also sections on substitute materials for general industry and building construction purposes. L. Michaels, S. Chissick, 553 pp., 1979. Volume 2 covers dust control, personal protection, electron microscopy of asbestos and a major review of the disease, mesothelioma. S. Chissick, R. Derricott, Univ. of London, King's College, 652 pp., 1983.

J5067	Vol. 1 & 2	202.50
J5067-2	Vol. 1	132.00
J5067-3	Vol. 2	93.00

Hazardous Waste Audit Program

A guide for generators and owners/operators of treatment, storage and disposal facilities to audit compliance with the U.S. Environmental Protection Agency (EPA) hazardous waste management regulations found in 40 CFR Parts 260-265. Includes a guide for auditing and maintaining your present compliance status and a summary of EPA's personnel training requirements. 707 pp., 1982.

J5062 . . . . 67.00

Environmental Statutes

A collection of the major environmental laws ranging from the Clean Air Act to the Toxic Substance Control Act. Each act is presented in its entirety, including administration and standards. Hardcover, 681 pp.

J5090 . . . . 45.00

Remedial Action Technology for Waste Disposal Sites

Discusses technology designed to control, treat or remove contaminants from uncontrolled hazardous waste sites. Includes descriptions, design, construction, operating costs, advantages/disadvantages and examples of specific action taken for clean-up situations. P. Rogoshewski, H. Bryson, K. Wagner, 500 pp., 1983.

J5097 . . . . 42.00

Encyclopedia of Occupational Health & Safety

A two volume set for those concerned with worker health and safety. Presented objectively and systematically, even for those with no specialized medical or technical knowledge. Subjects such as toxicology, industrial hygiene, accident prevention, occupational medicine and ergonomics are covered. A total of 1150 articles are prepared by 900 internationally known specialists from 60 different countries and 20 international organizations. L. Parmeggiani, ed., International Labor Office, 1983.

J5080 . . . . 180.00

Biodegradation Techniques for Industrial Organic Wastes

This text provides data on proper treatment techniques for the biodegradation of hazardous and toxic organic compounds in industrial waste. Design and performance comparisons of selected biological treatment processes and operational methods are presented. Three in-depth studies at biological treatment facilities and one pilot operation are reviewed and compared. D.J. DeRenzo, ed., 358 pp., 1980.

J5089 . . . . 32.50

Industrial Hygiene Aspects of Plant Operations

Volume 1, Process Flows, fills the need for a collection of information on the recognition, measurement and control of potential hazards associated with plant operations. The process flow format is employed in which pertinent industrial hygiene information has been presented for each main step of the operation. Lester V. Cralley, Ph.D., CIH, Lewis J. Cralley, Ph.D., CIH, 630 pp., 1982. Volume 2, Unit Operations and Product Fabrication discusses unit operations and special procedures for assembling parts and materials into final products. L.V. Cralley, L.J. Cralley, J.S. Mutchler, 700 pp., 1984.

No.	Description	Each
J5059	Vol. 1	65.50
J5059-2	Vol. 2	85.00
J5059-3	Vol. 1 & Vol. 2	126.45

Guidelines for the Selection of Chemical Protective Clothing

The first complete reference for the proper selection of chemical protective clothing, including gloves. Contains User's Matrices that bring together recommendations for fourteen major clothing and glove materials for approximately 300 chemicals. Included are materials such as Viton®, butyl rubber, neoprene, nitrile, polyethylene, etc. Recommendations reflect information gathered on chemical degradation, permeation and rate of permeation. Sources and definitions of chemical protective clothing are also provided. Along with permeation theory, test methods, definition of technical terms and bibliography. Published 1983 by Arthur D. Little under sponsorship of the EPA.

J5057 . . . . 31.50

Safe and Efficient Plant Operation and Maintenance

A practical, up-to-date guide on chemical plant operation and maintenance that includes theoretical and practical knowledge to help ensure optimum plant operation. The areas treated in detail include general operation and maintenance, safety and hazardous materials handling, energy conservation, plant utilities, startup and turnaround and managing plant personnel. Methods are provided not only for keeping the plant in proper order, but also for upgrading the operation to meet improved safety standards and criteria for more efficient operation. Richard Greene, ed., 418 pp., 1980.

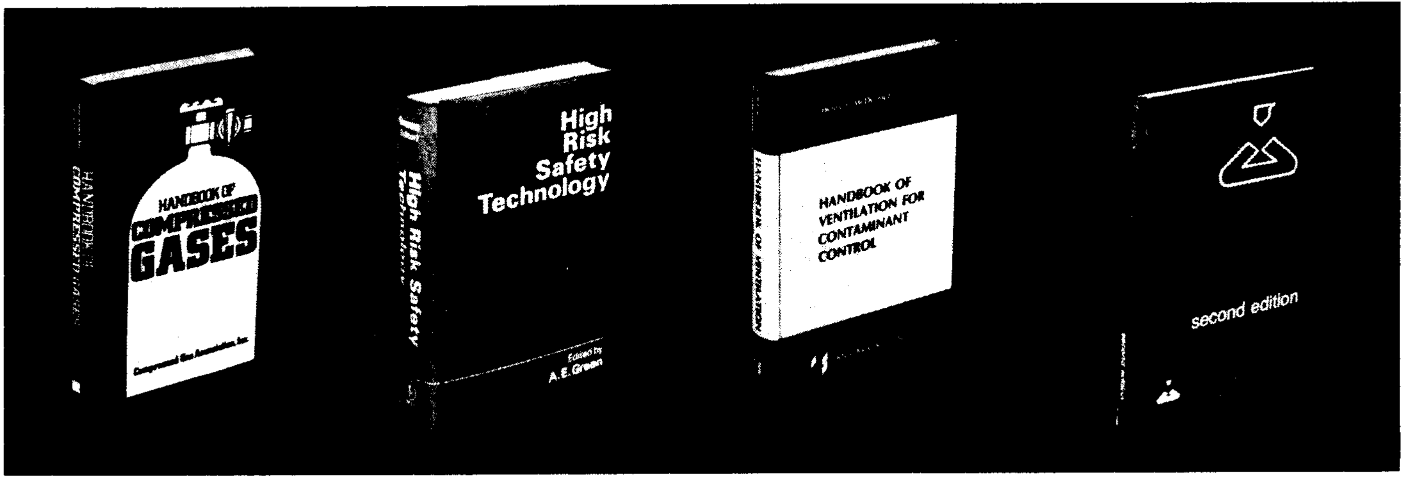
J5007 . . . . 43.95

Riegel's Handbook of Industrial Chemistry

A comprehensive review of twenty-four major industrial chemical process operations, chemistry, scope of the market and more. Topics include coal technology, rubber, synthetic plastics, petroleum, wood, explosives, pesticides, pharmaceuticals and many others. An excellent book for those wishing a basic understanding of the industry. James A. Kent, ed., 979 pp., 1983, 8th edition.

J5030 . . . . 66.50

Safety Books



Handbook of Compressed Gases

The most authoritative source of information on safety standards and the shipping, storage and use of gases in compressed, liquid or solid form. Coverage includes virtually every gas employed in significant quantities in modern life. Part I presents important standards for safety with compressed gases while Part II examines individual compressed gases and gas mixtures. A new chapter on handling and shipping gases in the form of cryogenic liquids near absolute zero is included. An invaluable reference for users of gases in industries ranging from petroleum and chemical to transportation. CGA. 916 pp., 1980, 2nd edition.

J2686. . . . . .49.50

System Safety Engineering and Management

The first book that combines system safety management with analysis. It establishes basic fundamentals of a system safety program and explains how to apply these principles to specific types of products, facilities or operations. H.E. Roland, B. Moriarty, 339 pp., 1983.

J5060. . . . . .45.00

Standard Handbook of Plant Engineering

A comprehensive handbook which provides information on the planning, construction, operation and maintenance of plant facilities. Areas of consideration include toxic and radiation hazards and noise and vibration control. R.C. Rosaler, J.O. Rice, ed., 1824 pp., 1983.

J5084. . . . . .102.00

High Risk Safety Technology

An excellent reference for evaluating the safety of technological systems. It covers the concept of risk, human factors and emergency planning, as well as safety technology in specific industries such as chemical and computer security. British, A.E. Green, 654 pp., 1982.

J5071. . . . . .75.00

Introduction to Safety Engineering

Establishes the Occupational Health and Safety Act as a philosophical framework and covers hazard recognition and control including industrial hygiene and protective equipment. Specific hazards, such as fire protection and control and radiation are discussed. D.S. Gloss, M.G. Wardle, 612 pp., 1984.

J5098. . . . . .58.00

Air Monitoring Methods for Industrial Contaminants

The need to monitor exposure to toxic chemicals in the workplace is as great as ever before, and for this reason, commercial suppliers have made available a variety of industrial instruments for air monitoring. This volume presents these commercial devices to be used for quantitative determination of 200 chemical substances in the workplace. David A. Halliday, ed., 430 pp., 1983.

J5101. . . . . .43.00

Handbook of Ventilation For Contaminant Control

(Including OSHA Requirements)

A complete working handbook that describes how to design and use exhaust ventilation systems. Helps to evaluate the need for ventilation in terms of OSHA standards and the selection of hoods. Henry J. McDermott, Regional Industrial Hygienist, Shell Oil Company, 368 pp. 1976.

J2010. . . . . .48.00

Landfill Disposal of Hazardous Wastes and Sludges

In this book landfill technology and directions for the disposal of hazardous and toxic substances are based on reports and guidelines of the Environmental Protection Agency. Topics covered include waste disposal alternatives and state and federal regulations. Marshall Sitting, 365 pp., 1979.

J5094. . . . . .55.00

Handbook of Chemical Property Estimation Methods

Predicting the environmental behavior of organic chemicals which depend on physical properties is made easier with the simple estimation methods found in this handbook. Twenty-six important properties are fully discussed, with step-by-step instructions and examples for each estimation method. Most estimations of these properties may be done quickly - in just a few minutes using no more than a hand calculator. W.J. Lyman, W.F. Reehl, D.H. Rosenblatt, ed., 960 pp., 1982.

J5021 . . . . .56.00

Industrial Respiratory Protection

Comprehensive overview of technical data for efficient respiratory protection in hazardous atmospheres. Valuable guide for industrial and biomedical engineers, equipment manufacturers and safety personnel. Covers toxicology effects, evaluating hazards by sampling and analysis, industrial ventilation, selection of appropriate respirators and the asbestos problem. M.F. Teresinski, P.N. Cheremisinoff, 349 pp., 1983.

J5025 . . . . .47.50

Detection and Measurement of Hazardous Gases

An excellent reference for those concerned with detection and measurement of hazardous gases. Chapters include: measurement of flammable gases and vapors, oxygen deficiency, personal monitoring, air sampling strategies and toxic gas monitoring. Ideal for industrial hygienists, safety personnel or plant managers. C.F. Cullis, J.G. Firth, ed., 226 pp., 1981.

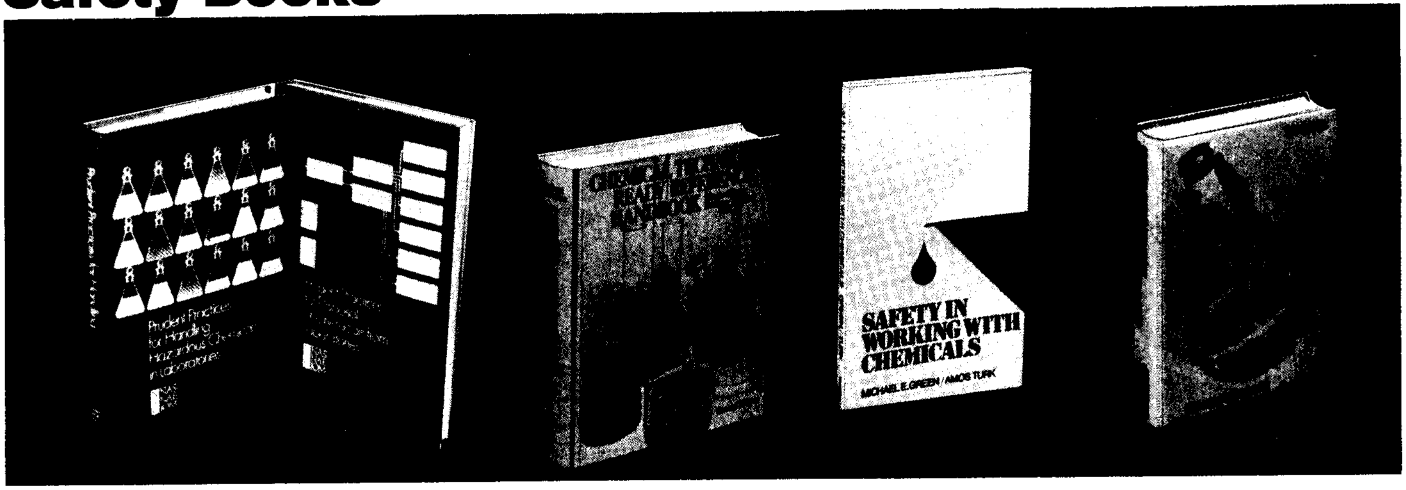
J5010 . . . . .48.00

Effects of Exposure to Toxic Gases: First Aid and Medical Treatment

A practical first aid guide for treatment of exposure to toxic gases. It also presents information on recognizing symptoms associated with exposure to toxic gases. Compiled from reputable medical sources. Matheson, 179 pp., 1977, 2nd edition.

J1457 . . . . .17.50

Safety Books



Prudent Practices for Handling Hazardous Chemicals in Laboratories

This guide is designed as a reference tool for laboratory science students and their teachers, institutional safety officers and research scientists. Recommends procedures for the safe handling and disposal of hazardous substances, along with broad recommendations for the development of laboratory safety programs. Although specific information is provided, it emphasizes general principles that can be adapted to the activities of any particular laboratory. 291 pp., 1981.

J2413 . . . . 25.00

Prudent Practices for Disposal of Chemicals from Laboratories

Contains recommended safe procedures for disposal of chemical waste via the sanitary sewer system, incinerator or landfill. Suggested guidelines for identifying, classifying and segregating laboratory waste and recommendations for transportation are included. 282 pp., 1983.

J2413-2 . . . . 25.00

Handbook of Laboratory Safety

An authoritative, exhaustive reference on virtually every aspect of laboratory safety. First aid, biohazards, chemical and radiation hazards are fully presented. A reliable reference for all lab personnel. N.V. Steere, 854 pp., 1972, 2nd edition.

J940 . . . . 74.25

Better Science Through Safety

The first safety book published for the teacher of chemistry, biology or physics. Covers safety topics recognized as an important part of the curriculum which includes eye protection, first aid, accident reporting, legal liability and safety for the handicapped student. Gerlovick and Downs, 145 pp., 1981.

J2414 . . . . 16.50

Clinical Laboratory Safety

Safety training and education are essential now more than ever in the clinical laboratory with an increase in testing and in complex instrumentation. Explores the hazards in the clinical laboratory and then supplies the detailed methods and actions necessary to assure safety of personnel. Accidents, emergencies, first aid and protective devices are discussed plus laboratory waste handling and disposal. Susan L. Rose, 304 pp., 1984.

J5100 . . . . 35.00

Chemical Technicians' Ready Reference Handbook

Proper procedures are just as important to the practice of safety as is the use of safety equipment. This handbook was designed to provide anyone with every single step to be followed when performing normal laboratory procedures. Procedures are written in simple sentence instructions for many laboratory functions. Shugar/Bauman, 867 pp., 1981, 2nd edition.

J2692 . . . . 52.50

Laboratory Safety: Theory and Practice

This book provides information on the hazards present in microbiological and research laboratories whose work is associated with viruses, carcinogens, recombinant DNA and other potential biohazards. A. Fuscaldo, B. Erlick, B. Hindman, ed., 384 pp., 1980.

J2684 . . . . 58.00

Safety in Working with Chemicals

An urgently needed guide to laboratory safety. This text covers basic laboratory rules, equipment hazards, chemical hazards, toxic and corrosive substances and radiation hazards. Actual procedures for cleanup, disposal of solvents, flammable materials and toxic substances and set-up of administrative procedures are provided. M.E. Green, A. Turk, 166 pp., 1978.

J1727 . . . . 19.00

Dictionary of Scientific and Technical Terms

A comprehensive, one volume dictionary covering every major field of science, engineering and technology from astronomy to zoology. There are 98,500 terms with over 115,000 definitions. These definitions are written in clear, simple language that is understandable even to the nonspecialists. There are 100 fields represented, some of which are highly specialized, such as atomic physics and molecular biology. Definitions, synonyms, acronyms and abbreviations are given and more than 3000 terms are supplemented by diagrams, graphs, drawings or photographs. Sybil P. Parker, ed., 1781 pp., 1984, 3rd edition.

J5083 . . . . 81.00

The Chemist's Companion

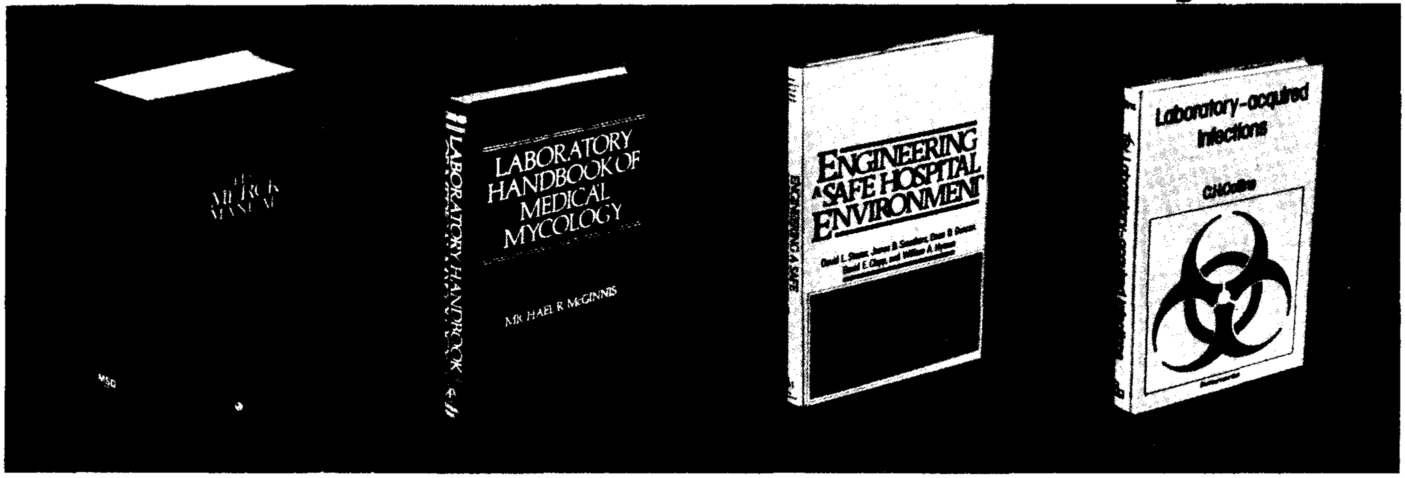
An extremely practical, information packed book of data for chemists, lab personnel, students and teachers. Includes nine chapters on such wide ranging subjects as spectroscopy, photochemistry, chromatography, molecular models, kinetics, experimental techniques and many other subjects. Provides an in-depth collection of facts and figures concerning practical chemical information. A comprehensive bibliography is included along with tables of isotopes, properties of elements, chemical and molecular bonds and much more. A. Gordon, R. Ford, 537 pp., 1972.

J2230 . . . . 56.00

Hazards in the Chemical Laboratory

This new, revised edition contains chapters on the Health and Safety at Work Act, 1974, reactive chemical hazards, safety planning and management, fire protection, health care and first aid, radiation precautions and hazardous chemicals. Information is given on over 480 chemicals which includes warning phrases, toxic effects, fire hazards and spills, disposal procedures for common laboratory chemicals and general properties with short qualitative descriptions. A valuable guidebook for the laboratory. L. Bretherick. Approximately 563 pp., 1981, 3rd edition.

J1720 . . . . 42.80



Environmental Health and Safety in the Hospital Laboratory

The safety reference written for those problems specific to the hospital laboratory. Includes sections on the hospital environment, infections, isolation procedures and precautions, safety guidelines, protective equipment, methods of fighting fires, a complete hazard identification system and much more. It offers suggestions for preparing safety guidelines, tables and manuals as well as a checklist for conducting safety inspections. Pertinent OSHA Standards are discussed. P. Flury, 200 pp., 1978.

J2022 . . . . .32.95

The Merck Manual of Diagnosis-Therapy

This manual is actually 24 concise textbooks covering detailed discussions of disorders, diagnoses and treatment options. It contains 2600 pages featuring more than 1500 subjects that are conveniently thumb indexed. Areas discussed are etiology, pathology and physiology. Vital information on new diagnostic equipment and techniques is presented. An up to date pharmacology section contains important information on dosages, pharmacokinetics, drug actions and interaction. 14th edition.

J5053 . . . . .33.50

Disinfection, Sterilization, and Preservation

Provides thorough coverage of disinfectants and antiseptics from surgery to cosmetics and from food preservation to wood preservation. Encompasses a wide range of disinfection and sterilization techniques, their applications in the health-related fields and a wide variety of testing procedures. The most comprehensive book on the subject and an indispensable reference for all involved in medicine, health and industrial activities. Edited by Seymour S. Block, Ph.D., University of Florida, Gainesville. (58 Contributors). 1050 pp., 1983, 3rd edition.

J1734 . . . . .112.00

Laboratory Handbook of Medical Mycology

Importance of fungi in medicine dictates a need to discuss important topics such as laboratory safety and emergency procedures, quality control of media and equipment, new isolation techniques, susceptibility testing and modern concepts for the identification of fungi. Photomicrographs with thorough descriptions as well as a complete glossary are given. M.R. McGinnis, 661 pp., 1980.

J5069 . . . . .65.95

Engineering a Safe Hospital Environment

A comprehensive reference which contains practical solutions to the safety problems encountered in hospitals today. It focuses on electrical, building, mechanical and laboratory safety, environmental control, radiation safety, infection control, fire protection and the safe use and operation of medical equipment. It provides summaries of important sections of standards, codes and regulations of the JCAH, NFPA and OSHA which govern hospital safety. This is an excellent reference for hospital administrators, doctors, nurses, clinical and biomedical engineering technicians. D.L. Stoner, J.B. Smathers, W.A. Hyman, D.E. Clapp, D.D. Duncan, 195 pp., 1982.

J5072 . . . . .42.00

Hazardous Waste Incineration Engineering

The engineering guidelines contained in this book are a compendium of material on the current state-of-the-art technology for hazardous waste incineration. The various chapters in the book detail the current practices of incineration technologies as well as air pollution control devices and the new emerging waste incineration technology. Several lengthy and detailed chapters are devoted to incineration and air pollution control, system design evaluation and overall facility design. T. Bonner, B. Desai, J. Fullenkamp, T. Hughes, E. Kennedy, R. McCormick, J. Peters, D. Zanders, 431 pp., 1981.

J5078 . . . . .51.95

Handbook of Hospital Safety

An authoritative, thorough reference on all aspects of hospital safety. Covers history and reasons for hospital safety, psychology of the hospital population and the human factors which affect safety within the hospital. Other topics include sanitation and infection control, fire prevention, safety in the emergency room, operating room, special care unit, pharmacy, lab and radiological facilities to name a few. A guide to the organization, function and authority of the hospital safety committee, this book is a must for every hospital safety or risk management program. Paul E. Stanley, ed., 398 pp., 1981.

J5045 . . . . .86.95

Laboratory - Acquired Infections

This book addresses the history, incidence cause and prevention of laboratory acquired infections. The first chapters cover how it is acquired, official actions and reactions of countries and organizations and classifications of both microorganisms and laboratories according to use. How to actually minimize equipment and technique related hazards and personal protective clothing are discussed. An entire chapter is devoted to microbiological safety cabinets including their evolution, airflows, lighting, electricity, gas, performance tests and decontamination. In addition, a discussion of chemical disinfection, autoclaving, incineration and disposal of contaminated liquid waste is presented. The final chapters of the book deal with the need for instruction in microbiological safety, plus considerations for a safe working environment. C.H. Collins, 277 pp., 1983.

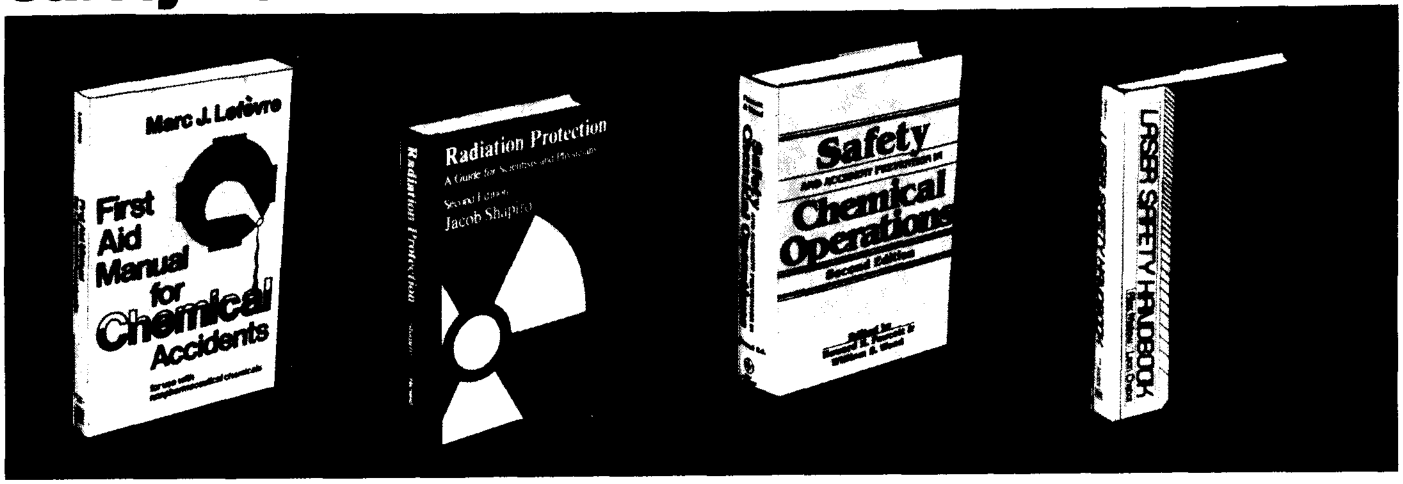
J5077 . . . . .60.25

Handbook of Hospital Acquired Infections

Five to ten percent of hospitalized Americans acquire an infection which was not present or incubating at the time of admission to the hospital. Infection control has emerged in the 1980's to be an important safety issue in hospitals. Topics covered include identifying and reporting infections, improving use of antibiotic agents, legal problems, infection control and investigating an epidemic. Richard P. Wenzel, M.D., 656 pp., 1981.

J5058 . . . . .107.00

Safety Books



First Aid Manual for Chemical Accidents

Provides a source of clear information on the proper treatment of persons exposed to dangerous levels of toxic chemicals. A 16 page index of nearly 500 chemicals provides a quick reference. Toxicology and symptoms of over-exposure and first aid-procedures in cases of inhalation, ingestion, skin contact and eye contact are given. Marc J. Lefevre, M.D., 218 pp., 1980.

J2685 . . . . .25.50

Lifesavers

The Complete Home Medical and Emergency Handbook

Fully illustrated step-by-step first aid for every emergency and mishap. Book features a unique quick access index to fast, simple instructions. Over 400 illnesses and disorders are listed with symptoms and directions on what to do about them. Paperbound, 8½" × 11". Martin I. Green, 255 pp., 1981.

J5020 . . . . .13.00

Safety Training Methods

A complete guide for those responsible for complete safety training programs in their organizations. Areas such as OSHA training requirements, safety record keeping, fire safety, hazard inspection, accident investigation and medical and first aid training are covered. Additional features include a dictionary of commonly used safety and health terms, a model safety program and valuable reference information. Jack B. ReVelle, 248 pp., 1980.

J5073 . . . . .39.50

Radiation Protection,

A Guide for Scientists and Physicians

An excellent book for those concerned about radiation protection. Chapters include principles of radiation protection, radiation dose calculations, radiation measurements, practical aspects of radionuclides and ionizing radiation. Appendices and selected bibliography are included. J. Shapiro, 480 pp., 1981, 2nd edition.

J2862 . . . . .35.00

Safety and Accident Prevention in Chemical Operations

A must reference for wherever chemicals are handled or used. Topics include Chemical Hazards and Worker Safety, Safety Education and Training, Flammable Materials, Radiation, Respiratory Hazards, Fire Extinguishing Agents, Personal Protective Equipment and others. Howard H. Fawcett, National Academy of Sciences and William S. Wood, ed, 880 pp., 1982, 2nd edition.

J1845 . . . . .99.00

Hazard Assessment of Chemicals

Two volume set examines the hazards of chemicals in the environment. Volume 1 reviews toxic substance information sources, trace metals from aquatic samples, xenobiotics, a case history of azaarenes and more. Volume 2 contains a collection of five subject reviews on the persistence of pesticides in soil systems, the epidemiological approaches to hazardous chemical assessment and two case studies of chemical spills involving vinyl chloride and TCDD. J. Saxena, F. Fisher, ed., Volume 1, 461 pp., 1981. Volume 2, 361 pp., 1983.

No.	Description	Each
J2864	Vol. 1&2	115.00
J2864-1	Vol. 1	75.60
J2864-2	Vol. 2	56.70

Vibration Effects on the Hand and Arm in Industry

A collection of papers on the medical, acoustical, engineering and legal aspects of exposure of the arm and hand to industrial vibrations. The papers cover methods of measuring vibration exposure, the effects of such exposure, including the development of "white fingers" and "dead hand" and the resulting dose-response relationship. Also included are papers on objective tests for diagnosis, methods for reducing vibration exposure and the legal ramifications for workers. A.J. Brammer, W. Taylor, 359 pp., 1982.

J5066 . . . . .49.00

Overexposure: Health Hazards in Photography

This is the first comprehensive reference book that addresses the health hazards associated with the materials in a photographic workspace. Guidelines are given for proper precautions and safety procedures to minimize hazards. A Trade Name Index lists commonly used products and details the chemical components. S. Shaw, 329 pp., 1983.

J5102 . . . . .21.00

Artist Beware

A comprehensive volume which details the hazards to which artists and craftspeople are exposed while working with art materials and the precautionary measures which need to be taken. It explains the hazards of exposure found in common art materials and the design of a safe studio with proper storage, ventilation and personal protective equipment. Also covered are hazards and precautions in individual art or craft processes such as painting, ceramics or dyeing. Michael McCann, Ph.D, 360 pp., 1979.

J2412 . . . . .18.95

Food Safety

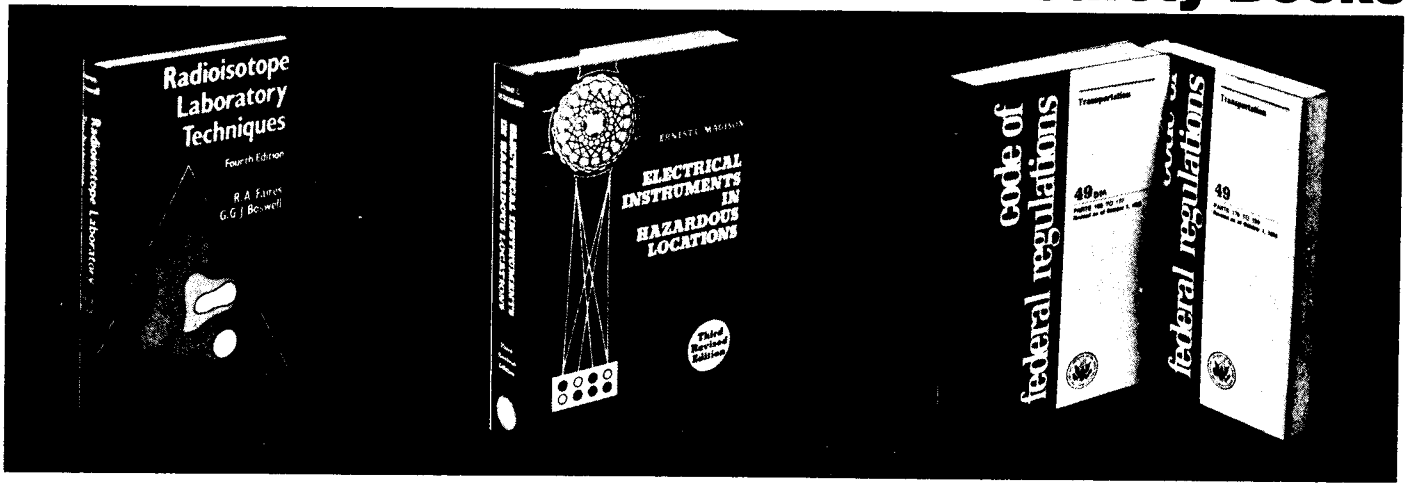
This book presents a systematic evaluation of the overall problem of food safety by examining the significant areas of potential hazard. Among the food safety issues highlighted are hazards of microbial origin, nutritional hazards, environmental contaminants, food hazards of natural origins and food additives. Each area is discussed in terms of its nature, extent and importance in overall food safety. H.R. Roberts, Ph.D, ed., 339 pp., 1981.

J2689 . . . . .65.00

Laser Safety Handbook

Comprehensive handbook that reviews the laser beam and associated hazards. It explains biological effects of laser radiation and protective standards covering intrabeam and extended source viewing. Also discussed are safety and training programs and atmospheric effects on laser beams. 6" × 9". A. Mallow, L. Chabot, 368 pp., 1978.

J1729 . . . . .40.00



Radioisotope Laboratory Techniques

Written for the laboratory personnel who use radioisotopes, this book presents a wide range of information on radiation, laboratory procedures, counting techniques and analysis using radioisotopes. Chapters include elements of nuclear physics, production of radioisotopes, the laboratory, hazard control, decontamination and disposal of waste, solid and liquid scintillation, applications and more. British. R.A. Faires, G.G.J. Boswell, 335 pp., 1981, 4th edition.

J2694 . . . . .48.00

Handling Radioactivity

A Practical Approach for Scientists and Engineers

Summarizes current knowledge of safe handling of radioactivity with particular emphasis on work at the laboratory level. Covers safety standards, shielding, lab and hot cell design and radiation dosimetry. A valuable at-hand reference tool for scientists and workers directly or indirectly involved in dealing with radioactive materials. Donald C. Stewart, 282 pp., 1981.

J5052 . . . . .56.00

Handling Radiation Emergencies

A valuable book for those involved in radiation emergencies. It presents basic techniques of self-protection and control of both fire and contamination. R.G. Purington, W. Patterson, 184 pp., 1977.

J5022 . . . . .22.50

Treatment, Recovery and Disposal Processes for Radioactive Waste

Presents the latest patented technology relating to radioactive waste. Obtained from U.S. Patents issued from 1975 to 1982, it describes immobilization techniques, storage containers and concentration processes. J.I. Duffy, ed., 187 pp., 1983.

J5039 . . . . .45.50

Electrical Instruments in Hazardous Locations

Discusses the fundamentals of electrically induced explosion and ignition in hazardous locations. Referenced to Article 500 of the National Electric Code and includes a review of explosion-proof housings and design considerations for intrinsically safe systems. E.C. Magison, 394 pp., 1980, 3rd edition.

J2198 . . . . .61.00

Intrinsically Safe Instrumentation: A Guide

Provides a clear and simple guide to intrinsic safety as a method of protection for electrical apparatus in hazardous locations. It also gives complete and detailed guidance on the differing types of approvals applicable to hazardous area electronics and correlation between U.K. and U.S.A. approaches to the subject. Robin Garside, softbound, 209 pp., 1983.

J5038 . . . . .41.00

Instrumentation for Environmental Monitoring

This comprehensive volume is a result of the Lawrence Berkeley Lab's survey of instrumentation suitable for the measurement of the quality of our environment. The text describes ionizing radiation and the instruments used for measurement. It includes units, sources and effects of radiation, basic detection methods and measurement of alpha, beta, gamma and x-radiation. Also discussed are nuclear power plants, spent fuel reprocessing, mining and milling as well as measurement of specific radionuclides. 1130 pp., 1983, Volume I, Radiation, 2nd edition.

J5049 . . . . .186.00

Standards and Practices for Instrumentation

A reference guide to instrumentation, including design, testing, usage and maintenance. Contains 50 current ISA Standards and Practices, 750 titles and abstracts of instrumentation-related standards and titles of standards from international organizations. Also includes a subject index for standards. Hardbound, 1100 pp., 1983, 7th edition.

J5055 . . . . .206.00

Destruction and Disposal of PCB's by Thermal and Non-Thermal Methods

This book was prepared from studies by TRW, Inc. and is intended as a guide to the available technology for thermal and non-thermal destruction and disposal of PCB's, as stated by EPA regulations. Part I describes fundamental processes of combustion, thermal destruction systems and flame chemistry relative to PCB incineration. Part II deals with various chemical, physical and biological PCB removal and/or destruction technologies. D.G. Ackerman and others, 417 pp., 1983.

J5088 . . . . .55.00

Land Treatment of Hazardous Wastes

This book examines the possibilities for improving the efficacy of land treatment for hazardous waste and presents a critical review for the disposal of a number of hazardous waste chemicals. It is divided into two parts. In part one, topics of consideration include the interaction of soils with waste constituents and factors affecting the degradation and inactivation of waste in soils. Part two of the book addresses specific industries in relationship to the kinds of waste generated, chemical characteristics of the waste, degradation and disposal techniques and basic research needs. Industries included are petroleum, pesticides and pharmaceutical. J.F. Parr, P.B. Marsh, J.M. Kla, 421 pp., 1983.

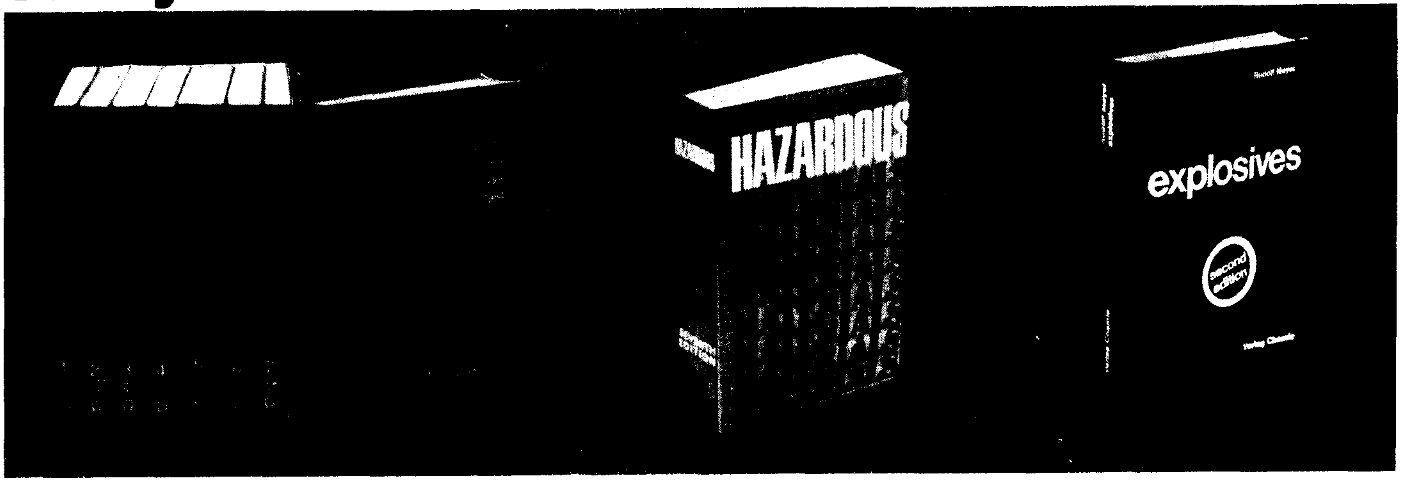
J5079 . . . . .51.50

Government Publications

A collection of government regulations from the Federal Register which includes the two part **Transportation of Hazardous Materials,** Title 49, Parts 100-177, 178-199 (1983), the **EPA Hazardous Waste Regulations,** Title 40, Parts 190 to 399 (1983), the **General Industry Standards,** Title 29, Part 1910 (1983) and **Occupational Health Guidelines for Chemical Hazards** (1981).

No.	Description	Each
J5031	DOT Regulations, Parts 100-177	25.00
J5031-2	DOT Regulations, Parts 178-199	22.25
J5032	EPA Hazardous Waste	10.00
J5033	General Standards	16.00
J5034	Occupational Health Guidelines	42.50

Safety Books



National Fire Codes

A vital reference for those dealing with fire safety. This comprehensive set of guides is an annual compilation of the Codes, Standards, Recommended Practices, Manuals, Guides and Model Laws published and adopted by NFPA. Each of 8 softbound volumes measures 8½" x 11", 1984.

J5016 . . . . .267.00

Flammable and Combustible Liquids Code Handbook

Based on the 1981 edition of NFPA 30, FLAMMABLE and COMBUSTIBLE LIQUIDS CODE, this handbook outlines recommended procedures and specifications for the storage and handling of flammable and combustible liquids. Topics include tank storage, pipes, valves and fitting, container and portable tank storage, industrial and bulk plants and others. An excellent book for safety officers, plant engineers, maintenance and other personnel dealing with flammable liquids. NFPA, 246 pp., 1981.

J2851 . . . . .30.95

Flash Point Index of Trade Name Liquids

A comprehensive listing of flashpoints for over 8,800 tradename products, including liquids having a flashpoint or Underwriter Laboratories, Inc. classification. The principal uses, manufacturer and references are also given for each trade name product. Compiled by the NFPA, 308 pp., 1978, 9th edition.

J5017 . . . . .12.50

Industrial Fire Hazards Handbook

The need for continuous fire protection is an important aspect of a safety program. This book provides an outline for major industrial processes and identifies fire hazards associated with them. It discusses risk management, life safety and fire hazards of special processes. Each section is written and referenced by an expert in the field. G. McKinnon, P. Tasner, M. Hill, ed., NFPA, 933 pp., 1979.

J5015 . . . . .51.75

Fire Protection Guide on Hazardous Materials

A complete reference on the use, storage and transportation of hazardous materials. It contains sections describing the fire hazard properties of flammables which include flammability limits, extinguishing methods, flash points and the NFPA 704 hazard identification rating. Also covered are the flashpoints of trade name liquids, fire and explosion hazards, personal protection, types of shipping containers and storage. Also covers hazardous chemical reactions which consists of a compilation of recorded experience with chemical reactions that have potential for danger. The last section is a detailed explanation of the NFPA 704 hazard identification system which includes numerical ratings for health, flammability and reactivity hazards. Soft bound, 5" × 7½", 1979.

J5013 . . . . .25.00

Safe Use of Solvents

This book offers a broad collection of information discussing problems with specific solvents, solvent abuse and safe usage. Has many applications for use in industry, laboratories and warehouses. Includes guidelines for identification and classification of solvents, a check list of safe handling and storage procedures and information on the health hazards of many solvents. A.J. Collings, S.G. Luxan, ed., 315 pp., 1982.

J5029 . . . . .58.00

Fire Protection Handbook

A most comprehensive guide referencing the needs of the fire protection community and detailing the practices of good fire protection and fire prevention methods. Includes information on fire loss, characteristics and behavior of fire, fire hazards of materials, building services and industrial occupancies. Also, fire safety in building design and construction, fire alarm systems, extinguishing system design and agents and much more. Written by the NFPA staff with additional assistance from outside experts. The hard cover book measures 8½" × 11", over 1275 pp., 1981, 15th edition.

J5014 . . . . .78.00

Chemical Emergency Action Manual

Gives specific instructions in case of chemical spill, leak, fire or exposure. It outlines immediate hazards for rescuer and victim and provides medical instructions. Fifty-nine potentially dangerous chemicals are presented. American Lung Association of Western New York, 160 pp., 1982, 2nd edition.

J5054 . . . . .40.50

Explosives

An encyclopedia of explosives. Contains about 500 entries arranged in alphabetical order, including formulas and descriptions of explosive chemicals, additives, fuels, oxidizing agents and a 1500-entry subject index. A well known reference by Rudolf Meyer. 440 pp., 1981 edition, English.

J1517 . . . . .81.50

Explosions

Powders and gaseous substances, when not handled properly, can cause devastating explosions. Examines the course and causes of various explosions, protective measures to prevent explosions and applications of protective measures on technical equipment. W. Bartknecht, 251 pp., 1981, (German translation).

J5040 . . . . .96.00

Explosion Hazards and Evaluation

Incorporates new data relative to the accidental explosion process. Explains how to estimate the magnitudes of explosions, how to predict overpressures and how to estimate thermal radiation effects. It includes simplified procedures for blast and impact resistance design and summarizes more sophisticated methods. All procedures and prediction methods are illustrated by example problems. Concludes with guidelines for explosion accident investigation. W.E. Baker, P.A. Cox, P.S. Westine, J.J. Kulesz, R.A. Strehlow, 807 pp., 1983.

J5074 . . . . .176.00

APPENDIX C

ADDITIONAL CHEMICAL SAFETY AND MANAGEMENT SOURCES

AT YOUR FINGER TIPS, film, presents material safety data sheets. Available from ITS, 823 Eastgate Drive, Mount Laurel, NJ 08054.

DISPOSING OF SMALL BATCHES OF HAZARDOUS WASTES, M. Ghassemi, S. Quinlivan, G. Gruber, H. Casey, prepared for the Office of Solid Waste, The Environmental Protection Agency, Report Number SW-562, 1976. Contract EPA (800) 424-9346.

CANCER CAUSING CHEMICALS, N. Irving Sax, 1981, available from Lab Safety Supply Catalog, p. 189 (see Appendix B).

CHEMICAL BOOBYTRAPS, 10 minutes, 16 mm film, sound; color, available from General Electric Company, Audio Visual Section, 60 Washington Avenue, Schenectady, NY 12301.

CHEMICALS AND INDUSTRIAL PROCESSES ASSOCIATED WITH CANCER IN HUMANS, International Agency for Research on Cancer: Lyon, September 1979, Monographs Supplement 1.

EYE AND FACE PROTECTION, film, Edward Fiel Production, Cleveland, OH.

HANDBOOK OF LABORATORY SAFETY, N.V. Steere, Second Edition, CRC Press, Cleveland, OH 44128, 1971, $33.95.

PRUDENT PRACTICES FOR DISPOSAL OF CHEMICALS FROM LABORATORIES, National Academy Press, 2101 Constitution Avenue N.W., Washington D.C. 20418.

SAFETY FIRST IN SCIENCE TEACHING. For further information, contact Paul H. Taylor, Director, Division of Science Education, Department of Public Instruction, Raleigh, NC 27611, and Carolina Biological Supply Company, 2700 York Road, Burlington, NC 27215.

SAFETY IN THE CHEMISTRY LAB, 25 minutes, 16 mm film, sound, color, available from Public Health Service, Audio Visual Center, Center for Disease Control, Atlanta, GA.

SCIENCE TEACHING AND THE LAW, B.W. Brown, W.R. Brown, 1969, National Science Teachers Association, 1742 Connecticut Avenue N.W., Washington D.C. 20009. Request updated guidelines from the same association.

STANDARD RECOMMENDED GUIDE FOR DISPOSAL OF LABORATORY CHEMICALS AND SAMPLES (DRAFT), contact Terry M. McKee (Task Group Chairman) for further information at Browning-Ferris Industries, Houston Laboratory, 4400 South Wayside Drive, #107, Houston, TX 77087, (713) 641-0526.

28 GRAMS OF PREVENTION, 24 minutes, 16 mm film, sound, color, available from Fisher Scientific Company, 711 Forbes Avenue, Pittsburgh, PA 15219, (412) 562-8300.

WHAT YOU DON'T KNOW CAN HURT YOU, film, available from ITS, 823 Eastgate Drive, Mount Laurel, NJ 08054.

PERIODICALS

Journal of Chemical Education (monthly), Division of Chemical Education, American Chemical Society. For subscription rates, write to the Journal of Chemical Education, Circulation Services, 119 West 24th Street, New York, NY 10011.

DEVELOPING AN OSHA ACCEPTABLE ACADEMIC CHEMISTRY DEPARTMENT, P.J. Taylor, Journal of Chemical Education, 55, A439 (1978). Of general interest but may be dated.

HIGHLIGHTING SAFETY PRACTICES TO STUDENTS, M.M. Renfrew, Journal of Chemical Education, 55, 145 (1978).

SAFETY IN THE ACADEMIC LABORATORY, J.A. Kaufman, Journal of Chemical Education, 55, A337 (1978).

A UNIVERSITY-LEVEL COURSE IN LABORATORY SAFETY, G.G. Lowrey, Journal of Chemical Education, 55, A235 (1978); 55, A263 (1978).

SOCIETIES/ASSOCIATIONS/AGENCIES

American Chemical Society (ACS)
Chemical Health and Safety Division
1155 Sixteenth Street N.W.
Washington D.C. 20036
(202) 872-4600

The society has available abstracts of symposia sponsored or cosponsored by the Council Committee on Chemical Safety since 1963 and the ACS Division of Chemical Health and Safety, since 1977.

HEALTH AND SAFETY GUIDELINES FOR CHEMISTRY TEACHERS, December 1979, Kenneth M. Reese, Department of Educational Activities, American Chemical Society, 1155 Sixteenth Street N.W., Washington D.C. 20036.

SAFETY IN ACADEMIC CHEMISTRY LABORATORIES, August 1979, Third Edition, American Chemical Society, 1155 Sixteenth Street N.W., Washington D.C. 20036.

Audio Course on Hazardous Materials, American Chemical Soceity, Educational Activities Department.

Chemical Manufacturers Association
2501 M Street N.W.
Washington D.C. 20037
(202) 887-1100

GUIDE TO SAFETY IN THE CHEMICAL LABORATORY, 1972, Second Edition, Chemical Manufacturers Association, Van Nostrand Reinhold Company, Division of Litton Educational Publishing Inc., New York, NY.A more recent edition may be available.

National Science Teachers Association
1742 Connecticut Avenue N.W.
Washington D.C. 20009

SAFETY IN THE SECONDARY SCIENCE CLASSROOM.

New York State:

Department of Education

Bureau of Educational Management Services
Cultural Education Center
Room 3059
Albany, NY 12230
(518) 474-3384

This unit has prepared a set of Toxic Information and Training Data Sheets for toxic materials used in schools. (See also your local BOCES office for a complete set.)

Bureau of Science Education
Cultural Education Center
Albany, NY 12234
(518) 474-7746

Department of Environmental Conservation
Division of Solid and Hazardous Wastes
50 Wolf Road
Room 209
Albany, NY 12233
(518) 457-0927

Department of Health
Bureau of Toxic Substances Assessment
Corning Tower
Empire State Plaza
Albany, NY 12237
(518) 473-3793

Provides information about the New York State Toxic Substance Law, commonly known as the "Right-to-Know Law", and about specific toxic substances.

Department of Labor
OSH Intergovernmental Relations
State Office Building Campus
Building 12
Room 579
Albany, NY 12240
(518) 457-5508

Provides on-site consultation concerning health and safety hazards for private and public employers. Enforces the NYS Occupational Safety and Health (OSH) Act, which is comparable to the Federal OSH Act but applies to public employers only. Enforces certain sections of the "Right-to-Know Law".

United States:

Department of Health and Human Services
National Institute for Occupational Safety and Health (NIOSH)
4676 Columbia Parkway
Cincinnati, OH 45226
(513) 684-8302

MANAGEMENT OF HAZARDOUS CHEMICAL WASTES IN RESEARCH INSTITUTIONS, Proceedings of the 1981 NIH Research Safety Symposium, NIH Publication No. 82-2459, Washington D.C., Scientific Editor, Eric B. Sanson, Ph.D., May 20-21, 1981.

MANUAL OF SAFETY AND HEALTH HAZARDS IN THE SCHOOL SCIENCE LABORATORY, AN OCCUPATIONAL SAFETY AND HEALTH TRAINING MANUAL FOR SCHOOL SCIENCE INSTRUCTORS, a reference to hazards of experiments in chemistry, earth science, biology and physics. Codes experiments so that teachers can determine the relative danger of an experiment.

Supplement: SCHOOL SCIENCE LABORATORIES, A GUIDE TO SOME HAZARDOUS SUBSTANCES, prepared by the Council of State Science Supervisors, 1984. This publication was made possible by a contract with the U.S. Consumer Product Safety Commission. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402.

NIOSH/OSHA POCKET GUIDE TO CHEMICAL HAZARDS.

REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES, issued annually.

Department of Transportation
400 7th Street S.W.
Washington D.C. 20590
(202) 426-4000

Environmental Protection Agency
401 M Street S.W.
Washington D.C. 20460
(202) 382-4700

Occupational Safety & Health Administration (OSHA)
Health Standards
200 Constitution Avenue
Washington D.C. 20210
(202) 523-7075

APPENDIX D

Representative Haulers Who Transport Laboratory Chemicals

Schools using commercial haulers should verify that the transporters' permits are current.

BATTERY DISPOSAL (Disposal of reactive chemicals)
Research Parkway
Clarence, NY 14031
(716) 759-2868

CECOS INTERNATIONAL, INC. (Various wastes)
56th Street & Pine Avenue
Niagara Falls, NY 14302
Connie Pasisz
CECOS International, Inc., Niagara Falls, NY;
CECOS/CER, Williamsburg, OH.
(716) 282-2676
9A-090
8/31/83
NYD080336241

CHEMICAL WASTE DISPOSAL CORPORATION (Various receiving stations)
42-14 19th Avenue
Astoria, NY 11105
Murris Levy
(212) 274-3339
2A-029
12/31/83
NYD077444263

CLEAN INDUSTRY INC. TERMINAL (Lab packs)
(Home Office: Linden, NJ)
43-09 Vernon Boulevard
Long Island City, NY 11101
(212) 729-2121
NYD089806012

DELAWARE CONTAINER COMPANY (Solvent mixtures)
West 11th & Valley Road
Catesville, PA 19320
Wiliam J. Ries
(215) 383-6600
PA-039
3/31/83
PAD064375470

EAST COAST ENVIRONMENTAL SERVICE (Various wastes)
454 Quinnipac
New Haven, CT 06513
R. Fioro
(203) 469-2376
CT-006
5/31/83
CTD089631956

ENVIRONMENTAL MANAGEMENT CORPORATION
4211 Seneca Street
West Seneca, NY 14224
(716) 675-5300

(EMC provides a laboratory chemical disposal service. They will either pick-up the pre-packed chemicals or will both pack and pick up the waste materials.)

FRONTIER CHEMICAL WASTE PROCESS, INC.
4626 Royal Avenue
Niagara Falls, NY 14303
(716) 285-8208
9A-0788,2295
NYD043815703

(Various wastes)

HAZMAT ENVIRONMENTAL GROUP, INC.
269 Parkside Avenue
Buffalo, NY 14214
(716) 835-5129

HAZ-O-WASTE CORPORATION
Canal Road
Wampsville, NY 13163
(315) 697-3979

RADIAC RESEARCH CORPORATION
261 Kent Avenue
Brooklyn, NY 11211
John Tekin
(212) 963-2233
U.S. Ecological Richland, W. Beatly, NV;
Radiac Research, Brooklyn, NY.
2A-004
4/30/83
NYD049178296

SCA CHEMICAL WASTE SERVICES INC.
Box 200
1135 Balmer Road
Model City, NY 14107
(716) 754-8231
NYD049836679

(Various wastes)

TONAWANDA TANK TRANSPORT
1140 Military Road
P.O. Box H
Buffalo, NY 14217
(716) 873-9703

WASTE TECHNOLOGY SERVICES INC.
730 Main Street
Niagara Falls, NY 14301
(716) 282-4100

(WTS develops comprehensive programs to satisfy school districts' chemical disposal requirements. It also provides a laboratory chemical packaging service to accomplish laboratory clean-outs, manifesting and transportation.)

The attached brochure is an example of the types of corporations in business to provide laboratory waste management services to schools and other organizations. Use this sheet to list the names or to attach the brochures of other companies involved in the same type of service. Call each company to obtain details of the kinds of service provided as well as to check their current permit status.

APPENDIX E

The article "Prudent Practices for Handling Hazardous Chemicals in Laboratories", McKusick, B., Science, Vol. 211, pp. 777-780, February 20, 1981, copyright 1981, by the AAAS, is reprinted with the permission of both the author, Blaine C. McKusick, and Science magazine and is included as a summary of the volume by the same title.

Reprint Series
20 February 1981, Volume 211, pp. 777–780

SCIENCE

Prudent Practices for Handling Hazardous Chemicals in Laboratories

Blaine C. McKusick

A National Research Council (NRC) committee chaired by Herbert O. House recently issued a report with the above title (*1, 2*). The committee was formed in response to chemists' concerns about long-term toxicities of many chemicals used in research laboratories. The goal of the committee was to develop authoritative guidelines for the handling and disposal of chemicals in laboratories. It was thought that the guidelines would be useful to laboratory supervisors and would help agencies to develop appropriate policies for health hazards in laboratories as distinct from pilot plant and manufacturing operations.

Summary. A National Research Council report has recommended practices for safe handling and disposal of hazardous chemicals in laboratories. They are a practical alternative to detailed regulations on individual chemicals.

Philip Handler, president of the National Academy of Sciences, in a letter transmitting the report to Eula Bingham of the Occupational Safety and Health Administration (OSHA) and other federal officials, said of it:

> The report provides safety guidelines for handling chemicals in laboratories—particularly in research laboratories whether they be in academia, government, or industry—where numerous chemicals are stored in small quantities, many of them used only infrequently; where a given chemical is rarely handled for an extended period; and where perhaps the greatest risks arise from working with substances of less-than-well-known toxicity and from acute accidents. A balanced approach is presented to the full range of hazards associated with chemicals in a laboratory setting—risks from fire, explosion, acute toxicity, and chronic toxicity including carcinogenicity. While no set of procedures is likely to make a research laboratory entirely risk-free, the report's thesis is that, with adequate physical facilities, including properly operating ventilation; handling all new substances as though they were toxic until actual toxicological data are available; using appropriate protective clothing and gloves when necessary; and an institutional commitment to a vigorous safety program, the laboratory can be a safe workplace. Experience, especially in industry, has shown this.

This article is mostly drawn from the NRC report and states its main conclusions and recommendations.

The hazards of chemicals in laboratories are quite different from those in pilot plants or manufacturing plants. In the laboratory one generally works with milligrams or grams of material, in plants with pounds or tons. In laboratories one tends to work with a wide variety of chemicals, many new or little studied; in plants one tends to work with a relatively small number of chemicals for weeks, months, or years, and their properties are better known than those of most laboratory chemicals. Regulations that require extensive monitoring of exposure levels, medical surveillance, voluminous record-keeping, and specific work practices for individual chemicals may make good sense in a large-scale plant operation that involves the same people for years. To apply the same regulations to a laboratory that uses regulated chemicals only intermittently and on a small scale, as well as many chemicals of unknown but sometimes highly hazardous properties, will restrict research without much increase in safety. A more effective way to achieve a high level of safety in the laboratory is to develop and follow good general guidelines for handling all chemicals. Such guidelines should apply to all chemical research laboratories, for they are similar in character whether in universities, government, or industry. They should apply equally well to research laboratories in other sciences, such as biology and physics, where chemicals may be used more sparingly, but where the awareness of chemical hazards tends to be lower. They should likewise apply to analytical and teaching laboratories that use chemicals. Such are the guidelines described in the NRC report.

Laboratories contain a great variety of hazards, and indeed, much of the training of a scientist is learning how to carry out laboratory operations safely. The hazards can be grouped as physical or chemical.

Physical Hazards

The physical hazards—fire, explosion, electric shock, cuts—have been overshadowed in recent years by the toxic hazards of chemicals. However, safety can be improved with respect to these more familiar hazards, which still claim too many victims. Electrical heating has largely banished the Bunsen burner and its kin from the laboratory, thus lessening the chance of fire and explosion. However, more can be done to remove sources of fire and sparks. For example, the quantity of flammable liquids stored in the laboratory should be limited, and motors should be of the nonsparking induction type.

With regard to explosions, there is general awareness that certain classes of compounds, such as acetylides, azides, ozonides, and peroxides, are explosive.

The author is assistant director of Haskell Laboratory for Toxicology and Industrial Medicine, E. I. du Pont de Nemours and Co., Wilmington, Delaware 19898. He helped prepare the National Research Council report on which this article is based.

0036-8075/81/0220-0777$01.00/0

Yet there is insufficient awareness that ethers and alkenes can form explosive peroxides on long exposure to air.

The extensive introduction of electrical heating and instrumentation into the laboratory, while decreasing fire hazard and increasing productivity, has increased the potential for shock. Three-prong grounded equipment is much safer than the old-style two-prong type, and two-prong receptacles should be replaced. With ground-glass joints becoming common, the incidence of cuts from unskillful shoving of glass tubing into stoppers is declining. Cuts from glassware are still common, however, and many are preventable by greater care and the use of leather gloves.

Chemical Hazards

By chemical hazards we mean the toxic effects associated with chemicals. All substances, natural or synthetic, have toxic effects at some dose level by some kind of exposure. It is well known that ingesting a small amount of potassium cyanide (about 200 milligrams) can kill a human; it is less well known that 250 grams of table salt is also lethal. Because all chemicals are potentially harmful and few have been thoroughly studied toxicologically, a good strategy for controlling chemical hazards is to minimize exposure to all chemicals. In practice this means having a good, properly installed hood; checking its performance periodically; using it properly; carrying out most operations in the hood; protecting the eyes; and, since many chemicals can penetrate the skin, avoiding skin contact by good techniques and appropriate use of gloves and other protective clothing. If these simple rules are followed conscientiously, one is unlikely to get into serious trouble with laboratory chemicals.

Toxic effects are classified as acute or chronic. Acute effects are observed soon after exposure and include burns, inflammation, allergic responses, damage to the eyes, lungs, or nervous system (for example, dizziness), and, as in the above example of potassium cyanide, death. The effect and its cause are usually obvious, and so are the methods to prevent it. In the past, acute effects received more attention than chronic effects. Although the latter now have the spotlight, acute effects must not be neglected. Not only are they important in themselves, but an institution's incidence of acute effects is a good indicator of its general level of safety.

Most acute effects arise from inhalation or skin contact, so they should not be a problem if one follows the admonition to "work in a hood and keep chemicals off your hands." Ingestion of a chemical rarely occurs; it is usually the result of some poor practice, such as eating in the laboratory or not washing hands before eating.

Chronic Hazards

Chronic hazards cause effects that result from long exposure or effects that appear after a long latency period. The effects may involve cumulative damage to any of numerous organs. Some chronic effects are reversible if exposure to the chemical is stopped, but others are irreversible, especially after extensive damage has occurred.

Of the chronic effects of chemicals, cancer has received the most attention lately. Only about two dozen chemicals have been definitely established as human carcinogens. However, hundreds have been found to be carcinogenic to laboratory animals at some dose level, and many that have not been tested are probably carcinogenic to some degree. Because different species can be affected quite differently by particular chemicals, there is no direct correlation between carcinogenicity in animals and carcinogenicity in man. Nevertheless, it appears that a significant number of chemicals used in laboratories have some degree of potential for carcinogenicity in man.

The question arises whether laboratory exposure to potential human carcinogens puts chemists at greater risk of cancer than members of other professions or the general public. Several epidemiologic studies of relative mortality among chemists indicate that chemists have a higher than expected risk of death from cancer. However, a recent study comparing 3,686 male Du Pont chemists with 19,262 male Du Pont nonchemists in the same salary categories found a somewhat lower cancer mortality among the chemists (*3*). The evidence from epidemiology is thus equivocal, and the NRC report recommends further research. However, whether or not chemists are at a greater risk of cancer than others, the undeniable hazard of handling a variety of chemicals is sufficient reason for laboratories to employ good practices.

Accordingly, the NRC report recommends laboratory practices that should enable one to work safely with most substances, whatever their chemical, physical, or toxicological properties, whether known or unknown. The report summarizes these practices as "Procedure B." It also recommends a more stringent "Procedure A" for substances of known high chronic toxicity if amounts in excess of a few milligrams to a few grams are to be used. Examples are the heavy-metal compounds dimethylmercury and nickel carbonyl and the potent carcinogens benzo[*a*]pyrene and hexamethylphosphoramide. OSHA has published detailed procedures that must be followed when working with 2-naphthylamine, acrylonitrile, vinyl chloride, and 15 other chemicals that the agency has classified as carcinogens. The NRC report outlines these procedures, which are more stringent than Procedure A.

Laboratory Ventilation

The key to safe handling of chemicals in the laboratory is a good, properly installed hood, and the NRC report devotes many pages to hoods and the subject of ventilation. It recommends that in a laboratory where workers spend most of their time working with chemicals, there should be a hood for each two workers, and each worker should have at least 2.5 linear feet of working space at the hood face. Hoods are more than just devices to prevent undesirable vapors from entering the general laboratory atmosphere. When closed, they place protective barriers between workers and chemical operations. Moreover, a hood is an effective containment device for spills. A hood should not be used to store more than small amounts of chemicals and other materials, for large amounts block the flow of air and lower hood efficiency. Chemicals should be stored in ventilated cabinets instead.

Air velocity at the face of a hood should be about 60 to 100 feet per minute; surprisingly, velocities greater than this may degrade hood performance by creating turbulence within the hood that can cause vapors to spill out into the laboratory. Equipment should be placed as far back in a hood as practical. However, vapor concentration falls off so rapidly as a chemical is moved back from the face of a hood that merely taking care to carry out operations at least 10 centimeters behind the front edge of the hood is an effective aid to safety. Hoods should have a gauge so the user can tell at a glance if the hood is operating properly. Periodic inspections should be made to check on such things as the air velocity at several points along the face of the hood, whether the hood is overcrowded, and the airtightness of the ducts and exhaust system.

Hoods are just one aspect of the total

ventilation system of a building with laboratories in it. The laboratories will probably contain glove boxes, ventilated storage areas, and other air outlets. Air of proper temperature, humidity, and purity for the occupants will be coming into each laboratory, as will air for the hoods and other special facilities. Changes that affect one part of this complex system affect all. With sharply rising energy costs, there is a temptation to lower the cost of heating, cooling, and humidifying air by cutting down the airflow to laboratory buildings. Such changes should be carefully examined before being executed, as they may lower the airflow through hoods so much that the hoods no longer provide adequate protection. By imparting a false sense of security to the laboratory worker, an inadequate hood can be worse than none at all.

Protective Equipment

Specialized equipment can minimize exposure to the hazards of laboratory operations. Impact-resistant safety glasses are basic equipment and should be worn at all times, for unlikely accidents are often the most hazardous ones. Safety glasses may be supplemented by face shields or goggles for particular operations, such as pouring corrosive liquids. Because skin contact with chemicals can lead to skin irritation or sensitization or, through skin absorption, to effects on internal organs, protective gloves are often needed. There is no glove material that serves all purposes; natural rubber, butyl rubber, neoprene, and polyvinyl chloride are four of the most commonly used materials, and each has its own spectrum of chemicals for which it is an effective barrier. Aprons, lab coats, and jump suits are among the kinds of apparel that may sometimes be useful or even necessary.

Laboratories should have fire extinguishers, safety showers, and water fountains to flush chemically contaminated eyes. Respirators should be available for emergencies. These and other kinds of emergency equipment, such as first-aid materials and blankets for covering injured persons, are generally best kept in a central location. Emergency equipment must be inspected periodically.

Procurement and Storage of Chemicals

Safe handling of hazardous chemicals begins with the person who needs and orders them. Before ordering them he must be sure that they can be stored, handled, and disposed of safely.

The chemicals will generally arrive at a receiving room, from which they will be sent to storerooms. The receiving and storeroom personnel must be trained in handling containers of hazardous chemicals and dealing with chemicals in case of spills.

Too often in the design of laboratory buildings, insufficient storage space is provided. This may result in overcrowding and in storing incompatible chemicals together. The storage rooms should be cool and well ventilated. Bulk quantities of flammable liquids should be kept and dispensed in a separate room, preferably in a fire-resistant building away from the main building. Cylinders of compressed gases should also be in a separate area and should be grouped by type (for example, flammable, highly toxic, corrosive). Highly toxic substances should be segregated in a cool, dry area away from direct sunlight. Stockkeeping should be on a first-in, first-out system. Stored chemicals should be inspected at least annually, and any that have deteriorated, lost their identification, or begun to leak should be discarded.

In the laboratory, storage of large amounts of highly toxic, reactive, or flammable chemicals is to be avoided. Hazardous materials are best stored in ventilated cabinets connected to a hood. Bottled chemicals, especially liquids, should be in trays that will contain the material if bottles break. Flammable liquids should not be stored in refrigerators that are not of an approved, explosion-proof type.

Chemicals in the laboratory should be inventoried periodically, and in the interest of safety, unneeded items should go back to the storeroom or be discarded.

Disposal of Chemicals

The Resources Conservation and Recovery Act (RCRA) and local laws increasingly regulate the disposal of chemical wastes, and familiarity with these laws is the first step in developing a disposal plan.

Used or unwanted chemicals must be disposed of in ways that do not harm people and have minimal impact on the environment. Many chemical wastes can be handled satisfactorily by sewage treatment systems. Such wastes can be safely flushed down the sink to the sewer system, but the limitations of this method must be recognized. Only water-soluble substances should be disposed of in this manner. Flammable materials and strong acids and bases should be well diluted. Volatile chemicals that are highly toxic or bad-smelling should not be put down the drain, as they may emerge from an interconnected drain and affect people elsewhere in the building. Local regulations often set further limits on this method.

Other liquid wastes must be collected in labeled bottles or cans to be disposed of on the site or by a contractor. Usually the liquids should be segregated into several classes, such as hydrocarbons and water-soluble compounds. Segregation of halogenated compounds is desirable if they are used in large volume, for on incineration they yield hydrogen halides that may require scrubbing. Because the cost of acceptable waste disposal is rising dramatically, recovery of laboratory chemicals that were formerly discarded is becoming economically attractive. Examples are mercury and common solvents like toluene and acetone.

Solid wastes must be collected in a systematic way. Bottles of solid chemicals must be labeled and placed in metal drums or buckets.

Before disposal, the most hazardous substances, such as strong carcinogens, peroxides, and vesicants, should be chemically transformed to less hazardous materials when feasible. For example, dimethyl sulfate, a carcinogen in animal tests, is readily hydrolyzed by alkali to methanol and sulfate.

The final disposal of wastes is one of the most difficult problems of a research institution. Incineration is the most environmentally acceptable way to handle most organic chemicals as well as products of biological research contaminated with chemicals, such as animal carcasses, feed, and excrement. A high-temperature incinerator will convert these materials to elemental oxides that generally present little problem. Secondary equipment such as electrostatic precipitators or an afterburner may be attached, so modern incinerators are complicated, expensive devices that require trained operators and mechanics. Nevertheless, a large institution will often find it best to have its own incinerator to ensure that wastes are properly disposed of. This also avoids the need for surveillance of contract haulers and disposers and much of the extensive labeling and record-keeping required under Department of Transportation regulations and the cradle-to-grave provisions of the RCRA.

Solid chemical wastes not suitable for incineration must be buried in a landfill approved by the Environmental Protection Agency. Finding an approved landfill at a convenient distance is often difficult. Moreover, the problem is worsening because communities do not want landfills for hazardous waste disposal nearby and will fight to keep them away. On top of that, there is a shortage of reliable contractors to haul waste away and put it in landfills. As a result there is a rising interest in incinerating all hazardous wastes that are combustible and minimizing the amount of those that are not.

Safety Program

An effective laboratory safety program must have strong support from the head of the laboratory and must be based on the participation of all members of the laboratory. The goal is that all those directing or carrying out operations with chemicals be safety-minded so that possible hazards are foreseen and guarded against before experiments start. A safety coordinator who can advise on safe practices and inspect the laboratory for compliance with its rules is essential to a good safety program. However, he cannot relieve the head of the laboratory of the responsibility for the safety of that laboratory, nor the managers or professors for the safety of the operations under their jurisdiction, nor the individual employees or students for the safety of their own operations.

Many of the best safety programs are in industry. The following features are common in such programs: monthly meetings of the head of the laboratory with the laboratory managers to review safety performance and plan improvement; monthly meetings of all members of each research group to act similarly within their area; monthly inspection of each area by some of the employees working in that area; quarterly inspections of the whole laboratory by a committee of employees; a handbook of rules and practices for handling chemicals; and easy access to books and data sheets giving the chemical, physical, and physiological properties of laboratory chemicals so that they can be known before experiments are started (*4*). The importance of commitment to safety at the top of the laboratory organization can hardly be exaggerated; a laboratory's safety record is directly related to its management's commitment. For the laboratory management to be effective, of course, they must have strong support for the safety program from the administration of the organization of which the laboratory is a part.

In principle, any laboratory, whether in industry, academia, or government, can emulate the laboratories with the best safety records. Those who manage laboratories or work in them will find good guidance for safety policies and practices in the NRC report (*1*).

Conclusion

No facilities or procedures can make chemical operations totally free of hazards. However, the laboratory can be a safe place to work if there is institutional determination to have a strong safety program; active participation in it by the whole staff; good ventilation, including an ample supply of well-designed hoods; appropriate protective clothing; storage, handling, and disposal of all chemicals in ways that recognize that every chemical can be toxic under some circumstances; and acceptance of the main principles of the NRC report. The facilities and operations in a laboratory must be monitored regularly, with particular attention to the ventilation facilities. However, for most laboratory environments, the regular analysis of air for many chemicals is unnecessary and impractical.

References and Notes

1. Committee on Hazardous Substances in the Laboratory, National Research Council Assembly of Mathematical and Physical Sciences, *Prudent Practices for Handling Hazardous Chemicals in Laboratories*, xiv + 291 pp., $12 (National Academy Press, 2101 Constitution Avenue, NW. Washington, D.C., 1981).
2. The committee included Herbert O. House, Georgia Institute of Technology, chairman; Robert A. Alberty, Massachusetts Institute of Technology; Jerome A. Berson, Yale University; Robert W. Day, University of Washington; Thomas S. Ely, Eastman Kodak Co.; Ronald W. Estabrook, University of Texas Health Science Center; Anna J. Harrison, Mount Holyoke College; Donald M. Jerina, National Institute of Arthritis, Metabolism, and Digestive Diseases; Marvin Kuschner, State University of New York Health Science Center; Elizabeth C. Miller, University of Wisconsin-Madison; Robert A. Neal, Vanderbilt University; J. E. Rall, National Institute of Arthritis, Metabolism, and Digestive Diseases; George Roush, Jr., Monsanto Co.; Alfred W. Shaw, Shell Development Co.; and Howard E. Simmons, E. I. du Pont de Nemours and Co. William Spindel, National Research Council, was the study director.
3. S. Hoar, thesis, Harvard School of Public Health, Boston (1980); *J. Occup. Med.*, submitted.
4. The NRC report includes a compilation of the chemical, physical, and physiological properties of 33 common laboratory chemicals known to constitute a hazard under some conditions. This kind of data sheet, if available for about a thousand chemicals and kept up to date, would be a big aid to safety in the laboratory.

APPENDIX F

CHEMICAL/SCIENTIFIC SUPPLY HOUSES

The following list of Chemical/Scientific Supply Houses is provided as a reference to companies frequently used by science instructors. It is not intended to be a comprehensive directory of such companies.

J.T. BAKER CHEMICAL COMPANY
Reagents and Laboratory Products
222 Redschool Lane
Phillipsburgh, NJ 08865
(201) 958-2151

(Reagents, lab safety products, information)

Customer Service and Order Department
(201) 859-5411

DIFCO LABORATORIES
P.O. Box 1058A
Detroit, MI 48232
(313) 961-0800

(Primarily biological supplies)

FISHER SCIENTIFIC COMPANY
711 Forbes Avenue
Pittsburg, PA 15219
(412) 562-8300

FLINN SCIENTIFIC, INC.
P.O. Box 231
910 West Wilson Street
Batavia, IL 60510
(312) 879-6900

(Reagents, lab safety information, delayed shipping service for the more hazardous chemicals)

HELLIGE
877 T-Stewart Avenue
Garden City, NY 11530

(Reagents, scientific instruments, testing outfits)

LA MOTTE CHEMICAL PRODUCTS COMPANY
Educational Products Division
Chestertown, MD 21620
(301) 778-3100

(Environmental measurement test kits, instruments, no reagents)

MALLINCKRODT, INC.
Science Products Division
P.O. box 5840
St. Louis, MO 63134
(314) 895-2000

(Reagents, plasticware, lab safety products, information)

MCB REAGENTS
MCB Manufacturing Chemists, Inc.
An Associate of E. Merk,
Dormstradt, Germany
An EM Industries Company
480 Democrat Road
Gibbstown, NJ 08027
(201) 561-4000

(Reagents, lab safety products, information)

MERRELL SCIENTIFIC DIVISION
Education Modules Inc.
1665 Buffalo Road
Rochester, NY 14624
(716) 426-1540

SARGENT-WELCH SCIENTIFIC COMPANY
Industrial Collegiate Division
7300 North Linder Avenue
P.O. Box 1026
Skokie, IL 60077
(312) 677-0600

SILVER BURDETT COMPANY
25 James Street
Morristown, NJ 07960
(201) 538-0400

(Reagents, textbooks, films, etc.)

G. FREDERICK SMITH CHEMICAL COMPANY
Columbus, OH 43223
(614) 224-5343

(Reagents, specialty apparatus)

TAYLOR CHEMICALS, INC.
7300 York Road
Baltimore, MD 21204
(301) 823-1573

(Reagents)

ARTHUR H. THOMAS, COMPANY
Vine Street at 3rd
Philadephia, PA 19106
(215) 574-4500

(Publishes a comprehensive handbook of laboratory safety equipment, safety tips)

Reagent supply houses must develop chemical management and safety information designed to enable the purchaser to more safely manage their products.

The J.T. Baker Chemical Company, for example, supplies detailed coded product labels to those who work with its chemicals. The Baker label contains the following information:

A) Numerical Hazard Code and Hazard Symbol

B) Laboratory Protective Equipment Recommendations

BAKER SAF-T-DATA™ Guide

An easy-to-understand hazard classification appears on J. T. Baker labels. It will help increase your awareness of vital occupational health and safety practices. Using the BAKER SAF-T-DATA™ System as a guide you can quickly learn the hazards each substance presents to your health and safety, personal laboratory protective equipment that should be used for handling, and the recommended storage of compatible products by color code.

A NUMERICAL HAZARD CODE

Substances are rated on a scale of 0 (non-hazardous) to 4 (extremely hazardous) in each of four hazard categories:

- **Health hazard** - the danger or toxic effect a substance presents if inhaled, ingested, or absorbed.
- **Flammable hazard** - the tendency of the substance to burn.
- **Reactivity hazard** - the potential of a substance to explode or react violently with air, water or other substances.
- **Contact hazard** - the danger a substance presents when exposed to skin, eyes, and mucous membranes.

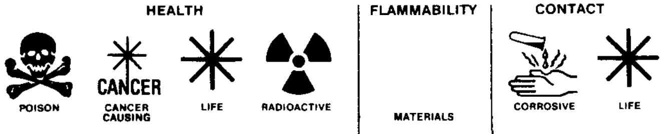
Rating Scale

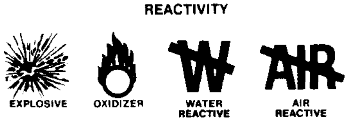
4	3	2	1	0
Extreme	Severe	Moderate	Slight	None*

*No scientific data in the standard references that suggests the substance is hazardous

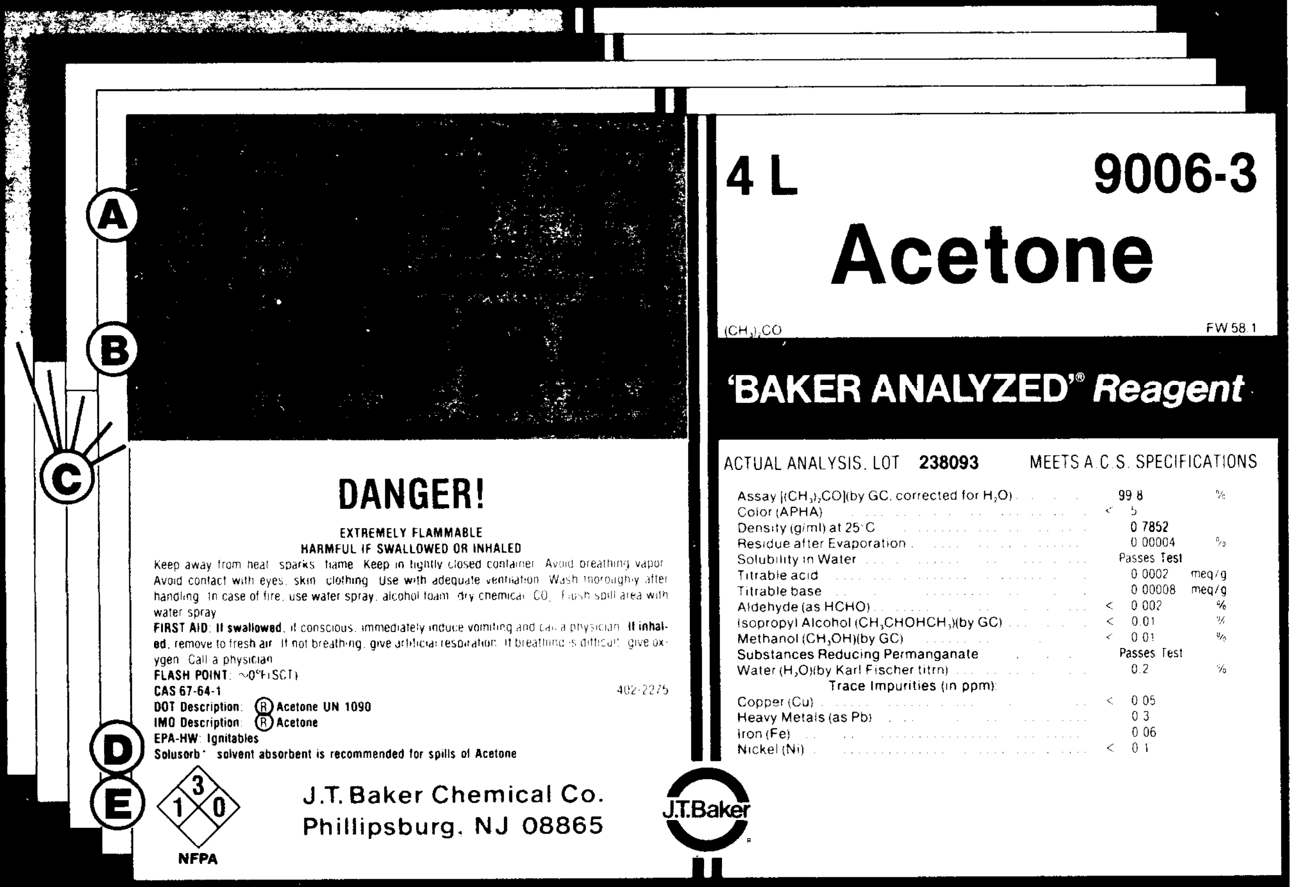
HAZARD SYMBOL

A substance rated 3 or 4 in any hazard category will also display a hazard symbol. These easy-to-understand pictograms emphasize the serious hazards related to a substance:





? *A question mark indicates there is insufficient published scientific data in the standard references to assign a numerical rating in a particular hazard category. A 4 (extreme hazard) rating should be assumed.



4 L 9006-3

Acetone

$(CH_3)_2CO$ FW 58.1

'BAKER ANALYZED'® *Reagent*

ACTUAL ANALYSIS, LOT **238093** MEETS A.C.S. SPECIFICATIONS

Assay [$(CH_3)_2CO$](by GC, corrected for H_2O)		99.8	%
Color (APHA)	<	5	
Density (g/ml) at 25°C		0.7852	
Residue after Evaporation		0.00004	%
Solubility in Water		Passes Test	
Titrable acid		0.0002	meq/g
Titrable base		0.00008	meq/g
Aldehyde (as HCHO)	<	0.002	%
Isopropyl Alcohol ($CH_3CHOHCH_3$)(by GC)	<	0.01	%
Methanol (CH_3OH)(by GC)	<	0.01	%
Substances Reducing Permanganate		Passes Test	
Water (H_2O)(by Karl Fischer titrn)		0.2	%
Trace Impurities (in ppm):			
Copper (Cu)	<	0.05	
Heavy Metals (as Pb)		0.3	
Iron (Fe)		0.06	
Nickel (Ni)	<	0.1	

DANGER!

EXTREMELY FLAMMABLE
HARMFUL IF SWALLOWED OR INHALED

Keep away from heat, sparks, flame. Keep in tightly closed container. Avoid breathing vapor. Avoid contact with eyes, skin, clothing. Use with adequate ventilation. Wash thoroughly after handling. In case of fire, use water spray, alcohol foam, dry chemical, CO_2. Flush spill area with water spray.

FIRST AID: If swallowed, if conscious, immediately induce vomiting and call a physician. **If inhaled**, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

FLASH POINT: ~0°F (SCT)

CAS 67-64-1 402-2275

DOT Description: Ⓡ **Acetone UN 1090**

IMO Description: Ⓡ **Acetone**

EPA-HW: Ignitables

Solusorb® solvent absorbent is recommended for spills of Acetone

3 1 0
NFPA

J.T. Baker Chemical Co.
Phillipsburg, NJ 08865

B LABORATORY PROTECTIVE EQUIPMENT

This series of pictograms suggests the personal protective clothing and equipment recommended for use when handling the substance in a laboratory situation. The pictograms relate to the combination of hazards presented by the substance.

The stop sign indicates the substance represents a special extreme hazard and the MSDS and other references should be consulted before handling

C STORAGE COLOR CODING

The SAF-T-DATA label suggests a unique method for setting up your chemical storage area. Compatible products are labelled with the same color. Simply group these colors together and follow the recommendations for appropriate storage:

■ **BLUE** - health hazard. Store in a secure poison area

■ **RED** - flammable hazard. Store in a flammable liquid storage area.

☐ **YELLOW** - reactivity hazard. Store separately and away from flammable or combustible materials.

☐ **WHITE** - contact hazard. Store in a corrosion-proof area.

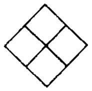
▨ **ORANGE** - substances with no rating higher than 2 in any hazard category. Store in a general chemical storage area.

STRIPED LABELS - incompatible materials of the same color class have striped labels. These approximately 40 products should not be stored adjacent to substances with the same colored labels. Proper storage must be individually assessed.

D SPILL CONTROL CODE

This statement indicates which J.T. Baker spill control kit is recommended for use with the substance.

E NFPA SYSTEM*



This system was adopted by the NFPA in 1975 to safeguard the lives of firefighters. It is based on the hazards created by a substance in a fire situation. For this reason, the hazard ratings in the Baker SAF-T-DATA™ System, which are based on substances in a laboratory situation, will not always correspond with the NFPA ratings

*National Fire Protection Association

J.T. Baker ( ]emical Company)

Printed in USA ‿/82

C) Storage Color Coding to Enable the Grouping of Compatible Products

D) Spill Control Guide

E) National Fire Protection Association (NFPA) System Rating.

Refer to the Baker Saf-T-Data Guide on the following page for further details about that company's lab safety and management system.

APPENDIX G

The following is a laboratory safety handbook which the chemical reagents supply house, MCB Manufacturing Chemists, Inc. includes in its buying guide to assist laboratory personnel in the safe management of chemicals. Other reagent manufacturers have similarly responded to the increased demand for information regarding safety practices.

Reprinted with permission by MCB, it is included in this guide as a brief review which highlights many of the major areas of concern for those who are directly involved with the use of laboratory chemicals.

Laboratory Safety

MCB is committed to safety in the laboratory. With the introduction of MCB's safety handbook to the updated Laboratory Safety Section in this buying guide, we have attempted to assist laboratory personnel in the handling, storage, and disposal of hazardous chemicals.

In addition, MCB offers many exceptional products which make the laboratory a safer place to work —

- New Plastic Coated gallon bottles — spill and splash protection in the event of breakage. (white section ∗)
- MCB's Spills Bucket — especially formulated for adsorption of acid and alkali spills (white and dark blue section ∗)
- EM Ether Peroxide Quants® — detects 5 different explosive peroxides with a simple dip and read strip. (dark blue section ∗)
- Saftepak® — The purity of glass with the safety of metal; a glass bottle enclosed in a metal can to guard against breakage and spillage in extreme handling conditions. (white section ∗)

Laboratories interested in safety should always refer to the MCB Buying Guide as a source for products and information for safety.

∗ Refer to the colored section listed to locate and order these products.

Laboratory Safety — Part Six Contains:

Classification of 21 Hazardous or Potentially Hazardous Chemical Groups.

Spill containment; cleanup; and exposure procedures.

Spill And Exposure* Classification of 21 Hazardous or Potentially Hazardous Chemical Groups

*"*Registry of Toxic Effects of Chemical Substances*" NIOSH 1976

Waste Disposal

Throughout this section reference is made to "packaging spilled material for future disposal." MCB can not give specifics on the disposal of any particular chemical since the regulations governing waste disposal vary by geographic location.

We recommend that you contact an EPA approved waste facility for all disposals.

Acid Chloride Spills

As a group, acid chlorides are highly reactive. This reactivity adds to their usefulness but it also demands that laboratory spills be given proper attention. However, the attention required need not hamper the use of these chemicals as laboratory reagents.

Three factors should be remembered when considering methods to clean up acid chloride spills:

(1) Reactivity with water.

(2) Corrosiveness of the chemical and its decomposition products.

(3) Irritability of the chemical and its decomposition products.

Problems associated with these factors can be easily solved with common sense and general laboratory safety.

Don't Use Water! — Water must not be used on most acid chloride spills unless the water can be delivered in deluge quantities. Most acid chlorides react vigorously with water, producing corrosive decomposition products. In addition, the exothermic reaction will cause increased vaporization of the reagent, which may have a pungent irritating odor even under the best of conditions. Reagent spills should first be absorbed with sand, sodium bicarbonate, or a mixture of both. The damp mixture can then be scraped up with a plastic, ceramic or metal scoop. Successful use of this technique requires that sand and bicarbonate be kept available in handy containers throughout the laboratory. Keep the materials dry.

If the quantity of used sand is not too large it can be disposed of by dropping small amounts into a large bucket of water. After thorough washing, the sand may be added to other lab waste for disposal. Waste acid chlorides can be disposed of by reaction with water and neutralization.

As in the handling of most reagent accidents, safety glasses and rubber gloves are needed for safe cleaning-up of acid chloride spills. Gloves do not permit prolonged contact but they offer adequate protection for the removal of most spills. Splashes on the skin or in the eyes should be rinsed immediately with a heavy flow of water for at least twenty minutes. Clothing splashed with acid chlorides should be removed and washed before reuse.

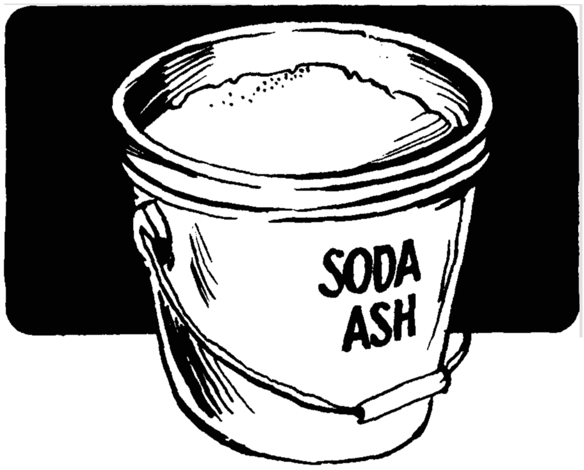
Avoid Fumes — Small spills which occur in a clear open area, such as the floor or the center of a lab bench, can be cleaned with only a brief exposure to fumes. Other spills may be larger or occur in an inconvenient spot, causing longer exposure periods. In these cases of longer exposures, nothing can take the place of a self-contained respiratory device. This equipment consists of a face mask and a cylinder of air which can be carried or strapped to the belt or to a shoulder harness. Gas-mask respirators can be used if it is known that the mask canister is adequate for the particular acid chloride and its decomposition products.

The occurrence and effects of spills can be minimized by observing a few general precautions. Limit the size of reagent bottles in the lab — keep larger quantities in a separate area. Do not fill bottles to capacity — leave adequate head space. It may be difficult to store reagent bottles in a cool spot, but at least do not store them in a warm spot. Keep the bottles in a tray, preferably ceramic or glass lined. If possible, place distillation units in fume hoods, in trays. Keep a supply of sand and sodium bicarbonate nearby. Finally, do not use water to fight a fire involving acid chlorides — use a dry chemical or CO_2 extinguisher. Water can be used for small amounts if the water is delivered in deluge quantities.

Alkali Metals and Alkoxides

Handling Hazards — The most hazardous properties of the alkali metals are their flammability and violent reactions with water. A release of hydrogen accompanies the water reaction. If the reaction temperature is high enough, the hydrogen will ignite. Sodium, potassium, and rubidium react violently in this manner. Lithium reacts slowly with water at room temperature but at higher temperatures the reaction occurs explosively. Under certain conditions, some of the metals may ignite spontaneously upon exposure to air. In order to prevent ignition, the metals are stored under a layer of kerosene or similar hydrocarbon. The covering liquid must be free of moisture and halogenated hydrocarbons. In industry, large amounts of the metals may be stored under an inert gas.

The reactivity of alkali metals limits the type of fire extinguishers which can be used on burning metal. Violent reactions occur if the hot metals come in contact with water, alcohol foam, carbon dioxide, and carbon tetrachloride or other halogenated hydrocarbons. Dry soda ash (anhydrous sodium carbonate, Na_2CO_3) is the recommended extinguishing agent for sodium and potassium. Powdered lithium chloride and sodium chloride are recommended for lithium fires. Powdered graphite is effective on all alkali metals.



Approved extinguishing powders are available for use on sodium, potassium, and NaK mixtures. One powder consists of graphite with an organic phosphate additive. Another effective powder is a mixture of calcium chloride and a powdered nonburnable plastic, plus additives to improve flowing. When heated, the plastic-salt mixture forms on air-tight covering.

Melting points of the alkali metals range from 28.5°C for cesium to 186°C for lithium; contact of the molten metal with the skin or eyes can cause severe damage. At room temperature, momentary contact of the dry metal with dry skin causes no damage. However, skin moisture may be sufficient to cause a reaction, releasing hydrogen which can ignite and cause thermal burns. If the alkali metals are splattered or spilled on the skin, the particles should be removed quickly and the affected areas washed thoroughly with water. If the metal ignites before it can be removed, or if molten metal contacts the skin, removal of the metal prior to washing may require too much time. Under these circumstances, immediate washing with water is recommended despite the metal-water reactions. If the water is delivered in deluge amounts, there will be a mechanical removal of the metal. A sufficient flow will provide heat transfer and prevent the build up of hydrogen around the metal particles.

One alternate treatment has been suggested for use with Na or K spills. Experimental work with a number of materials showed that a mixture of 1-2.5% stearic acid in mineral oil would effectively coat the metal to prevent ignition. The mixture is used for both skin and eye contacts. Removal of the metal is followed by a thorough water rinse.

Alkali metals splattered or spilled in the lab can be covered with a layer of soda ash and then scraped up for immediate disposal. Small amounts of waste metal can be disposed of by dropping it into a container of alcohol. Ethyl or methyl alcohol is usually used but the reaction heat may cause ignition of the solution. The reaction is more orderly with butyl alcohol. Heading is needed to force a reaction with tertiary alcohols. After the reaction has ceased, the alcohol can be mixed with water for disposal.

Alkoxides are flammable and are usually used in a manner which increases the fire hazard. Alcoholic alkoxide solutions are often added to another flammable organic and then heated or refluxed. Reactions capable of generating flammable vapors should be carried out in a well ventilated area or fume hood. A fire-resistant tray under the reaction apparatus will minimize the spread of liquid in the event of equipment failure.

Alkali metal alkoxides react with moisture to form alcohol and hydroxide. Tightly closed containers will minimize the decomposition but some alkoxides will darken in a closed bottle. A buildup of alcohol vapor in the container is possible.

Antimony
See Heavy Metals

Aromatic Amines

Toxicity — Many of the more important aromatic amines have hazardous properties similar to those of aniline. Generally, the toxicity of these compounds is a far more serious hazard than their flammability.

Aromatic amines are one of the few chemical groups which can cause rapid systemic poisoning by being absorbed through the skin. Absorption of aniline, m-nitroaniline, benzidine and other amines can occur when the chemicals are present in the pure state or in mixtures. Toxic amounts of solid amines may be absorbed as readily as the liquid amines. Trace amounts present on clothing, shoes, and gloves may also be absorbed. Absorption occurs readily through healthy intact skin — open cuts are not a requisite for the absorption of toxic amounts of these chemicals.

Aniline and other aromatic amines react in the blood to convert hemoglobin to methemoglobin. Iron in the hemoglobin molecule is present in the ferrous state. It is present as ferric iron in methemoglobin. The conversion from ferrous iron to the ferric derivative reduces the oxygen-carrying capacity of blood and the body tissues suffer from oxygen starvation. In severe cases of poisoning the aromatic amine may directly attack the nervous system and blood system.

In addition to absorption through the skin, aromatic amine poisoning can also occur by ingestion or inhalation. The odor of aniline can be detected at airborne concentrations of less than 1 part per million (ppm) and the suggested limit for continuous 8-hour exposure is 5 ppm. This is equivalent to 19 milligrams of aniline per cubic meter of air (mg/m^3). The suggested limit for nitroaniline is 1 ppm, which is equivalent to 5.6 mg/m^3.

The vapors of aniline and other aromatic amines are heavier than air. Forced ventilation may be needed to prevent vapor accumulation where these materials are handled.

Flammability — In general, the aromatic amines will burn but they are not considered a fire hazard at normal temperatures. Use water, carbon dioxide, or dry chemical to extinguish fires involving aromatic amines. Fire may cause rapid vaporization of the amine and respiratory equipment may be needed.

Aniline has been given an Underwriters' Laboratory rating of 20-25 in the classification of flammable liquids. This indicates a low-order fire hazard, slightly above the paraffin oil class which has a rating of 10-20. Despite the relatively low order of flammability, large storage tanks of aniline and other amines should be grounded to eliminate static electricity. Electrical wiring and electrical equipment used in connection with storage areas should be explosion proof.

Spills — Prompt action is needed to prevent poisoning if aromatic amines are spilled on the skin or clothing. Remove the wet clothing and wash the skin thoroughly. Most of the amines are only slightly soluble in water and prolonged washing is required. Use a deluge stream of water. Use soap if it is available. After removal, contaminated clothing should be dried and then washed before reuse. Persons splashed with more than just minor amounts of an amine should receive prompt medical attention.

The use of solvent-proof gloves and aprons can reduce the chances of skin contact. Use the proper eye protection. Treat eye splashes with a prompt, twenty-minute water wash. Get medical attention.

Small laboratory spills can be removed with absorbent paper which can be placed in a covered container for later disposal.

Large spills which cannot be flushed away with water can be absorbed with sand, soil or a similar material. Transfer the wet material to covered containers. Many of the aromatic amines are biodegradable and the wet absorbent can be buried unless prohibited by local regulations.

Most cases of industrial poisoning have resulted from accidental spills. Failure to remove the wet clothing and wash the affected parts of the body has had fatal results. Poisoning by aromatic amines can occur with small amounts of the chemical. Small amounts of aniline left in an "empty" drum caused a case of near-fatal poisoning when the liquid splashed on a worker who was not familiar with the toxic nature of this amine. Workers have been poisoned by handling commercial cleaning fluids which contained a corrosion-inhibiting aromatic amine. Infants have been poisoned by diaper laundry marks, which were applied with an aniline-containing ink. A small amount of the chemical splashed on the shoes or clothing should not be disregarded. Moisture on the skin and the covering effect of the shoes or clothing provide conditions for very efficient absorption.

Aromatic Halogenated Amines and Nitro Compounds

Toxicity — In general, the addition of halogens to aniline or nitro compounds does significantly change the toxicity. The toxicity of chloroanilines and chloronitrobenzenes is considerably greater than that of aniline and nitrobenzene. This is similar to the addition of halogens to straight-chain compounds, which causes a significant increase in toxic properties.

Chlorodinitrobenzene is a solid, and in practice, is less toxic than liquid nitrobenzene or dinitrobenzene, but it is a more severe skin irritant and sensitizer. Its effects vary because of individual susceptibility but most people will show some reaction, ranging from mild itching to dermatitis. After sensitization, which can occur from repeated small contacts, skin reactions can result from contact with only minute amounts of the dust.

Most of the halogen derivatives can be absorbed into the blood through inhalation or by skin penetration. Continued absorption over an extended time could result in permanent damage to the liver and kidneys. Absorption through the skin can occur with both solid and liquid chemicals.

The most common toxic effect of exposure to these halogenated compounds is the production of methemoglobin in the blood. This is also the primary toxic effect of aniline and nitrobenzene. Formation of methemoglobin reduces the oxygen-exchange capacity of the blood. A decrease in red oxyhemoglobin causes the blood to appear like dark venous blood. The lips and tongue appear blue or purple, a condition known as cyanosis.

In cases of slight or moderate poisoning, the early stages of methemoglobinemia and cyanosis usually develop without the individual being aware of his condition. Later, headache and dizziness may develop. These disorders are easily reversible if the absorption is completely halted — most cases of methemoglobinemia are corrected within 48 hours. Treatment usually consists of bedrest and possible administering of oxygen.

Flammability — The halogenated derivatives of aniline and nitrobenzene are similar to the parent compounds in flammable properties. The chemicals will burn but they are not considered fire hazards under normal handling conditions. When heated, however, some liquid and solid chemicals in this group will give off vapors which form explosive mixtures with air. Dry chemical or carbon dioxide extinguishers may be used on fires involving these halogenated aromatics. Water spray may be more effective than a direct stream. Respiratory protection may be needed because of the increased vaporization of the burning or heated chemicals.

Spills — The most important aspect of spill clean-up is the prompt removal of material splashed on the skin. Many of the toxic halogenated aromatic amines and nitro compounds can be absorbed rapidly through the skin. In most cases, large spills are needed to bring about toxic effects. However, individual susceptibility varies widely, and some persons may be made ill after light contact with these chemicals. Some chemicals, such as chlorodinitrobenzene, must be washed off rapidly to avoid sensitization. Contaminated clothing should be removed immediately, allowed to dry, and laundered before re-using. Rubber gloves which are used frequently should be changed occasionally and allowed to dry — constant use may weaken the rubber and allow the penetration of some chemicals.

Chemicals splashed in the eyes should be removed by flushing with water for at least 20 minutes. Applying water with cupped hands may not be adequate. Use an eye bubbler or a gentle stream of water from a hose. The stream of water from a drinking fountain may also be used.

Spills can be removed with any available absorbent — sand, sponge, cloth, or paper. The materials should be discarded without delay, to prevent handling by persons not familiar with the toxicity hazards.

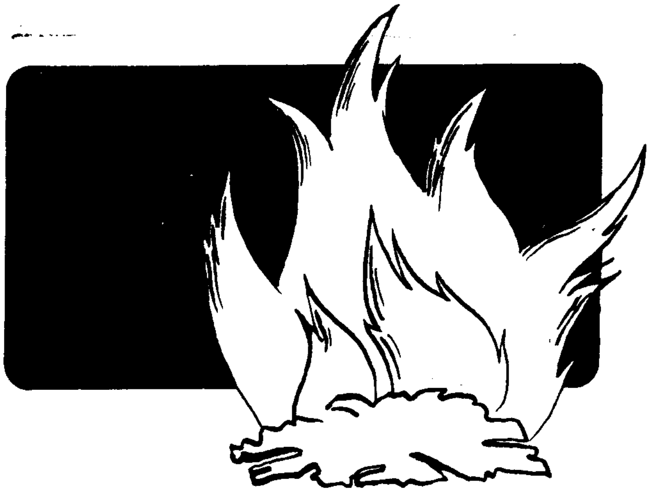
Small spills can be flushed away with water. Final traces left on floors or benches can be easily removed by scrubbing with a strong soap solution.

Aromatic Nitro Compounds

Toxicity — Aromatic nitro compounds must be handled with caution because of their high toxicity and the ease with which they are absorbed into the blood system. In the blood, most of these compounds react with hemoglobin, converting it to methemoglobin which is a less-efficient oxygen carrier. Destruction of erythrocytes may also occur.

These changes cause an oxygen deficiency, which results in a general darkening of the skin and a blue or purple color in the lips, tongue, or ears. Dizziness, nausea, vomiting, and a variety of similar symptoms occur. Severe cases of poisoning may be fatal.

Toxic amounts may be taken in by ingestion, absorption through intact skin, or inhalation of vapors. Ingestion is an efficient but not a frequent intake route. Oral doses of 1-5 grams have been reported as fatal, even when spread over a period of a few days. Skin absorption occurs rapidly with either liquid or solid compounds. Inhalation of small amounts over a period of time could cause poisoning. For an 8-hour work day, suggested vapor limits for most of the important aromatic nitro compounds range from 1 to 5 milligrams of chemical per cubic meter of air (mg/m^3). The low vapor pressure of these compounds helps to reduce the chances of excessive exposure. However, the heavier vapor density may make forced ventilation necessary in some areas.



Flammability — Most liquid aromatic nitro compounds have high auto-ignition temperatures and are not considered fire hazards at normal handling temperatures. However, open flames may easily ignite these chemicals. A burner flame directed at the edge of a layer of nitrobenzene will cause ignition within a few seconds. When the flame is removed the nitrobenzene will continue to burn.

Water, CO_2, and dry chemicals may be used for fires involving aromatic nitro compounds. CO_2 extinguishers will provide an efficient blanket to cut off oxygen but the CO_2 fog is not effective in lowering the temperature. An extinguished fire could, therefore, re-ignite.

Trinitro aromatics are unstable at elevated temperatures. Trinitrobenzene is a white solid which melts at 122°C and will explode if heated rapidly. Trinitrotoluene (TNT) is a pale yellow crystalline solid which melts at 81°C, decomposes slowly at 150°C, and will explode at 240°C. Trinitrophenol (picric acid) is a pale yellow crystalline solid which melts at 123°C and explodes at temperatures above 300°C.

Aromatic nitro compounds which are considered stable, even at elevated temperatures, may not be stable in certain mixtures. Nitrobenzene does not react when heated with either phenol or aluminum chloride. However, violent reactions have occurred when all three chemicals were heated together to 120°C. Stoichiometric amounts of nitrobenzene and nitric acid, in the absence of water, will detonate with an energy release equivalent to the release from an equal weight of nitroglycerin. Miscible mixtures of nitrobenzene and nitric acid, containing up to 10% water, are less sensitive and release less energy when detonated. The three component system is not sensitive when the water content is increased to cause an immiscible system.

Spills — Aromatic nitro compounds which are splashed on the skin must be washed off immediately. Remove contaminated clothing without delay. Most of the aromatic nitro compounds are only sparingly soluble in water and prolonged washing with soap and water is needed to remove them from the skin. Contaminated clothing must be washed thoroughly before re-use. Immediate medical attention should be obtained for persons splashed with more than minor amounts of an aromatic nitro chemical.

Material spilled on the floor or lab bench may be absorbed with sand, absorbent paper, or cloth. If local regulations permit sewer disposal, spills may be washed into drains with a generous amount of water. Flush the drains thoroughly with cold water.

Use rubber gloves to remove spilled material. Wear protective shoe covers. Remove shoes when they become wet with aromatic nitro chemicals. Allow them to dry thoroughly before re-use.

The toxicity of nitro compounds is well documented. Material spilled on the skin is the most frequent cause of poisoning. Fatalities have occurred with massive nitrobenzene spills, despite the fact that the splashed workers washed off the chemical soon after the spill occurred. Several different nitro compounds, including nitrobenzene, have caused fatal poisoning when contaminated clothing was not removed. Solid aromatic nitro compounds have also caused fatalities.

Serious poisoning from acute inhalation is infrequent. However, poisoning has resulted from repeated exposures to subacute vapor concentrations.

Arsenic
See Heavy Metals,

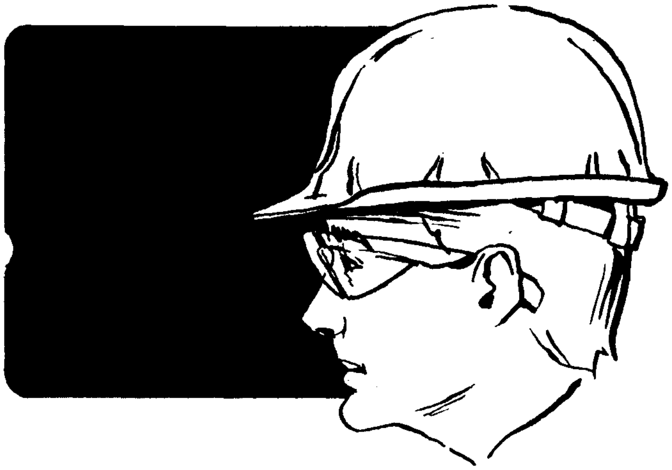
Azides

Azide compounds contain the group, -NNN. Many of these compounds, both inorganic and organic, are unstable and decompose with explosive violence. Because of this characteristic, lead azide $Pb(N_3)_2$ and several other metal azides are utilized in detonators for explosive charges. A number of the azides are useful for laboratory syntheses, chiefly in organic elimination reactions and nucleophilic substitution reactions.

In addition to the taming of nitroglyercine, by combining it with an inert material to form dynamite, Alfred Nobel also worked out a method to reliably initiate the detonation of explosives. He discovered that small amounts of certain compounds could be detonated by electrical or thermal ignition, with the production of a shock wave capable of detonating so-called high explosives. These high explosives, such as TNT, cannot be reliably detonated by direct ignition and Nobel's discovery of this technique has been described as a prelude to the development of sophisticated modern explosives.

The explosive force of lead azide arises from a rapid decomposition in which chemical energy is transferred, as heat, to the gaseous decomposition products. Pressure generated by the extremely hot, rapidly expanding gases, forms the shock wave which detonates the next component in the explosive charge.

The explosive nature of the azides requires handling precautions when the chemicals are used as laboratory reagents. Many have toxic properties which must also be considered.



Toxicity — Much of the knowledge of azide toxicity has been gained from industrial exposures and laboratory studies involving hydrazoic acid, HN_3. The pure compound is highly explosive and is seldom encountered. However, dilute aqueous solutions and HN_3 vapors from azide reactions have caused noticeable and measurable effects in industrial and laboratory workers.

HN_3 is easily absorbed into the blood stream after inhalation of the vapor or spray. The chief physiological effect is a marked lowering of the blood pressure with an accompanying rise in heart beat and in increase in the respiration rate. Eye and nose irritation, headache, weakness, and unsteadiness have also been reported following continued industrial exposures. Recovery from these effects is rapid and low level exposures which cause these symptoms do not appear to cause any permanent abnormal conditions. A study of ten men exposed to HN_3 in the production of lead azide revealed that blood pressures began to drop soon after the start of each work shift. Pressures returned to normal about two hours after exposure ceased. Headache and other symptoms also disappeared rapidly. These ten men, ranging in age from 31 to 52 years, had worked at this occupation for periods up to 16 years. Concentration of HN_3 in the area of maximum concentration was under 4 parts per million on twelve different days. Physical examinations and a number of clinical tests failed to disclose any abnormalities which could be related to HN_3 exposure.

Acid solutions of sodium azide will generate HN_3. In one exposure case, the acidification of 10 grams of NaN_3 generated enough HN_3 to affect the chemist doing the work. It is interesting to note that the fume hood in which this work was done, was not operating properly.

Hydrazoic acid is volatile and easily purged from aqueous solutions. Experimental animal exposures have shown that air bubbled through 0.6-1.2% hydrazoic acid solutions will remove enough HN_3 to be fatal to mice, rats, and guinea pigs.

The toxicity of lead azide is due to the azide group and not the metal cation. This was proven by one study in which different groups of rats received varying amounts of lead azide, lead carbonate, and sodium azide in their diets.

Animals receiving lead carbonate had a life expectancy similar to a control group maintained on a regular diet. Life expectancy was low in the lead azide group and somewhat lower in the group which received sodium azide.

Laboratory Hazards — Most organic azides and heavy metal azides are explosive and many are extremely sensitive to shock and heat. The more sensitive azides are seldom used in laboratory work other than that associated with the production of explosives. In these situations, the hazards are recognized and the necessary precautions are well known.

Azides of the alkali metals and alkali earth metals are not considered explosive under most lab conditions. These azides can be decomposed smoothly and this technique is used to obtain pure nitrogen or the metals. The greatest hazard in the use of these azides is the inadvertent production of a shock sensitive material. For this reason, each use should be well planned. Procedures, once established, should be followed — explosions have resulted when procedures were scaled up, after a long series of uneventful work with lesser amounts of azide reagents. Azides in solution may be converted to less reactive compounds by the proper chemical reactions. Spilled or waste solids should be promptly cleaned up. Small amounts may be dissolved in water for chemical destruction. No work with azides should be undertaken until consideration is given to storage, chemical reactions and possible by-products, waste storage, and waste disposal. The precautions needed will depend on the particular azide used, the conditions of use, the available laboratory and waste facilities.

Cadmium
See Heavy Metals,

Carbon Disulfide

Flammability — The flammability and toxicity of carbon disulfide are hazardous properties of major importance to both the industrial user and the laboratory worker. Its flammability has earned a rating of 110+ in the Underwriters' Laboratory classification of flammable liquids. As a comparison, ethyl ether has a rating of 100 and ethyl alcohol has a rating of 70. Vapors of the volatile liquid may travel to an ignition source and flash back to the vapor source. The ignition source could be an ordinary light bulb, a steam line, or a steam radiator. Many pieces of common lab equipment are also capable of producting these temperatures.

Static electricity must be considered as an important and common ignition source. Charges may develop on personnel or operating equipment. A tiled or concrete floor does not rule out the possibility of personnel generating a static charge. The type of clothing being worn and the humidity are more important factors than the type of floor covering.

Flowing non-polar solvents may cause a static charge. A non-polar solvent, being poured from one container into another, can generate a charge on the container from which it is being poured. A spark may jump to a nearby conductor, causing an ignition if CS_2 vapors are present. If possible, pour non-polar solvents with the spout or lip of one container touching the edge or lip of the other. If this is not possible, connect the two containers with a wire. One container should be on a grounded surface. Non-polar solvents flowing through a non-conductive pipe can also generate a charge. Properly grounded pipes have been made unsafe by the use of a non-conducting material such as rubber or plastic cement.

Laboratory equipment used in CS_2 atmospheres should be grounded. Locate variable transformers outside of hoods in which CS_2 is used.

Toxicity — High purity CS_2 has an ether-like odor. Reagent and technical grades have a foul odor caused by traces of other sulfur compounds. In some grades the odor cannot be relied upon as an index of significant levels of airborne CS_2. The recommended limit for continuous 8-hour exposure is 20 parts per million (equivalent to 60 milligrams of CS_2 per cubic meter of air).

Laboratory Spills — Because of the toxicity of CS_2, small lab spills should be allowed to evaporate instead of trying to clean up the spill. If evaporation is not feasible, the spill can be absorbed with cloth, paper, or a sponge. The used, wet absorbing item can be placed in a beaker and allowed to evaporate in a fume hood. In lab storage areas, where large quantities of CS_2 are handled, an adequate supply of an inert absorbent should be maintained. Large amounts of the used absorbent can be kept under water and then transferred to a waste facility. Water may be ineffective for fires involving CS_2. Use carbon dioxide or dry chemical extinguishers. Water is useful as a blanket for open containers or tanks. An air-pack or other supplied-air breathing apparatus is required for adequate protection during fire fighting and prolonged spill clean-up. Rubber gloves are also necessary.

Accident Causes — The precautions outlined above are not merely based on theoretical conditions which are not encountered in the actual use of CS_2. The precautions are supported by accident reports. Explosions have occurred when CS_2 was allowed to accumulate in drains which also received acid or steam. Temperature of the CS_2 was increased enough to result in an explosion. Sparks from a rod used to free caked material in a piece of equipment were sufficient to ignite CS_2 vapors. Static electricity or heat from a light bulb ignited CS_2 vapors after a spill occurred during the filling of 10-gallon drums. Static electricity from an employee's clothing has ignited CS_2 vapors. The presence of an unsuspected catalyst caused an explosion of several ounces of CS_2 when a reaction was carried out in a metal vessel instead of the glass-line vessel usually used.

Because of its toxicity and flammability, carbon disulfide has been replaced by other chemicals in many industrial and laboratory situations. However, the chemical has been used successfully through recognition of its hazardous properties and compliance with safety regulations.

Caustic Alkalies

Two of the more common caustic alkalies are sodium hydroxide (caustic soda, lye), NaOH, and potassium hydroxide (caustic potash), KOH, Ammonia gas, NH_3, concentrated ammonium hydroxide, NH_4OH, and calcium oxide (quick-lime) CaO, are also highly alkaline although not as generally corrosive as NaOH or KOH.

According to the dictionary definition, the word "caustic" may be used to describe any chemical which is corrosive or capable of destroying by chemical action. However, the term is generally used in connection with highly alkaline chemicals.

Toxicity — The major toxicity problem in the use of caustic alkalies is their corrosive action on tissue. Severe, painful tissue damage can rapidly result from acute exposures in which significant amounts of caustic alkali are inhaled, splashed on the skin, or swallowed.

It is unlikely that a person will voluntarily remain in an area containing damaging amounts of alkali dust, mist, or of ammonia gas. The materials are much too irritating. For example, the odor of ammonia is detectable at airborne concentrations of 50 parts per million, which is the recommended limit for continuous working exposures. However, accidental releases could easily produce airborne alkali concentrations which are damaging and fatal, for even brief periods of exposure. The entire respiratory tract may suffer tissue damage. Pulmonary edema may develop, resulting in collapse and death.

Contact with the skin or eyes is the most common hazard of caustic alkali handling. Unlike inhalation exposures, contact injuries occur frequently in the laboratory. Only small amounts of concentrated alkalies are needed to cause damage which may range from annoying irritation to deep flesh burns and permanent visual impairment. Mist or spray, which is too light to cause a skin break, may cause dermatitis. If the exposure is constant, a more serious skin problem may develop, requiring prolonged medical treatment.

Flammability — Sodium hydroxide and potassium hydroxide are not fire hazards. Ammonia will form explosive mixtures with air, but this situation only occurs with rapid, large releases. The explosive range of ammonia in air is 16% to 27%, by volume, and these concentrations are well above those which would cause severe irritation. Thus, there would be adequate warning of vapor build-up from small continuous gas leaks.

Fire may cause glass containers to break, allowing the mixing of alkalies and other chemicals. Subsequent reactions could generate toxic vapors, presenting an additional hazard to anyone trying to extinguish the fire. Flammable or explosive reaction products may also be formed.

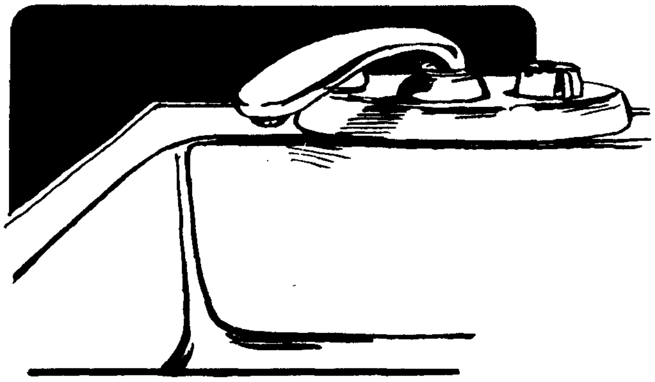
Spills — The most important aspect of any spill is the prompt removal of alkali which contacts the skin or eyes. Concentrated caustic alkalies are not easily rinsed from the skin — continuous flushing with water is needed. The same is true for material splashed in the eyes — use an eyebubbler or a gentle flow of water from a hose. Flushing for at least 20 minutes is recommended. Small splashes on the fingers, hands, or arms usually will not cause any irritation if the material is promptly washed off. These body parts can be easily held in a heavy and continuous flow of water from a sink faucet. Other parts of the body will be more difficult to flush thoroughly and medical attention should be promptly obtained. Obtain medical attention for all eye splashes.

Ingestion is unlikely in the lab but sudden direct releases or an explosive reaction may cause involuntary swallowing of material sprayed in the face. Neutralizing solutions may be taken if they are immediately available and if prior medical approval has been granted for their use. If these solutions are not available a large amount of water should be taken at once to afford dilution. Obtain medical attention immediately. Do not induce vomiting.

Laboratory spills of caustic alkalies are not difficult to remove from the floor or lab bench. Dry, solid material may be swept together and brushed onto a shovel, dust-pan, or piece of heavy cardboard.

Clean sand is useful for absorbing spilled liquid. The wet sand can be discarded with other waste chemicals. It can be washed prior to disposal by dropping small amounts into a large container of water.

Reports of caustic alkali spills and injuries are common in the medical and safety literature. The striking point about these reports is that most of the injuries were not caused by a lack or proper procedures or adequate safety equipment. Procedures were available, but disregarded — safety equipment was used, but used improperly. For example: goggles were worn loosely so that splashed alkali solutions were able to run down the face and into the eyes; safety glasses were so badly scratched that they had to be removed in dim light, just prior to a splash which reached the eyes; one injured worker could not use an eye bubbler because the water contained a large amount of rust — the bubbler should have been tested frequently; contrary to the established procedure, a technician used the same cylinder to measure alkali and acid, with water rinses between each measurement — face and eye burns were sustained from a vigorous reaction which occurred when one rinse was omitted.



Chlorohydrins

Toxicity — Chlorohydrins can cause poisoning by being swallowed, inhaled, or by absorption through the intact skin. Ethylene chlorohydrin has only a faint ether-like odor which may not be noticed until after a chronic toxic level is reached. First effects are irritation of mucous membranes, vomiting, dizziness, and headache. Severe poisoning produces delirium and collapse. Fluids may accumulate in the lung or brain and this edema could be fatal. The recommended limit for continuous 8-hour exposures is 5 parts of vapor per million parts of air (5 ppm). This is equivalent to 16 milligrams of ethylene chlorohydrin per cubic meter of air (16 Mg/m^3).

With ethylene chlorohydrin, skin irritation cannot be relied upon as a warning of skin absorption — there is not immediate irritation, and only mild discomfort may result after prolonged contact. Experiments with laboratory animals have shown that fatal amounts can be absorbed without producing any skin irritation. The fatal skin dose for man is estimated at less than 5 milliliters, if the liquid is held in contact with the skin.

The chronic toxicity of epichlorohydrin vapor is similar to that of ethylene chlorohydrin. The recommended atmospheric limit for continuous exposure is 5 ppm. At 15-20 ppm the odor is noticeable and some persons will experience eye and throat irritation.

There is usually only mild irritation when epichlorohydrin first touches the skin. Prolonged contact will cause surface blisters, deeper tissue damage, and severe pain. Even small amounts of liquid on the skin can produce pain if the person has been sensitized by some previous contact.

Propylene chlorohydrin has toxic properties similar to ethylene chlorohydrin and epichlorohydrin. It can cause poisoning after intake by inhalation, ingestion or absorption through intact skin.

Chlorohydrins easily penetrate cloth, rubber, or leather. Gloves, therefore, do not afford enough protection to permit prolonged contact. Neoprene or polyethylene gloves will give better protection than rubber gloves.

Flammability — The chlorohydrins will burn at elevated temperatures but they are not considered fire hazards under normal conditions. Open cup flash points are 140°F for ethylene chlorohydrin and 105°F for epichlorohydrin. Water and CO_2 extinguishers may be used on fires involving these chemicals.

Boiling points are 116°F for ethylene chlorohydrin and 129°F for epichlorohydrin. Toxic amounts of these chemicals can be easily volatilized and respiratory equipment is necessary for fighting fires around exposed chlorohydrin containers. Canister-type respirators can be used for brief periods if the absorbent is approved for organic chemicals. Supplied-air respirators should be used for exposures greater than 5 minutes.

All of the chlorohydrin chemicals are hydrolyzed slowly during storage, forming small amounts of hydrochloric acid. Steel and tin containers may be used. Aluminum, copper, and lead cannot be used — a violent reaction can occur between ethylene chlorohydrin and aluminum. Laboratory quantities can be stored in glass containers — leave sufficient head space and store out of direct sunlight.

Spills — The removal of spilled chlorohydrin liquid requires caution to minimize skin contact and vapor inhalation. Small spills can be removed with absorbent paper. Wear rubber gloves. Spills can also be absorbed with clean sand. Place the wet sand in a tightly covered container for prompt disposal. Respiratory equipment may be needed for spill clean-up.

Clothing splashed with chlorohydrins must be removed immediately. Wash the affected skin with generous amounts of soap and water. Allow the clothing to dry thoroughly and launder before reuse. Contaminated leather goods are difficult to clean thoroughly — they may have to be discarded. Wash contaminated rubber gloves with soap and water before reusing. Material splashed in the eyes should be given prompt attention. Wash thoroughly with water for 20 minutes and obtain medical attention. Vomiting should be forced if chlorohydrins are swallowed — large amounts of salt water will induce vomiting. Obtain medical attention immediately.

Fatal cases of ethylene chlorohydrin poisoning, from inhalation and skin absorption, have been reported. In two separate cases, the victims were working in the open, using the liquid as a cleaning solvent. They had no respiratory protection and became ill after 1.5 and 2.25 hours of exposure. One man was wearing gloves. Both deaths occurred within 24 hours after the start of exposure. Tests were made under the same conditions that prevailed in one of these exposures and the airborne concentration of ethylene chlorohydrin was determined as 300 ppm (about 1 mg/liter of air).

Despite the toxicity of these chemicals, they have been produced on a large scale with few incidents. Precautions and safeguards have kept exposures low.

Chlorosulfonic Acid

Chlorosulfonic acid, $SO_2(OH)Cl$, is a clear colorless liquid which may become cloudy and straw-colored on standing. Fuming occurs in moist atmospheres.

Toxicity — Contact with moisture causes chlorosulfonic acid to decompose, forming hydrochloric and sulfuric acids. The effects of inhalation, therefore, are the same as the effects of these two strong acids. Decomposition occurs in the atmosphere or in the moist passages of the respiratory system. There is severe irritation of the nose, mouth, and throat. Massive exposure results in pulmonary edema. This condition of excessive lung fluids is a common result of acid inhalations. In advanced edema, breathing is difficult and chest pains often develop. Lung failure may follow. Treatment usually consists of administering oxygen under pressure. Drugs, including sulfanilamide, may be given to prevent infection.

Lung damage from daily chronic exposures is unlikely. Atmospheric levels below the onset of irritation do not cause damage and persons are not likely to voluntarily remain in areas with irritating atmospheres. Most of the significant industrial exposures are acute exposures. They result from equipment failure, faulty work habits, or laxity in the use or upkeep of safety equipment. Seldom do they occur because of some unexpected or uncontrolled reaction which was overlooked in the operation design.

Skin and eye burns are more common than cases of excessive inhalation. This is especially true in laboratory operations. Burns from chlorosulfonic acid are treated in the same manner as burns caused by hydrochloric or sulfuric acids. Thorough flushings of the skin or eyes for 20 minutes must be done immediately to avoid painful second-degree skin burns or permanent eye damage. Obtain medical attention for any eye contact.

Flammability — Chlorosulfonic acid will not burn. However, it will react with metals and release hydrogen which can burn or explode. Processes which produce hydrogen as an off-gas are designed so that forced ventilation prevents the formation of explosive gas-air mixtures. The formation of hydrogen gas must be considered a possibility in any operation in which moisture can combine with the acid, forming the decomposition acids (HC1 and H_2SO_4) which can react with traces of metal or the reaction vessel itself, if it is metal.

Hydrogen formation is not a problem in the storage or use of laboratory amounts of the pure acid kept in glass bottles. However, large amounts stored in metal drums require careful handling. The drums should be vented often enough to prevent the build-up of excessive pressures. During venting, take precautions to prevent hydrogen ignition — keep sources of ignition (flame, sparks) away from the drums. Don't cause sparks in moving or opening the drums. Thoroughly drain and rinse empty drums before storing, discarding, or shipping.

Dry chemical and CO_2 extinguishers may be used on fires involving chlorosulfonic acid. Water can be used to cool closed containers or in those situations where the advantages of water would outweigh the disadvantages of the acid-water reaction. Deluge amounts of water may be idicated, in place of a spray, if the volume of water is sufficient to dilute and wash away any spilled acid.

Spills — If chlorosulfonic acid is spilled on the skin it should be given the same attention and treatment given to spills of sulfuric and hydrochloric acids. The affected parts of the skin must be immediately washed with water. Ointments should not be applied until after a thorough water rinse. Clothing splashed with acid should be removed for complete rinsing.

Treat eye splashes with a 20-minute water wash. Do not apply ointments — the grease may prevent proper rinsing. Get medical attention.

Spilled acid can be washed away with water if the resulting reaction will not cause a new hazard. Usually, rinsing with large amounts of water will not be possible in laboratories. A generous amount of sand should be used, first, to absorb the spill. After removal of the sand, spread a layer of mixed sand and lime on the residual acid or the remaining wet spot. If the acid soaks into a porous bench top or hood floor, flood the spot with a calcium hydroxide solution to neutralize the acid.

Wear the proper equipment when removing acid spills. Eye protection and rubber gloves should be used in all cases. Additional protection will be needed for the safe removal of large spills.

Chromium
See Heavy Metals,

Chromium Trioxide

Toxicity — Chromium trioxide exhibits a variety of toxic effects. The effects may be due to its behavior as an acid or an oxidizing agent, or to the action of the Chromate ion. Contact with CrO_3 dust or concentrated solutions may cause skin inflammation or open sores which are commonly known as chrome ulcers or chrome holes. Continued inhalation may cause damage to the respiratory tract, ranging in severity from minor corrosion of nose tissues to fatal lung disorders.

Severe disorders can result if CrO_3 is swallowed. The fatal dose is estimated to be less than 6 grams.

Dermatitis and skin ulcers are the most common injuries resulting from CrO_3 exposures. Transient irritation usually occurs first, with inflammation and dermatitis developing after repeated contact. Skin abrasions favor the development of chrome ulcers. They usually appear first at the knuckles or cuticles, areas where small abrasions are common and where materials tend to accumulate. The initial appearance of skin disorders and the frequency with which new ulcers appear depends on individual variability, the degree of exposure, and personal work and hygiene habits.

The recommended limit for airborne hexavalent chromium is 0.1 milligrams per cubic meter of air. Repeated inhalation of chromium trioxide dust or mist above this level could result in painless ulceration of the nasal septum, the wall of tissue in the middle of the nose. The ulcers continue to develop until complete and permanent perforation occurs.

Absorption of hexavalent chromium into the blood stream, from inhaled or swallowed material, may cause disorders in other parts of the body. Kidney damage is the most frequent result of Cr^{+6} absorption.

Flammability — Chromium trioxide will not burn. However, contact with iso-butyl and n-butyl alcohol, plus many other organics, will generate heat. In some cases the amount of heat will be sufficient to cause ignition. Paper and wood react more slowly and may char. Spontaneous ignition occurs on contact with ethyl alcohol. This reactivity of CrO_3 can be easily and safely demonstrated. Place several drops of ethyl alcohol on a watch glass, and place the glass in a sink or fume-hood free of combustibles. Drop in several small particles of CrO_3. Small flashes will occur upon contact of the two materials and the ethyl alcohol will ignite.

Containers of CrO_3 should be stored in a manner which excludes the possibility of contact with organics. Empty CrO_3 bottles should be thoroughly rinsed with water prior to disposal to eliminate the possibility of reactions in a waste container.

Water can be used for fires involving chromium trioxide.

Spills — The removal of CrO_3 spills in the laboratory usually is a simple matter. Dry material may be picked up with a dust-pan or any convenient flat piece of metal or stiff paper. Rinse the paper with water before discarding. Do not allow the chemical to remain in contact with the metal — transfer the material to a glass container. Wear safety glasses and rubber gloves while removing spills.

Spilled solutions can be absorbed with sand. Wear rubber gloves.

Chromium trioxide should be removed from the skin by thorough washing soon after contact. Remove contaminated clothing and launder before re-use. Splashes in the eye should be treated immediately with a prolonged water flushing. The corrosive action of CrO_3 could cause severe pain and permanent damage to eye tissue.

Most lab work involving the use of CrO_3 will generate only small amounts of waste material. Waste chromium can be precipitated as highly insoluble lead or barium chromate. Add, while stirring, a solution of lead or barium nitrate to the Cr^{+6} solution until the precipitation is complete. Allow the precipitate to settle and decant the supernatant liquid. Discard the chromate precipitate with other solid lab waste.

Hexavalent chromium can be converted to the less toxic trivalent state with many reducing agents including sodium bisulfite, sodium sulfite, and ferrous salts. Iron or aluminum metal can be used but the reduction may proceed slowly — the rate depends on the CrO_3 concentration and the metal finish. The reaction with sodium sulfite proceeds rapidly and smoothly.

Cyanides and Nitriles

The cyanide ion, ($—C{=}N$), occurs in a wide variety of important laboratory and industrial chemicals. When combined with an inorganic ion, the compound is known as a cyanide (such as sodium cyanide, NaCN). Organic compounds containing the CN group may be called cyanides, or they may be named after the acid which would be formed from hydrolysis of the compound. Thus, the compound CH_3CN may be called methyl cyanide or acetonitrile, because hydrolysis would yield acetic acid, CH_3COOH. The nitrile nomenclature is preferred.

Hydrogen cyanide, HCN, and the inorganic cyanides are used as fumigants, pesticides, and rodent poisons for ships, buildings, and in agriculture; in the treatment of gold and silver ores; electroplating baths; as stains and dyes; and as laboratory reagents for analytical chemistry and organic syntheses. Nitriles are used in organic syntheses, chiefly in addition reactions to obtain a product with one added carbon atom. The lower molecular weight liquid nitriles also have some use as solvents. Nitriles are widely used in polymer production.

Toxicity — Cyanide compounds are powerful poisons which prevent the utilization of oxygen by the body tissues. This is accomplished by the selective inhibiting of many respiratory enzymes. The cyanide ion forms a complex with an essential part of the enzyme, thus preventing the enzyme from performing its catalytic duty in the transfer of oxygen from the blood to the tissues. Oxygen remains bound in the blood, and venous blood becomes the same bright red color as arterial blood. Victims of cyanide poisoning are sometimes described as having a cherry-red skin color, imparted by the unusual distribution of oxygenated blood. Despite the presence of oxygen, the tissues suffer from asphyxiation and there is a rapid collapse of body functions.

Cyanides rapidly appear in the blood after they are inhaled, swallowed, or absorbed through the intact skin. Toxic effects appear immediately with large doses and the victim may collapse within seconds. At first breathing is rapid, then irregular and gasping. There may be convulsions and death may occur within a few minutes. Lesser doses cause dizziness and headache; vomiting may occur with ingestion cases. Breathing becomes rapid, then irregular; collapse, heavy sweating, and convulsions follow. If the dose was not fatal, the victim's breathing becomes more regular and he regains consciousness. The cyanide in the body is converted to the much less toxic thiocyanate, and the respiratory activities return to normal. In most non-fatal cases, complete recovery takes a few days. Severe non-fatal poisoning will occasionally result in permanent damages.

Poisoning from acute exposures are more common than poisoning from chronic, daily exposures. The continuous conversion of absorbed cyanide to thiocyanate prevents a cyanide build-up in the blood and tissues from the smaller exposures.

Nitriles are slightly less toxic than cyanides. However, they cause a greater irritation of the nose and eyes. After absorption, their toxic action is similar to that of the cyanides.

Flammability — With the exception of hydrogen cyanide, HCN, the inorganic cyanides are not considered fire hazards. Hydrogen cyanide is a flammable liquid which boils at 26°C and is easily ignited. In some operations, HCN may be evolved but laboratory work will seldom produce enough HCN to be considered a fire hazard. Caution must be used with HCN cylinders. CO_2 and dry chemical extinguishers can be used for HCN fires — water can be used for fires involving other inorganic cyanides.

Liquid nitriles ignite easily and require the attention normally given to moderately flammable liquids. Exclude open flames in areas where nitriles are used; exclude sparking equipment in areas of high vapor content; maintain laboratory supplies at a minimum. Acrylonitrile is capable of spontaneous polymerization under certain conditions and the reaction may occur with explosive force. Commercial grades of acrylonitrile contain an additive to inhibit polymerization but the inhibitor may be ineffective at elevated temperatures.

Carbon dioxide, dry chemical, and alcohol foam are recommended for fires involving nitriles. Water can be used but it may be ineffective because of the low flash points of the liquid nitriles. Respiratory equipment may be needed. The use of a cannister type gas mask is limited by the vapor concentration and supplied-air respirators should be used. A high concentration of vapors, mist, or dust will make skin absorption an important mode of poisoning. Exposures should be limited unless full protective clothing is available.

Spills — Cyanides or nitriles which contact the skin or eyes should be washed off immediately. Remove contaminated clothing and do not reuse until it is washed thoroughly. Obtain prompt medical attention for eye splashes. Laboratories which use cyanides frequently should have approved first-aid equipment for the prompt treatment of poisoning victims.

The Toxicity of these compounds dictates that spills be given immediate attention. Brush or sweep up cyanides and transfer to a container for disposal. Cyanides in solution can be converted to less toxic compounds. Boiling the solution with sulfur or a polysulfide produces thiocyanates; addition of ferrous sulfate to alkaline solutions produces ferrocyanides.

Small amounts of spilled liquid nitriles can be removed with absorbent paper or sand. Nitriles can be converted to less toxic compounds. Acrylonitrile can be oxidized to a cyanate by alkaline chlorination and other nitriles can be converted to amides by reaction with hydrochloric acid. The method selected should be reviewed thoroughly and then tested on a small batch of the waste material.

Ethers

Toxicity — Ethers are not considered highly toxic but they can cause disorders ranging from transient dizziness to fatal poisoning. Chronic exposure to ethyl ether brings about a loss of appetite, headaches, and sleepiness. Single exposures to massive amounts of ether can cause intoxication and collapse. The recommended limit for continuous 8-hour exposure is 1.2 milligrams per liter of air.

Exposure to isopropyl ether produces the same effects as exposure to ethyl ether. The recommended airborne limit for continuous exposure is 2.1 mg/l.

Dioxane and ethylene oxide are more toxic than ethyl and isopropyl ether. Early signs of excessive exposure are irritation of the nose and eyes, nausea, and vomiting. Continued exposure to excessive concentrations of dioxane can cause kidney and liver damage. Dioxane can be absorbed through the skin. Continued exposure to ethylene oxide can dull the sense of smell, reducing the ability to recognize excessive concentrations. Tetrahydrofuran will cause eye and nose irritation; prolonged excessive exposure may cause kidney or liver damage. Recommended airborne limits are: dioxane, 0.36 mg/l, ethylene oxide, 0.09 mg/l; tetrahydrofuran, 0.58 mg/l.

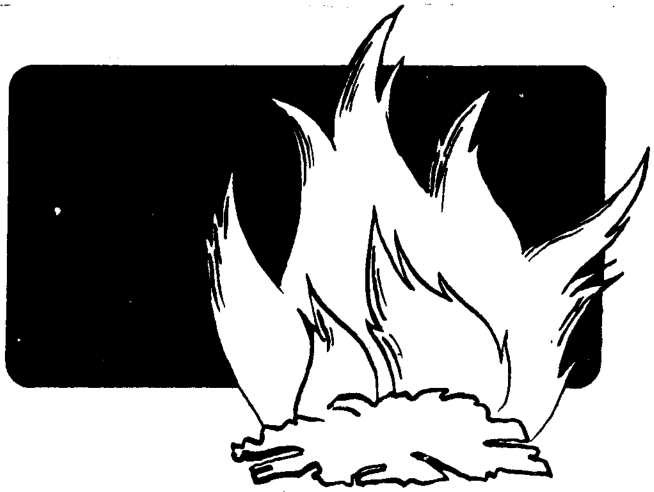
Skin contact with ethers will cause drying and repeated contact may cause dermatitis. Irritation, pain, and blisters may also result from prolonged contact.

Flammability — The ethers are highly flammable and, under certain circumstances, they may form explosive peroxides. The precautions required for the storage and handling of ethyl ether are, in general, applicable to all ethers.

Ethyl ether has a flash point of — 45°C. Starting at this temperature, the vapors just above an ethyl ether surface can be ignited by an open flame or spark. Ether vapors are heavier than air and they can accumulate in a low spot, flow to an ignition source, and flash back to the vapor source. Because of the high volatility and low flash point, laboratory work with ether should be confined to fume hoods whenever possible. Evaporate ether solutions at low heat, in a hood free of other combustibles. Remove or turn off any devices with open, operating electrical relays.

Static electricity can ignite ether vapors. A charge may be accumulated when ether is poured from one container to another — use grounded containers or keep the containers in contact while pouring. Whenever possible, ether should be stored in safety cans which have spouts that facilitate container contact while pouring. The cans should be equipped with flame arresters which help prevent ignition of the can contents by flames entering the pour spout. Safety cans are also useful for collecting waste ether. Glass bottles used to store ether should be as small as possible to minimize breakage spills.

Carbon dioxide and dry chemicals are recommended for extinguishing ether fires. Water spray may be used but a direct stream may scatter the burning ether. Burning vapors above a beaker or flask can be extinguished by covering the vessel mount with a watch-glass or anything else which effectively cuts off the oxygen supply.



Ethers react slowly with oxygen to form explosive peroxides. The rate of formation depends on the particular ether and the storage conditions. Frequent exposure to air and sunlight hasten the formation. The peroxides are less volatile than the ethers, and distillation or evaporation will concentrate the peroxides. An explosion could occur when a distillation nears completion. Evaporation can also cause an accumulation of peroxides around the cap or stopper of a container of ether. Ether which is to be used in operations involving distillation should be first tested for peroxides by shaking a sample with an acidified solution of potassium iodide. Peroxides will liberate iodine, causing a red color. Ether can be freed of peroxides by shaking with a solution of ferrous sulfate, sodium sulfite, or other suitable reducing agent.

Damaging and fatal laboratory explosions have been caused by ether peroxides. One chemist was fatally injured by an explosion which occurred when he turned the cap on a bottle of isopropyl ether. A less serious explosion occurred when a glass stopper was replaced in an empty 250-ml ethyl ether reagent bottle. A flask containing allyl ether exploded near the end of a distillation — the ether had been added to the flask and then stored two weeks, with occasional exposure to sunlight, before the distillation was started.

Spills — Ether spills can be removed with a sponge, rag, or absorbent paper. The wet material can be placed in a fume hood and allowed to evaporate. In any spill removal, consideration must be given to the flammability and inhalation hazards — it may be best to leave the area and allow the spill to evaporate.

Eyes splashed with ether should be flushed with water immediately. Small splashes on the skin will evaporate quickly. Larger spills should be washed off with soap and water. Clothing or shoes wet with ether must be removed and allowed to dry thoroughly before reuse.

Halogenated Hydrocarbons

Toxicity — The most general toxic effect of the halogenated hydrocarbons is their anesthetic or narcotic action. Symptoms vary, but may include dizziness, fatigue, headache, nausea, and mental confusion or stupor. There may be an inability to concentrate and visual disturbances. Several chemicals will cause irritation of the eyes, nose, and throat before other effects are noted. Delayed effects are usually more important in regard to general health and recovery from exposure. Many of the chemicals will cause kidney or liver damage. Others cause damage to the nervous system.

Inhalation is the most common absorption route. Severe poisoning and rapid death may occur if certain chemicals are swallowed but ingestion is not considered an industrial or laboratory problem. Absorption of toxic amounts through the skin can occur with several of the organic halides. With some chemicals, skin contact causes burns or irritation. Because of their solvent properties, the halogenated hydrocarbons remove oil from the skin. Dermatitis and other skin problems can result from continued contact.

In general, the saturated organic halides are more toxic than the halides of the unsaturated ethylene series. Bromo and iodo derivatives are usually slightly more toxic than the chloro compounds. Compounds containing fluorine are less toxic than the corresponding bromo or chloro chemicals.

There is little satisfaction in comparing the toxicities of the halogenated hydrocarbons beyond the general statement in the preceding paragraph. Different orders of toxicity are obtained if the chemicals are first considered with regard to their immediate effects from massive acute exposure and then with regard to their delayed effects from prolonged chronic exposures. For application to industrial situations, the toxicity based on chronic exposure is more important. This toxicity is reflected in the suggested maximum allowable concentrations for a continuous 8-hour exposure period. Under this classification, 1, 1, 2, 2-tetrabromoethane is one of the most toxic halides, having a suggested limit of 1 part per million parts of air (ppm). This is equivalent to 14 milligrams per cubic meter of air (mg/m³). Suggested limit for 1, 1, 2, 2-tetrachloroethane is 5 ppm (35 mg/m³).

Suggested exposure limits refer only to the material after it is airborne. Volatility must also be considered in evaluating possible exposures. For example, trichloroethylene and tetrachloroethylene both have a suggested limit of 100 ppm. However, at 25°C, the vapor pressure of trichloroethylene is 74.3 mm Hg while the vapor pressure of tetrachloroethylene is only 18.4 mm Hg.

Flammability — Several halogenated hydrocarbons are flammable enough to be considered as major fire hazards. Others will not burn and are used in fire extinguishers. Methyl chloride, ethyl chloride, and chloroethylene (vinyl chloride) are flammable gases which are normally used as compressed liquids. Vapors of these chemicals are heavier than air and may accumulate, spread to an ignition source, and flash back to the main container. Static electricity, generated by pouring a non-polar liquid, may jump from one container to an ungrounded point and produce a spark which is capable of igniting solvent vapors.

CO_2 and dry chemical extinguishers are most effective for fires involving organic halides. Water may be ineffective unless it is applied as a fog or gentle spray.

Flammable products may result from the contact of organic halides with certain metals or chemicals. Methyl chloride reacts with aluminum to produce complexes which will ignite spontaneously. Trichloroethylene will react with strong alkalies to form gaseous products which can ignite or explode. Other halides may react in the same manner. At elevated temperatures, many organic halides decompose with the formation of products which are far more toxic than the original chemical. One of the most toxic decomposition products is carbonyl chloride (phosgene), $COC1_2$. Because of these toxic products, fire extinguishers containing carbon tetrachloride, methyl bromide, and other organic halides, should not be used in closed or poorly ventialted areas unless adequate respiratory equipment is worn.

Spills — The organic halides vary widely in their effects when splashed on the skin. Many produce only a local irritation; the refrigerants can cause frost bite; some will produce severe burns if allowed to remain in contact with the skin; 1,2-dichloroethane, carbon tetrachlodide, and 1, 1, 2, 2-tetrachloroethane, can be absorbed in toxic amounts. Because they all have some effect, clothing splashed with any organic halide should be removed and the affected parts of the body washed with soap and water. Allow contaminated clothing to dry in a well-ventilated area and then wash before reuse.

Effects of eye splashes vary from mild irritation to permanent damage. Wash the eyes thoroughly with water and obtain medical attention.

Don't be misled by the words, "safe solvent". Under normal, properly controlled, working conditions, the "safe" solvents may be virtually non-toxic. However, spills or other accidents which result in unusual amounts of vapor or massive skin contact require prompt attention. Fatal cases of poisoning have resulted from massive exposures to the "safer" solvents.

Small spills on the lab floor or bench can be removed with rags or absorbent paper. Wear solvent-proof gloves. Larger amounts can be absorbed with dry sand. Keep the moist material in a closed container.

Hydrazine and Its Derivatives

Toxicity — The hydrazine compounds require precautions during handling and storage because they are both health and fire hazards. Anhydrous hydrazine (H_2NNH_2) is the most toxic of this group of chemicals. Small amounts of vapor are irritating to the eyes, mucous membranes, and skin. The liquid is caustic and can cause severe burns when splashed on the skin. Eye splashes can result in permanent damage. Only slight effects may be noted during exposure to hydrazine vapors. Eye inflammation could occur hours later. It may persist, along with temporary visual problems, for several days. Other symptoms of chronic poisoning are general weakness and vomiting.

Toxic amounts of hydrazine can be taken into the body by inhalation or absorption through the skin. Exposure to massive amounts first produces stimulation and convulsions, then depression and coma. In the blood, hydrazine attacks red corpuscles reducing the oxygen supply. Cyanosis may result — lips, tongue, and ears turn blue or purple. The suggested exposure limit for an 8-hour period is 1 part of vapor per million parts of air (1 ppm). This is equivalent to 1.3 milligrams of hydrazine per cubic meter of air (1.3 mg/m³).

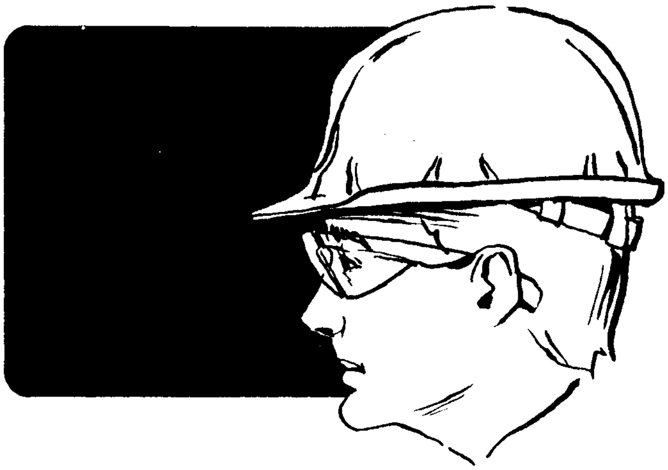
Unsymmetrical dimethylhydrazine, $(CH_3)_2NNH_2$, is another caustic water-miscible compound. It is commonly called UDMH and is a well-known missile fuel. Toxicity of UDMH is similar to that of hydrazine. It is irritating to the eyes, skin, and respiratory tract, and can be absorbed through the skin. Weakness or lethargy are the first signs of poisoning. UDMH is more volatile than hydrazine and may present greater handling problems.

Hydrazine hydrate ($H_2NNH_2H_2O$) is a corrosive and toxic liquid which requires the same precautions used for anhydrous hydrazine and UDMH.

Salts of hydrazine are considered poisonous but they are less toxic and less of a problem than the liquid hydrazine compounds. They are easily capable of causing skin irritation and dermatitis. Monohydrogen sulfate ($H_2NNH_2H_2SO_4$) is the most convenient and commonly used hydrazine salt.

Flammability — Anhydrous hydrazine, UDMH, and hydrazine hydrate are highly flammable and react violently with many materials. Anhydrous hydrazine ignites at various temperatures depending on the surface which it contacts. Ignition occurs at room temperature, 23°C, with a surface of ferric oxide (iron rust), at 160°C with stainless steel, and at 270°C with borosilic glass. Spontaneous ignition may occur on contact with finely divided porous material or wood and metal surfaces.

UDMH can ignite spontaneously on contact with hydrogen peroxide and other strong oxidants. The vapor is twice as heavy as air and may creep some distance to an ignition source. Flash point of UDMH is about — 15°C. That is, starting at — 15°C, UDMH gives off enough vapor to form a flammable mixture with air. At this temperature and above, a burning match or other flame will cause a flash of fire if the flame is brought close to the liquid surface. In the absence of flame, oxidants, or other materials with which it reacts explosively, the normal autoignition temperature is 270°C.



Spills — Trays should be used for holding reagent bottles or lab equipment whenever there is a chance of a spill of hydrazine liquids. Not all trays are compatible with these chemicals. Use trays made of porcelain, type 304 stainless steel, or polyvinylchloride. A violent exothermal reaction may occur with type 316 stainless steel or other steels containing high amounts of molybdenum.

Small quantities of hydrazine liquids can be kept in glass bottles. Clean the bottles thoroughly before using — trace residues on the glass may lower the ignition temperature. Leave adequate head space. Store in a cool spot, out of direct sunlight. Large amounts in storage may be kept in type 304 stainless steel containers. Use the precautions necessary for the storage of highly flammable liquids.

Clothing splashed with hydrazine liquids must be removed immediately because of the skin burns which can result and the chance of absorption through the skin. Wash the skin thoroughly with large amounts of water. Splashes in the eye can cause permanent damage — wash the eyes thoroughly with water and get medical attention.

Wear rubber gloves and safety glasses when cleaning up spills. Respiratory equipment may also be needed. Flush spills with large amounts of water. If flushing is not possible, first dilute the spilled material with water — as much as practicable. For small pools on lab benches or floors, use a pipet and rubber bulb to pick up the liquid by suction. Transfer the liquid to a beaker, dilute with water, and neutralize carefully in a fume hood, with sulfuric acid. If hydrazine soaks into a porous surface, first remove the standing liquid and then flood the damp spot with a 5% solution of boric acid (H_3BO_3).

Spills can be asborbed in clean sand — do not use sand containing organic matter. Dispose of the wet sand as soon as possible. Sawdust or soil should not be used to soak up hydrazine liquids, except as a last resort. Keep the wet material spread out as much as possible to dissipate heat and prevent spontaneous combustion. Discard immediately.

Inorganic Amides

Inorganic amides are characterized by the general formula MNH_2, where M is usually an alkali metal or alkaline earth metal. Other metals which form amides are zinc, cadmium, nickel, and silver. Non-metal inorganic amides include sulfamide, $SO_2(NH_2)_2$; sulfamic acid, (OH) SO_2NH_2; and monochloramine, $CLNH_2$. The alkali metal amides are the most widely used amides. They are insoluble in organic solvents and are decomposed explosively by water. They can be prepared by reacting the alkali metal with liquid ammonia or by heating the alkali hydrides with ammonia gas. Amides of lithium, the alkaline earths, and the heavy metals will precipitate when potassium amide is added to liquid ammonia containing the soluble metal salts.

The common organic amides are much more stable than the inorganic amides.

Handling Hazards — Inorganic amides are reactive solids and violent reactions have occurred during the handling of these compounds. Sodium amide (also called sodamide) undergoes oxidation when exposed to air and sodium nitrite is formed. The resulting mixture of nitrite and amide is unstable and can explode with great violence. Lithium amide decomposes slowly in air but decomposes rapidly, without ignition, when heated.

The inorganic amides will burn and constitute a fire hazard when used or stored in any quantity. In the laboratory, stored amides should be limited to the quantity needed for daily work. In this case, safe handling means following the general precautions used with unstable, explosive compounds.

Storage — Only small containers of amides should be kept in the laboratory. The number of containers should be kept to a minimum. Laboratory-grade amides are usually sold in quantities of from 25 to 100 grams. No attempt should be made to combine the contents of several small bottles in one large container. Keep the containers tightly closed and do not keep the chemicals for long periods. Store in a cool, dry spot.

Inorganic amides should be returned to the storage area at the end of the work period. This is important if personnel unfamiliar with amides are to use the same area on a following shift or on a weekend.

If it is necessary to store large amounts of amides, the use of a satisfactory storage vault should be considered. The plant or laboratory fire brigade should be advised of the stored chemicals.

Fume Hoods And Shields — Reactions with amides which produce product gases should be carried out in a fume hood or arrangements should be made to scrub out toxic products. Untried reactions or reactions which are scaled up have occasionally produced unscheduled and violent reactions. Protective shields will reduce the effects of such reactions.

Procedures — Methods for using amides should be written and then followed closely. This point has added significance if more than one person is to carry out the same work. The procedures should include alternate steps if the desired reactions do not occur. Note those areas where close control is needed on temperature, pressure, or rate of reagent addition. Also note the protective equipment which is needed. Initial reactions for which published data is meager should be carried out first with small amounts of chemicals. Unusual reactions and hazardous reactions which do not appear to be documented should be reported in one of the chemical or safety journals.

Spills and Residues — Despite the reaction between amides and water, wastes and amide residues can be disposed of by dropping small amounts into a container of cold water. The usual products of the reaction are the metal hydroxide and ammonia. This method of disposal is only useful for small amounts of chemicals. Do not allow the wastes to accumulate — disposal of waste amides should be carried out on a daily basis. Wear the proper protective equipment.

Some consideration should be given to the precautions needed to clean up other chemicals used in amide reactions, such as liquid ammonia or flammable organics.

Brush up spilled amide solids immediately. Traces of residue can be cautiously washed away with water. Soak up amide solutions with inert material. Do not use water on fires involving amides — use a suitable dry chemical extinguisher. If only a few grams of an amide are involved, use any extinguisher which is suitable for the other burning material.

Lead
See Heavy Metals

Mercury and Its Derivatives

See Heavy Metals

Toxicity — Metallic mercury and mercury compounds can be absorbed into the body by inhalation, ingestion, or contact with the skin. Poisoning occurs from continued chronic exposures and from acute exposures to massive amounts. The effects vary, depending on the type of exposure.

Mercury poisoning, or mercuralism, from chronic inhalation exposure produces a variety of symptoms. The characteristic effects are emotional disturbances; unsteadiness, sometimes described as a static tremor, which eventually prevents the victim from performing even routine tasks; inflammation of the mouth and gums; general fatigue, memory loss, and headache. Kidney damage may also occur. The emotional difficulties usually include fearfulness, outbursts of temper, and excited response to criticism.

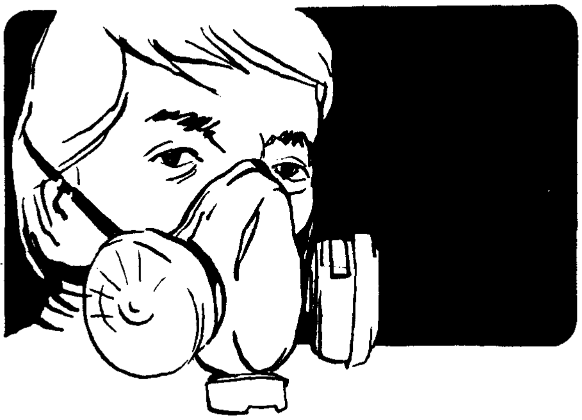
The exact reasons for these difficulties are not completely understood. It appears that mercury interferes with or inhibits enzyme systems, but the systems involved or the degree of inhibiting is not known. Evidence points to reactions with thiol compounds as the principal initial activity of absorbed mercury. There is no specific treatment for mercury poisoning except the administering of chelating agents to speed the elimination of mercury from the body.

In most cases of chronic inhalation exposures, the symptoms of poisoning usually disappear when the source of exposure is removed. Improvement may be slow and complete recovery may require years; fatalities and cases of permanent disability still occur, despite the well-known and much-reported hazards of mercury and its compounds.

Skin contact with mercury compounds produces irritation and various degrees of corrosion. Absorption into the body, through the skin, may be great enough to produce mercuralism. Swallowing of mercury can easily cause poisoning; as little as 1 gram of mercuric chloride may be a fatal dose.

For daily, continuous exposure, the recommended limit for airborne mercury is 0.1 milligrams per cubic meter of air. This limit is applicable to metallic mercury of inorganic mercury compounds. The limit for mercury in organic compounds is 0.01 mg/m^3.

Flammability — The commonly-encountered mercury compounds are not considered fire hazards. However, mercury or mercury compounds can react with other chemicals to form unstable products which can be easily exploded. Mercuric oxide can react with ammonia, or with ethyl alcohol and nitric acid, to form mercuric fulminate, $Hg\ (ONC)_2$, which can be detonated by heat or shock. Other reactions may produce equally explosive products. Supplied-air respirators may be needed for fighting fires involving mercury.



Laboratory Spills — At room temperature, air which is saturated with metallic mercury vapor will contain about 20 milligrams of mercury per cubic meter. Equilibrium conditions need not be considered for lab spills because air movements and air exchanges will prevent saturation. However, the volatility of mercury dictates a need for keeping containers closed and a need for minimizing spills.

Metallic mercury spills are common laboratory occurences. Spills may range from the daily loss of a few drops to the occasional loss of large amounts resulting from the breaking of a container or apparatus. Recovery of most spilled mercury is an easy task, but complete recovery is virtually impossible. Pools and droplets can be pushed together and then collected by suction. An efficient vacuum device for picking up mercury can be made from a filtering flask, rubber stopper, and several pieces of flexible and glass tubing.

In any mercury spill, unseen droplets are trapped in crevices. If spills are rare, and the laboratory has reasonable ventilation, the continued vaporization of the trapped mercury will present no problem. However, if spills are frequent and mercury from other sources is added to the general air level, the combined mercury concentration may exceed the recommended limit.

Several investigations of exposures in scientific laboratories have shown that spills can cause significant concentrations of airborne mercury. Surfaces which are apparently free of the metal will harbor microscopic droplets. Walking across a contaminated floor or producing virbations on a contaminated bench top increases the vaporization of mercury from these micro reservoirs. Electrical equipment, reaction gases, pump exhaust, open leveling bulbs, and other open containers are common sources of mercury vapor. Tamping a cigarette on a contaminated bench top causes traces to adhere to the tobacco, which may then add to the mercury intake.

The volatiltiy of residual mercury decreases rapidly soon after a spill. Oxide, dust, and oils coat the surface and form a fairly efficient barrier to continued vaporization. Sulfur dust has long been used to fix residual mercury; a water slurry of sulfur and calcium oxide is more effective.

Materials such as floor waxes, which will form a surface film, will reduce vaporization. One recent study indicated that an aerosol hair spray may be useful for fixing metallic mercury in hard-to-reach places.

Many difficulties can be avoided by the use of enameled or plastic trays under equipment which contains mercury. Some trays used for this purpose have a sloped bottom and a drain to facilitate spill removal. Cleaning or filtering of metallic mercury should be done in a fume hood.

Spilled mercury compounds and solutions can be removed by any method which will not cause excessive air exposures or skin contact. If sink discharges of mercury are not permitted, mercury in solution can be precipitated by adding a soluble chloride salt, such as sodium chloride. The precipitate can be collected and discarded with other solid lab wastes.

Nickel
See Heavy Metals

Oxalic Acid and Oxalates

Toxicity — When absorbed into the blood or tissues, oxalic acid and the soluble oxalates cause the precipitation of insoluble calcium oxalate. The decrease in available blood calcium and the presence of the insoluble salt combine to bring about a number of disorders.

Chronic inhalation and absorption over a period of time can produce blocking of the kidney tubules by a calcium oxalate deposit. Acute exposures to high concentrations of oxalic acid dust and mist are not common. The irritating effect on the mucous membranes should serve as an adequate warning of hazardous conditions.

Significant chronic absorption through the skin can occur by repeated contact with concentrated solutions. In the past, this type of absorption occurred most frequently because of hand contact with oxalic acid or oxalate cleaning solutions. Calcium oxalate is deposited in the tissues, restricting the blood supply. Pain and a bluish discoloration around the nails develop first. Continued contact may cause gangrene.

The same oxalate precipitation which may lead to gangrene in a worker's fingers is used to prevent coagulation in blood samples. Coagulation occurs through a series of reactions involving calcium and blood proteins. Sodium oxalate is a common anticoagulant which precipitates calcium, thus preventing the clotting process. This same precipitation also prevents cellular damage in certain plant cells which tend to accumulate oxalic acid. The acid is a reaction by-product which is toxic to cell protoplasm, and the precipitation with calcium effectively blocks its action.

Ingestion is the most common cause of poisoning by oxalic acid and soluble oxalates. Swallowing of these chemicals rapidly brings pain and vomiting — convulsions and death may follow. The more common soluble compounds are ammonium, potassium, and sodium oxalate. In addition to the effect of the absorbed material, oxalic acid also produces pain through corrosive attack of the tissue surfaces.

Oxalic acid and the oxalates seldom present any toxicity problems when used as laboratory chemicals. In lab operations such as weighing, preparing solutions, and titrating, the airborne material will seldom be of any importance because of the small quantities involved. Heating of concentrated solutions can give rise to irritating and corrosive vapors, but this operation should be carried out in a fume hood. Oxalic acid is hydrated and is usually written as $(COOH)_2 \cdot 2H_2O$. It is often dehydrated for lab use by heating at 100°C. However, the hydrate melting point is 101.5°C and even carefully-controlled drying will drive off a considerable amount of the acid. The fumes may corrode the oven and cause irritation of nearby personnel. Oxalic acid can be dehydrated easily with certain organic solvents; anhydrous oxalic acid is also commercially available.

Flammability — Under normal conditions, oxalate compounds are not considered fire hazards. The liquid oxalates have elevated flash points and must be moderately heated in order to ignite. Frothing may occur when water is used on the oxalates which have ignition temperatures above the boiling point of water. A water spray or fog is recommended for these fires. Respiratory equipment may be necessary because of the vaporization and sublimation of oxalate compounds.

Laboratory Spills — Oxalic acid spills can be easily and safely removed if adequate precautions are taken to protect against skin contact. For most lab spills, rubber gloves are all that is needed. Waste acid can also be treated with lime prior to disposal — the lime will neutralize the acid and remove the oxalate through the precipitation of calcium oxalate.

Material splashed in the eyes should be flushed out immediately with water. Obtain medical attention. Splashes on the skin should be washed off with water. Clothing contaminated with oxalate dust or solutions should be removed. Prompt medical attention must be obtained if oxalate compounds are swallowed. Forced vomiting is recommended as a first-aid treatment. Less than 10 grams of a soluble oxalate can be a fatal dose.

Perchlorates

Handling Hazards — Perchlorate fumes and dusts are irritating to the nose and throat and will cause skin problems if there is repeated contact. These difficulties are seldom encountered in the laboratory because of the small quantities normally used and because of the precautions taken when larger amounts are handled. The greatest hazard associated with the use of these chemicals is the violent reactions which can occur from unscheduled reactions.

Evaporation of acid solutions of perchlorate salts or perchloric acid must be carried out in a manner which allows the fumes to be collected. Fume hoods made for perchloric work are equipped with an exhaust scrubber or have a water spray in the exhaust duct. In hoods which have a constant spray, the water collects in a trough at the rear of the hood and runs into the sewer line, the concentration of dissolved perchlorates is usually low.

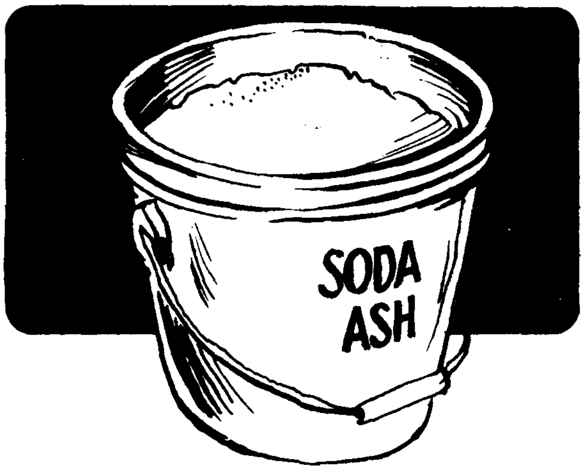
Collection of the discharged vapor is necessary because of the explosive compounds which can form with certain hood materials. The consequences of such combinations were clearly demonstrated several years ago by a series of unfortunate accidents which resulted during the dismantling of exhaust blowers from perchloric hoods. Perchloric fumes combined with the litharge-glycerine cement used as a seal and explosions occurred when attempts were made to remove the cement by chipping or sand blasting. Inert silica cements have since been recommended for use in perchloric hoods.

Organic solutions containing perchlorate salts are capable of violent explosions during evaporation or distillation operations. Small amounts of unstable organic perchlorates are formed which are less volatile than the solute being removed. Near the end of the operation, the temperature rises because of these less-volatile components. The higher temperature is enough to detonate the concentrated perchlorate residue. Whenever possible, an excess of water should be present to prevent the accumulation and to slow the temperature rise. Distillation or evaporation of organic-perchlorate mixtures should be halted with enough heel to keep the residues diluted. Distillations which are new or uncertain should be carried out with adequate shielding between the apparatus and laboratory personnel.

Spilled perchlorates should be removed without delay. Solid perchlorates spilled on unheated surfaces can be swept up without difficulty — use minimum pressure and abrasion. Perchlorates spilled on heated surfaces, such as a hot plate, may cause the ignition of a brush or paper used to sweep the spill away. Concentrated perchlorate solutions or perchloric acid should be flushed away with water. If flushing is not feasible, a floor mop and a generous amount of rinse water can be used if an inert absorbent is not available. Do not keep the used mop head — rinse it thoroughly in running water, or soak it in clean water, and allow it to dry before disposal. Sand or other inert absorbents should be kept handy in those areas where considerable amounts of perchlorates are used. If organic materials such as mops or sawdust must be used in an emergency, the spill should be diluted with water before clean-up is started. Spontaneous ignition of the organic material should be considered a possibility until it is thoroughly rinsed, or until it is burned.

Keep reagent bottles in a stainless steel or plastic tray. Rinse the bottles after each use, before returning to storage. Avoid storage or use on wooden shelves, cabinets, or bench tops. Keep in mind that a wooden surface which has soaked-up a perchlorate solution may ignite years later when the proper chemical is spilled in the same spot. Clothing soaked with perchlorate solution must be removed and thoroughly washed before reuse. Splashes on the skin or eyes should be rinsed off with a generous amount of water.

Deluge amounts of water should be used for fires involving perchlorates.



Peroxides

Toxicity — In general, the peroxides are irritating to the respiratory tract, skin, and eyes. All of the peroxides cause severe tissue damage if swallowed. The oral toxicity of some inorganic compounds is due to the action of the cation as well as the peroxide group.

A 30% solution of hydrogen peroxide is one of the most commonly used peroxide chemicals. Laboratory use of this material will seldom present inhalation problems, but minor skin irritation is common. Pouring from a pint bottle usually causes a few drops to run down the outside and the fingertips are often contacted. The skin may be slightly bleached and some pain will develop if the contact is repeated a few times within a short period. A brief water rinse soon after contact will prevent most of the irritation.

Flammability — Hydrogen peroxide will not burn but it is capable of causing spontaneous combustion when allowed to contact material which is easily oxidized. Despite the presence of an inhibitor, contaminants may easily initiate violent decomposition of the more concentrated solutions (70%). The 30% solution normally used for lab work is seldom a problem if the storage containers are not subjected to heat. Large amounts of water can be used for fires involving hydrogen peroxide.

Sodium peroxide and several other solid inorganic peroxides are powerful oxidizers. Mixtures with organic materials may be easily exploded. Friction or a small amount of water may ignite the mixture. Ignition can occur when spilled material is brushed together with paper or brushed across an organic surface. Dry chemical extinguishers are recommended for fires involving small amounts of material. Deluge amounts of water can also be used.

Most of the organic peroxides, liquid and solid, are fire and explosion hazards. One exception is di-tertiary butyl peroxide which is unusually stable and can be distilled without decomposition. Benzoyl peroxide, $(C_6H_5CO)_2O_2$, and lauroyl peroxide, $(C_{11}H_{23}CO)_2O_2$, are solids which are flammable when dry and may be exploded by shock or friction — the explosion tendency increases with increasing temperature. Tertiary butyl hydroperoxide, $(CH_3)_3COOH$, can have a flash point of about 30°C and it will undergo rapid decomposition at 90°C. Containers may be exploded by shock or heat. Acetyl peroxide, $(CH_3CO)_2O_2$, requires extraordinary handling precautions. Experienced investigators have used it safely as a reagent for organic syntheses but it is sensitive to heat and shock and is usually diluted with dimethyl phthalate to reduce the fire and explosion hazard.

Water and dry chemical extinguishers may be used for fires involving solid and liquid organic peroxides. Safety goggles and a supplies air respirator may be needed if more than a small amount of the chemical is involved.

Laboratory Spills — The possibility of ignition and violent decomposition must be considered in removing spilled peroxides.

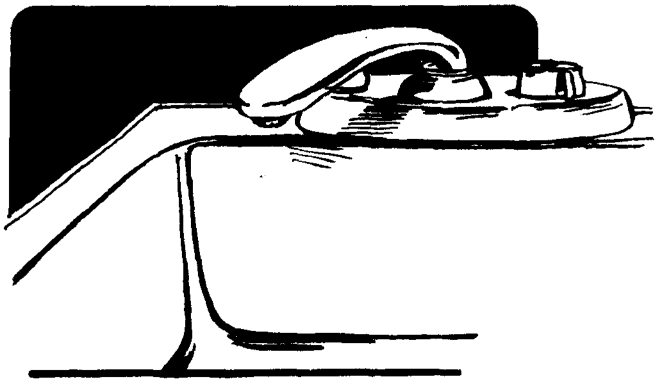
Peroxides which react with water can be covered with a layer of clean sand, vermiculite, or dry chemical from an extinguisher, and then removed with a plastic scoop. A plastic bottle with the bottom cut off would be an adequate scoop for the laboratory spills normally encountered. If the quantity of spilled material is minor, it can be disposed of by dropping small amounts into a large container of water.

Spills of liquid organic peroxides should be absorbed with a non-combustible material. Vermiculite is recommended. Remove the wet mixture with a plastic scoop for immediate disposal. Small amounts of wet absorbent can be dropped into a large container of 10% sodium hydroxide to destroy the peroxide.

Peroxides spilled on the skin should be washed off with water. Eye contacts should be treated immediately with water flushing before seeking medical attention. Remove contaminated clothing and rinse it thoroughly with water before drying. A fire blanket may not smother clothing fires caused by some organic peroxides — use a safety shower, or other available source of deluge water.

Lab spills and peroxide accidents can be minimized by using plastic trays for operations where spills may occur. Maintain laboratory stocks at a minimum.

Other handling precautions are indicated by accidents which have been reported. Do not store peroxides for long periods — old supplies have spontaneously exploded. Prevent accidental contact with all organics — traces of organic dust in the liner of a cap may have caused the explosion of a bottle of benzoyl peroxide. Only a small degree of friction is needed to detonate certain peroxide-organic combinations. Do not allow the accidental mixing of peroxides with materials which are easily polymerized — a fire resulted when benzoyl peroxide was poured into a beaker which had just been rinsed with methyl methacrylate. A high rate of polymerization may increase the temperature to the ignition point of one of the reactants. Finally, new work with peroxides should be carefully reviewed — violent explosions have occurred in reaction mixtures which contained only a few grams of organic peroxides.



Phosphorus

Solid elemental phosphorus has several molecular structures each identified by its characteristic color. White (or yellow) is the most important commercial form. Red phosphorus also has industrial and laboratory uses. Other forms are the black and brown varieties.

White phosphorus is highly reactive and requires tight controls for its safe use.

Toxicity — At one time, exposure to airborne elemental white phosphorus was a serious hazard. Now, the greatest hazard in the industrial and laboratory use of elemental phosphorus is the chance of skin burns or eye damage caused by uncontrolled reactions or spills. Exposures to phosphorus vapor are limited by closed production systems, attention to operating procedures, and the use of protective devices and protective clothing.

Chronic poisoning by white phosphorus causes a weakening of bones, leading to easy fractures. This bone necrosis occurs most frequently in the jaw, first causing a toothache, and then loosening of the teeth. The blood supply to the bone is slowed or blocked, permitting serious, and sometimes deforming, bone infections. workers handling white phosphorus are encouraged to develop a good program of dental care, including frequent brushing and regular dental examinations.

White phosphorus will ignite spontaneously on contact with air. For this reason it is covered with a layer of water or inert gas during storage and shipment. A phosphorus-water reaction will slowly cause the water covering to become acidic. The water must be changed or neutralized occasionally to prevent corrosion of equipment or metal containers.

Under certain conditions, white phosphorus reacts to form other toxic products. Reaction with alkalies may form phosphine, PH_3, a toxic gas. Therefore, water used to cover white phosphorus should not be adjusted above pH9, to limit the possibility of phosphine formation.

Red phosphorus is less toxic than the white form and cases of bone necrosis due to industrial exposures have not been reported. In laboratory uses, involving small amounts of the element, the oxidation of stored red phosphorus is more important than its toxicity.

Red phosphorus is moderately unstable but it is less reactive than white phosphorus. It will not ignite spontaneously on contact with air and, therefore, needs no water or inert gas cover. However, red phosphorus will react slowly with moisture and oxygen in the air. The exothermic oxidation is slow but the rate is accelerated by the increasing temperature. The oxidation products are hygroscopic acids which cause caking. Some phosphine is also formed.

Traces of metals will affect the oxidation rate of red phosphorus when it is exposed to air at room temperature and normal humidity. In decreasing order of affect, the important metals are copper, bismuth, silver, iron, nickel, cadmium, and tin. Copper and iron are the most important impurities found in commerical grades of red phosphorus. Removal of these metals improves the stability. The stability is greatly improved by the addition of aluminum hydroxide, sodium aluminate, or magnesium oxide.

Flammability — White phosphorus ignites spontaneously on contact with air. As the solid slowly burns it becomes liquefied, flows easily, and burns more rapidly. A covering of dirt or sand will stop the burning. Water spray and carbon dioxide may also be used but reignition can easily occur. Streams of water may spread burning white phosphorus, resulting in numerous separate fires.

Red phosphorus is not a fire hazard under normal conditions. In air, it will burn if heated above 260°C. Spontaneous combustion may occur if large amounts of red phosphorus are left open to the atmosphere. Water and CO_2 extinguishers may be used.

Spills — White phosphorus spilled or sprayed on the skin ignites and rapidly causes severe burns. The phosphorus reacts with tissue fluid and acids are produced which penetrate deeper into the tissue. Immediate and prolonged flushing with water is absolutely necessary to minimize burn severity. Washing with water alone is usually adequate as first-aid before medical attention but advantages have been reported for other treatments. At one time, the use of aqueous copper sulfate solutions (2-5%) was favored to inactivate any phosphorus remaining after a preliminary flushing with water. The copper sulfate leaves a dark coating on the phosphorus — the dark particles could then be picked off with tweezers. Alkaline solutions — two tablespoons of sodium carbonate or bicarbonate per pint of water — have been used to wash burns in order to convert any remaining phosphorus and to neutralize acids.

White phosphorus may produce fatal poisoning if swallowed. In adults, 0.1 gram is considered a fatal dose. Voluntary ingestion is unlikely but accidental swallowing could occur if a shower of phosphorus strikes the face unexpectedly. Immediate forced vomiting, using large amounts of water or salt water, is the recommended first-aid treatment. Eye splashes require prompt flushing with water. White phosphorus may cause permanent damage — red phosphorus is an eye irritant. Obtain prompt medical attention for all eye splashes or ingestions.

Silver
See Heavy Metals

Heavy Metals

The term "heavy metals" is non-specific, seldom defined, but often used in the scientific literature. In the most general sense, a heavy metal is any element with metallic properties and a specific gravity greater than 5. Usually, in any one discussion, the term refers to only a few metals which have a common property or effect. A discussion of the toxicity of heavy metal fumes usually includes a description of the effects of cadmium, mercury, lead, and zinc. When the subject is kidney changes caused by inhalation of heavy metal compounds, the elements considered usually include cadmium, mercury, lead, thallium, and uranium.

As industrial and laboratory hazards, the heavy metals exhibit great variations. In toxicity, they range from antimony and arsenic which can produce severe effects, to zirconium which has been labeled as virtually non-toxic. Conversely, antimony metal presents a low fire hazard but zirconium metal requires special handling precautions because of its pyrophoric nature. Also, some heavy metals are relatively innocuous in the metallic form while their soluble compounds are toxic. The brief list below will indicate the variability in a few important aspects of the more frequently encountered heavy metals.

Antimony — Based on animal studies, antimony has been classified as highly toxic. However, there have been only a few cases of industrial poisoning and these have occurred where the metal or its compounds were handled in large amounts. Laboratory users should recognize that a toxic gas, antimony hydride (SbH_3), can be generated when antimony compounds or alloys are treated with acid.

Arsenic — Despite the reputation conferred by years of crime stories, arsenic is not considered an important industrial hazard. When over-exposure does occur, it is seldom severe enough to cause the dramatic effects associated with the use of arsenic for murder or suicide. As with antimony, a toxic gas can be formed when arsenic-containing materials are treated with acid. Important amounts of this gas, arsine (AsH_3), could be generated in laboratory-scale operations.

Cadmium — In recent years, there has been a number of cases of cadmium poisoning due to the inhalation of fumes from soldering operations. Silver solder, often used for laboratory instruments, may contain up to 25% cadmium, by weight. Several hours of close work using such solders has resulted in acute exposures. Primary symptoms include throat irritation, chest pains, and abdominal pains. In several cases, death has occurred from pulmonary edema. The problem can be reduced by providing adequate ventilation for such work, and substituting solders containing no cadmium.

Chromium — In the hexavalent form, chromium compounds cause skin irritation and respiratory ailments. Continued exposure may cause kidney and liver disorders. The most common chromium hazard in most labs is minor splashes of chromate solutions. Small splashes on clothing or skin require immediate washing to prevent annoying burns. Splashes in the eyes require an immediate and thorough water rinse to prevent permanent damage. Spills of chromium trioxide should be removed immediately to prevent prolonged contact with organic materials. Instant ignition may occur when the trioxide contacts ethyl alcohol

Lead — The severity of its effects and the great industrial use of lead and its compounds, have combined to make lead one of the more important heavy metal hazards. In laboratory use, however, its heavy-metal physiological properties may be less important than the compound's physical properties. When lead azides or imides are used or formed, the explosive nature of the compounds is given prime consideration. The lab use of lead nitrate will seldom result in severe inhalation or ingestion exposures. A more likely hazard is the possible contact of the nitrate with organic material, or easily oxidized chemicals, resulting in an uncontrolled reaction which could scatter chemicals and glassware.

Mercury — Mercury can be absorbed into the body by inhalation, ingestion, or through the skin. Metal spills are one of the most common source of mercury vapor in laboratory air. As a result of a spill, mercury may be distributed over a wide area, exposing a large surface area of the metal. After spill removal, some metal will be trapped in corners and floor cracks. Vaporization will decrease as the metal droplets take on a covering of dust and wax. Although there is a possibility of toxic concentrations resulting from spills or open containers, only a gross disregard of sound housekeeping practices would lead to this condition.

Nickel — Nickel compounds will seldom be used in sufficient quantities to cause laboratory exposure hazards. One exception is nickel carbonyl, $Ni(CO)_4$, a gas which is toxic enough to be troublesome even when used in small quantities. The unusual nature of the carbonyl bond has been the subject of many lab investigations and the compound is useful for preparing pure metal and special organic compounds. Nickel powder, useful for hydrogen absorption in organic synthesis, has produced skin reactions. Persons affected may become sensitized to further contact with nickel-containing metals.

Silver — As in the case with many other heavy metals, most of the commonly used compounds of silver cannot be considered as lab hazards unless poor lab practices are followed. One exception is the product formed when silver compounds react with ammonia, or ammonium hydroxide, with or without the presence of organic compounds. Under proper conditions, silver azide, Ag_3N, or silver fulminate, $Ag_2C_2N_2O_2$, may form. The "proper conditions" are not completely understood and explosions have occurred when conditions prevailed which were considered unfavorable for the formation of explosive compounds. The unexpected reactions indicate that prolonged contact with ammoniacal solutions should be avoided when removing silver stains from lab glassware. Except for unusually hazardous compounds, the laboratory use of heavy metal compounds will not require any precautions other than those used with most chemicals. Material spilled on the skin should be washed off immediately; splashes in the eyes require immediate and thorough flushing with water plus follow-up medical attention; contaminated clothing should be removed if there is a possibility of the spilled material causing a skin reaction. Spills can be added to other lab waste for later disposal. Heavy metal nitrates and perchlorates are strong oxidants and should be stored and handled accordingly.

Toxic properties are not associated with all heavy metals. Compounds of iron and inorganic tin are not troublesome except where there is massive exposure or heavy exposure over a long period of time. Insoluble compounds of bismuth and zirconium are used in medical tests. Tantalum metal is used for surgical plates because it does not cause tissue reactions and it is inert in body fluids.

Incompatible Chemicals

Separate storage areas should be provided for "incompatible chemicals," chemicals which may react together and create a hazardous condition because of this reaction. Some examples of these incompatible chemicals are listed in the following table.

Examples of Incompatible Chemicals

Chemical	Keep Out of Contact With:
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkaline metals, such as powdered aluminum or magnesium, sodium, potassium	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, the halogens
Ammonia, anhydrous	Mercury (in manometers, for instance), chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)
Ammonium nitrate	Acids, metals powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Bromine	Same as for chlorine
Carbon, activated	Calcium hypochlorite, all oxidizing agents
Chlorates	Ammonium salts, acids, metals powders, sulfur, finely divided organic or combustible materials
Chromic acid	Acetic acid, naphthaline, camphor, glycerin, turpentine, alcohol, flammable liquids in general
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids, organic or inorganic
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, the halogens
Fluorine	Isolate from everything
Hydrocarbons (butane, propane, benzene, gasoline, turpentine, etc.)	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkali
Hydrofluoric acid anhydrous	Ammonia, aqueous or anhydrous
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, combustible materials
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases
Oxalic acid	Silver, mercury
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids
Potassium perchlorate (see also Chlorates)	Sulfuric and other acids
Potassium permanganate	Glycerin, ethylene glycol, benzaldehyde, sulfuric acid
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium)

Adapted from the *Dangerous Chemicals Code,* 1951, Bureau of Fire Prevention, City of Los Angeles Fire Department. This list is not complete, nor are all incompatible substances shown.

Storage Safety

To aid our customers in the proper storage of MCB chemicals, we are providing the following list.

Table 1 is chemicals recommended for refrigerated storage due to chemical decomposition, polymerization and etc.

Table 11 is also recommended refrigerated storage due to flammability, high volatility and etc.

Table III lists chemicals which polymerize or decompose due to freezing on extended storage at low temperatures.

Table IV lists chemicals which freeze during the winter months. In most instances the chemical purity is unaffected buy the hazard involved is the breakage of the container.

Table V lists reactive chemicals which should be stored in segregated areas from normal stock.

In most instances in Tables I-V we have only listed one grade, however the other grades should be stored in a similar manner.

Table I

The following items must be stored under refrigeration due to decomposition, polymerization, or other harmful effects.

X-Number	Name
AX0025	Acetaldehyde
AX0324	Acrolein
AX0335	Acrylic Acid
AX0365	Adenosinetriphosphoric Acid
AX1445	iso-Amyl Nitrite
BX0973	Bromoacetaldehyde Diethyl Acetal
BX1540	Bromosuccinimide
BX1705	3-Buten-2-one, Pract.
BX1975	tert-Butyl Hydroperoxide, Pract.
CX0955	2-Chlorocyclohexanone, Tech.
CX2120	Cupferron, Reagent, Crystals, A.C.S.
CX2283	1,3-Cyclohexadiene
DX1478	1,3-Dihydroxy-2-propanone
DX2403	Divinylbenzene, Pract.
EX0710	Ethyl Methacrylate, Monomer
GX0165	Gluthatione
GX0200	Glycidol
HX0435	Histamine, Base
HX0605	Hydrocinnamaldehyde
IX0325	Isoprene
LX0210	Lecithin
MX0002	Macabel Fast Red
MX0280	Mercaptoacetic Acid, 98%
MX0645	Methyl Acrylate, Pract., Stabilized
MX0805	2-Methyl-1-butene, 95%, Pract.
MX1010	Methylenedi-p-phenylene Diisocyanate
MX1315	4-Methyl-1-pentene, 95%, Pract.
MX1440	α-Methyl Styrene
NX0235	1-Naphthyl Isocyanate
PX0265	1-Pentene, 99.0%
PX2125	Pyruvic Acid, 99%
SX1030	Styrene, Stabilized
TX0422	Tetramethylsilane, Pract.
TX0475	Thioacetamide
VX0055	Veratraldehyde, (3,4-Dimethoxybenzaldehyde), Pract.
VX0175	Vitamin E
VX0180	Vitamin E Acetate

Table II

The following items should be stored under refrigeration because of their flammable properties or because of evaporation.

X-Number	Name
AX0025	Acetaldehyde
BX1220	Bromoethane, Reagent
BX1830	tert-Butylamine
CX0395	Carbon Disulfide
CX1300	1-Chloropropane
CX1330	3-Chloropropane
CX2430	Cyclopentane
DX1670	2,2-Dimethylbutane
EX0185	Ether, Reagent
FX0495	Furan
IX0185	Iodomethane
IX0325	Isoprene
MX0650	Methylal
MX0758	2-Methylbutane
MX0810	2-Methyl-2-butene, 99%
MX1045	Methyl Formate
MX1445	Methyl Sulfide
PX0170	Pentane, 98%
PX1840	Propylamine
PX1845	iso-Propylamine
PX1875	Propylene Oxide
TX1155	Trichlorosilane

Table III

The following items should not be subjected to cold temperature because the quality is affected by freezing.

X-Number	Name
FX0410	Formaldehyde, Material polymerizes below 40°F

Table IV

The following items will freeze below 20°C or 72°F; *however, this does not affect the quality.*

X-Number	Name	°C	°F
AX0073	Acetic Acid	16	60.8
AX0335	Acrylic Acid	14	57.2
AX0905	2-Aminoethanol	10	50.0
AX1130	1-Amino-2-propanol	1	33.8
AX1525	p-Anisaldehyde	1	33.8
AX1540	o-Anisidine	6	42.8
BX0220	Benzene	5	41.0
BX0265	Benzenesulfonyl Chloride	17	62.6
BX0400	Benzonitrile	−13	8.6
BX0440	Benzothiazole	0	32.0
BX0495	Benzyl Benzoate	20	68.0
BX1265	Bromoform	8	46.4
BX1350	1-Bromonaphthalene	4	39.2
BX1565	α-Bromotoluene	−4	24.8
BX1645	1,4-Butanediol	19	66.2
BX1660	2,3-Butanedione	−4	24.8
BX1690	2-Butene-1,4-diol	6	42.8
BX2160	Butyric Acid	−6.5	20.3
CX0800	m-Chloroaniline	−11	12.2
CX0840	o-Chlorobenzaldehyde	12	53.6
CX1680	Cinnamaldehyde	−7	19.4
CX2000	m-Cresol	12	53.6
CX2005	m-Cresol	10.5	50.9
CX2295	Cyclohexane	4	39.2
CX2325	Cyclohexanol	23	73.4
DX0070	Decyl Alcohol	6.5	43.5
DX0395	1,2-Dibromoethane	10	50.0
DX0625	Dibutyl Sebacate	−13	8.6
DX0655	Dichloroacetic Acid	12	53.6
DX0980	Dicyclohexylamine	−4	24.8
DX1485	Diiodomethane	6	42.8
DX1645	N,N-Dimethylaniline	2.5	36.5
DX1880	Dimethyl Phthalate	2	35.6
DX2100	Dioxane	11	51.8
DX2420	Dodecane	−10.5	13.1
DX2445	Dodecyl Alcohol	24	75.2
EX0340	Ethyl Anthranilate	14	57.2
HX0110	Heptanoic Acid	−7	19.4
HX0205	Hexadecane	18	64.4
HX0284	Hexamethylphosphoric Triamide	8	46.4
HX0355	Hexanoic Acid	−3	26.6
IX0340	Isoquinoline	24	75.2
MX0325	3-Mercaptopropionic Acid	17	62.6
MX0455	Methacrylic Acid	16	60.8
MX0720	Methyl Benzoate	−10	14.0
MX0830	2-Methyl-3-butyn-2-ol	3	37.4
MX1340	4-Methyl-m-phenylene Diisocyanate	22	71.6
MX1415	Methyl Salicylate	−7	19.4
NX0235	1-Naphthyl Isocyanate	6	42.8
NX0415	2,2',2'-Nitrilotriethanol	22	71.6
NX0825	Nonanoic Acid	10	50.0
OX0075	Octanoic Acid	16	60.8
OX0130	Octyl Alcohol	−15	5.0
OX0285	Oxalyl Chloride	−8	17.6
PX0770	Phenylhydrazine	20	68.0
PX1780	Propiophenone	20	68.0
PX1930	iso-Propyl Myristate	8	46.4
PX2020	Pyridine	11	51.8
SX0035	Salicylaldehyde	2	35.6
TX0110	1,1,2,2-Tetrabromoethane	0	32.0
TX0220	Tetradecane	6	42.8
TX0435	Tetra-iso-propyl Titanate	10	66.2
TX1025	Tributyl Chloride	−18	−0.4
TX1055	1,2,4-Trichlorobenzene	17	62.6
TX1180	Tridecane	−4	24.9
TX1495	Triphenyl Phosphite	24	75.2
UX0035	10-Undecenoic Acid	23	73.4
XX0045	p-Xylene	13	55.4

Table V

The following chemicals are classified as "Reactive Chemicals" by MC/B, and our recommendation is to segregate these from other chemicals in storage. These chemicals should not combine in the event of breakage. With the following chemicals fire and/or explosion is a hazard.

Reactive Chemicals

X-Number	Name
AX1315	Ammonium Nitrate
AX1335	Ammonium Perchlorate
BX0470	Benzoyl Peroxide
BX1685	2-Butanone Peroxide
BX1975	tert-Butyl Hydroperoxide
BX2020	tert-Butyl Peroxide
CX0217	Calcium Hydride
CX0621	Cesium
CX1595	Chromium Nitrate
CX1615	Chromium Trioxide
DX2025	m-Dinitrobenzene
DX2403	Divinylbenzene
HX0540	Hydrazine
HX0555	Hydrazine Hydrate
HX0560	Hydrazine Hydrate 85% in Water
HX0635	Hydrogen Peroxide
LX0075	Lauroyl Peroxide
MX0069A	Magnesium Perchlorate
NX0610	Nitroethane
NX0615	Nitromethane
NX0710	2-Nitropropane
NX0755	o-Nitrotoluene
NX0765	p-Nitrotoluene
PX1020	Phosphorous Red
PX1165	Picric Acid
PX1325	Potassium Metal
PX1381	Potassium tert-Butoxide
PX1520	Potassium Nitrate
PX1540	Potassium Perchlorate
SX0233	Sodium Dispersion
SX0235	Sodium
SX0299	Sodium Azide
SX0415	Sodium Chlorate

SX0435	Sodium Chlorite
SX0440	Sodium Chromate
SX0530	Sodium Dithionite
SX0538	Sodium Ethoxide
SX0635	Sodium Methoxide
SX0640	Sodium Methoxide 25% in Methanol
SX0655	Sodium Nitrate
SX0700	Sodium Peroxide
SX1020	Strontium Nitrate
UX0075	Urea, Compound with Hydrogen Peroxide

▲

WASTE DISPOSAL PROCEDURES *

Each MC/B chemical listed in Part One (alpha-numeric) of this catalog has been classified into one of the waste disposal procedures in this section. As shown in the example below the group classification disposal reference is represented by a ▲ and a number. Refer to the appropriate ▲ and number in this section for a recommended waste disposal procedure.

No warranty, guarantee, or representation is made by MCB Manufacturing Chemists as to the accuracy or sufficiency of any information or recommendation herein. Additional information or measures may be required or desirable because of particular or exceptional conditions or circumstances, or because of applicable federal, state, or local law.

EXAMPLE:

SX1070
Succinyl Chloride ....
MP 16 — 17°
$ClOCCH_2CH_2COCl$ FW 154.99
▲1a ←———————— Disposal Code
DOT-CS
TXDS: *ipr-mus* LD50: 62 mg/Kg

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* Laboratory Waste Disposal Procedures reproduced from the "Guide for safety in the Chemical Laboratory," 1972, with permission of the Manufacturing Chemists Association.

▲1a

Organic Acid Halides

Wear:

Rubber gloves, self-contained breathing apparatus (or work in an effective fume hood with full face shield), laboratory coat.

Spills:

Cover with sodium bicarbonate. If a small quantity is involved, scoop the mixture into a large beaker of water and let stand for a few minutes. Slowly pour into the drain with copious amounts of water. If a large quantity is involved, scoop the resulting bicarbonate mixture into a plastic bag, cardboard box or small fiber drum. This material can then be burned in an incinerator or spread on the ground and flooded with water. The site of the spill should be washed with soapy water.

Package lots:

Slowly sift or pour into a large glass or plastic vessel containing a layer of sodium bicarbonate. Mix thoroughly and add slowly to a large container of water with stirring. Slowly pour this mix down the drain with copious amounts of water.

Examples:

Acetyl bromide
Acetyl chloride
Benzene sulfonul chloride
Benzoyl chloride
Butyryl chloride
Chloroacetyl chloride
3-Chloropropionyl chloride
o-Chlorobenzoyl chloride
Crotonyl chloride
Dichloroacetyl chloride
Oxalyl chloride
Propionyl chloride
Trichloroacetyl chloride

▲1b

Inorganic Halides

Wear:

Rubber gloves, self-contained breathing apparatus (or work in fume hood), laboratory coat. For the more active compounds work from behind a body shield.

Spills:

Cover with excess sodium bicarbonate. If a small quantity is involved, scoop the mixture into a large beaker of water and let stand for a few minutes. Slowly pour into the drain with copious amounts of water. If a large quantity is involved, scoop the resulting bicarbonate mixture into a plastic bag, cardboard box or small fiber drum. This material can then be burned in an incinerator or spread on the ground and flooded with water. The site of the spill should be washed with soapy water.

Package lots:

Sift or pour onto a dry layer of sodium becarbonate in a large evaporating dish. After mixing thoroughly spray with 6M-NH_4OH while stirring. Cover with a layer of crushed ice and stir. Continue spraying with 6M-NH_4OH. When the smoke of NH_4Cl has partly subsided add iced water and stir. Dump this slurry into a large container. Repeat until all has been treated. Neutralize * and slowly siphon the suspension into the drain with excess running water.

Examples:

Aluminum bromide, anhydrous
Aluminum chloride, anhydrous
Chlorosulfonic acid
Ferric chloride, hexahydrate
Germanium tetrachloride
Silicon tetrachloride
Stannic chloride
Tin tetrachloride
Titanium tetrachloride

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* If excess of 6M-NH_4OH has been used, neutralize with 6M-HCl (use litmus paper indicator). If acidic, neutralize with 6M-NH_4OH.

▲2

Aldehydes

Wear:

Rubber gloves, self-contained breathing apparatus, laboratory coat.

Spills:

Eliminate all sources of ignition and flammables.

Small — Absorb on paper towel. Evaporate in fume hood and burn the paper.

Large — Cover with sodium bisulfite ($NaHSO_3$). Add small amount of water and mix. Scoop into large beaker. After one hour wash down the drain with a large excess of water. Wash site with soap solution.

Package lots:

(Choice of Procedures)

1 • Absorb on vermiculite. Burn in an open pit or open incinerator.

2 • Dissolve in a flammable solvent (such as acetone or benzene). Spray into the fire-box of an incinerator equipped with an afterburner.

Examples:

Acetaldehyde
Acrolein
Acrolein dimer
o-Anisaldehyde
Benzaldehyde
Butyraldehyde
Capryladehyde
Chloral
Chloralhydrate
Chloroacetaldehyde
Cinnamaldehyde
Crotonaldehyde
iso-Decaldehyde
2-Ethyl-3-propylacrolein
Formaldehyde
Formalin (MeOH free)
Formalin (15% MeOH)
Furfural
Glutaraldehyde
Glyoxal
Paraformaldehyde
Paraldehyde
Propionaldehyde
Salicylaldehyde
Valeraldehyde

▲3

Alkali and Alkaline Earth Metals, Metal Alkyls, and Alkoxides

Wear:

Leather gloves, large face shield, laboratory coat. (Class D fire extinguisher should be available)

Spills:

Small — Cover with excess dry soda ash. Mix and add slowly to butyl alcohol. After 24 hours dilute and add to drain with large excess of water.

Package lots:

OR Large spill — Mix with dry soda ash. Scoop into a dry bucket. In a remote area spread onto a large iron pan. Cover with scrap wood, paper and ignite with an excelsior train.

OR — Burn in an open pit incinerator.

OR — Direct "dry" steam onto the waste, spread on an iron pan. Beware of splatter.

Examples:

Aluminum alkyls
Aluminum ethoxide
n-Butyllithium
Calcium
Chlorodiethylaluminum
Diethyl zinc
Lithium
Potassium
Sodium
Sodium ethoxide
Sodium methoxide
Sodium-potassium alloys
Triethyl aluminum
Triisobutyl aluminum

▲4a

Chlorohydrins, Nitroparaffins

Wear:

Neoprene gloves, plastic laboratory coat, self-contained breathing apparatus. Provide good ventilation.

Spills:

Eliminate all sources of ignition.

On skin — Wash immediately with soap solution. Rinse thoroughly.

On clothing — Remove clothing immediately and place in a fume hood. Wash clothing before wearing again. Shoes are difficult to decontaminate and may have to be discarded and burned.

On bench and floor — Cover with soda ash. Mix and spray with water. Scoop into a bucket of water. Let stand two hours. Neutralize* and wash into sewer with large excess of water. Wash site with soap solution.

Package lots:

(Choice of Procedures)

1 • Pour or sift over soda ash. Mix and wash slowly into large tank. Neutralize and pass to sewer with excess water.

2 • Absorb on vermiculite. Mix and shovel into paper boxes. Drop into incinerator with afterburner and scrubber.

Examples:

iso-Amyl nitrate
iso-Amyl nitrite
1-Chloro-1-nitropropane
Chloropicrin
Cyclonite-RDX**
1,1-Dichloro-1-nitroethane
EPN
Ethylene chlorohydrin
Ethylene nitrate
Ethyl nitrite
Methyl ethylnitrosocarbamate
Nitroethane
Nitromethane
Nitropropanes
Propyl nitrate
Tetranitromethane

* Neutralize with 6M-HCl.

** Cyclonite-RDX: Burning not recommended except in an area equipped to contain a detonation. Decompose cyclonite-RDX by adding slowly to 25 times is weight of boiling 5% sodium hydroxide. Boil for ½ hour.

▲4b

Organic Halogen and Related Compounds

Wear:

Rubber gloves, self-contained breathing apparatus, laboratory coat.

Spills:

Eliminate all sources of ignition. Absorb on paper towels or with vermiculite. Place on an iron, glass or plastic dish in a hood. Allow to evaporate. Burn the paper or vermiculite. Wash site with soap solution.

Package lots:

(**Choice of Procedures**)

1 • Pour onto vermiculite, sodium bicarbonate or a sand-soda ash mixture (90-10). (If a fluoride is present, add slaked lime to the mixture.) Mix and shovel into paper boxes. Place in an open incinerator. Cover with scrap wood and paper. Ignite with an excelsior train; stay on upwind side. Or dump into a closed incinerator with afterburner.

2 • Dissolve in a flammable solvent. Spray into the fire box of an incinerator equipped with afterburner and scrubber (alkali).

Examples:

Aldrin
Allyl bromide
Allyl chloride
Allyl chloroformate
Allyl iodide
Amyl bromide
Benzal chloride
Benzotrichloride
Benzotrifluoride
Benzyl bromide
Benzyl chloride
Benzyl chloroformate
Bromobenzene
Bromoethane
Bromoethylene
o-Bromotoluene
n-Butyl bromide
n-Butyl chloride
t-Butyl chloride
Chlordane
Chloroacetophenone
Chlorobenzene
Chlorocresols
Chlorodiphenyl
2-Chloro-2-methyl propene
Chloranaphthalene
Chloroprene
Dibutyl dichlorotin
1,4-Dichlorobutane
1,3-Dichloro-2-butene
1,1-Dichloroethylene
1,2-Dichloroethylene
1,2-Dichloropropane
1,3-Dichloropropene
Dieldrin
Diethyl aluminum chloride
Diethyl sulfate
Dimethyl sulfate
Dimethyl sulfoxide
Dodecyl sodium sulfate
Epichlorohydrin
Ethyl bromoacetate
Ethyl chloride
Ethyl chloroacetate
Ethyl chloroformate
Ethylene dibromide
Ethylene dichloride
Ethyl fluoride
Ethyl fluoroacetate
Ethyl iodide
Fluoroethylene
Heptachlor
Hexachlorobenzene
Hexachloronaphthalene
Lindane
Methoxychlor
Methyl bromide
Methyl chloride
Methyl chloroformate
Methyl iodide
Octachloronaphthalene
Octafluro-2-butene
Octafluoropropane
Pentachloroethane
Pentachloronaphthalene
Pentachlorophenol
Propargyl bromide
Propyl bromide
Propyl chloride
Propylene disulfate
Sodium fluoroacetate
Sodium pentachlorophenate
1,2,4,5-Tetrachlorobenzene
Tetrachloroethane
Tetraethyl lead
Tetramethyl lead
Tributyl chlorotin
1,2,4-Trichlorobenzene
Trichloronaphthalene
1,2,3-Trichloropropane
Vinyl chloride
Vinylidene chloride

▲4c

Substituted Organic Acids

Wear:

Rubber gloves, self-contained breathing apparatus or all-purpose canister respirator, laboratory coat.

Spills:

Eliminate all sources of ignition. Turn on the fume hood if acid is volatile. Cover the spill on bench and floor with excess sodium bicarbonate and vermiculite. Mix and scoop into a large beaker of water. When reaction is complete, pour down the drain with a large excess of water. Wash site with soap solution.

Package lots:

(**Choice of Procedures**)

1 • Pour onto excess sodium bicarbonate. Mix and scoop into a bucket. Dump into a 55-gal. drum and fill with water. After 24 hours slowly pour into drain with large excess of water.

2 • Pour onto vermiculite in an open incinerator. Cover with scrap wood and paper. Pour waste alcohol over all and ignite with an excelsior train. Stay on upwind side.

3 • Dissolve in a flammable solvent such as waste alcohol. Spray into an incinerator with an afterburner and scrubber.

Examples:

Benzene sulfonic acid
Bromoacetic acid
Chloroacetic acid
Dichloroacetic acid
Ethylenediamine tetracetic acid (EDTA)
Fluoroacetic acid
Iodoacetic acid
Methanesulfonic acid
Trichloroacetic acid
2,4,5-trichlorophenoxy acetic acid
Trifluoroacetic acid

▲5

Aromatic Amines

Wear:

Butyl rubber gloves, plastic laboratory coat, self-contained breathing apparatus.

Spills:

On skin and clothing — Wash skin with strong soap solution immediately. Rinse thoroughly. Contaminated clothing should be removed, dried, and washed with strong soap solution — or destroyed. It may be necessary to destroy shoes by burning.

Small spills — Absorb liquids on paper towels. Brush solids onto paper. Place in an iron pan and allow evaporation in the fume hood. Add crumpled paper and burn. Wash site with strong soap solution.

Large spills — Cover large spills with sand and soda ash mixture (90-10). Mix and shovel into a cardboard box. Pack with much excess crumpled paper. Burn in an open pit or in an incinerator with afterburners and scrubber.

Package lots:

(Choice of Procedures)

1 • Pour or sift onto a thick layer of sand and soda ash mixture (90-10). Mix and shovel into a heavy paper box with much paper packing. Burn in incinerator. Fire may be augmented by adding excelsior and scrap wood. Stay on upwind side.

2 • Waste may be dissolved in flammable solvent (alcohols, benzene, etc.) and sprayed into fire box of an incinerator with afterburner and scrubber.

Examples:

Acridine
2-Aminodiphenylene oxide
2-Aminopyridine
Aniline
Anisidines
2-anthramine
Auramine
Aziridine
Benzidine ⁎
Benzyl amine
N-4-Biphenyl acetohydroxamic acid
2-Biphenyl amine
Chloroanilines
1,2,5,6-Dibenzacridine
1,2,7,8-Dibenzacridine
2,5,6-Dibenzcarbazole
3,4,5,6-Dibenzcarbazole
Dibenzyl amine
N,N-Diethyl aniline
3,3′-Dimethoxy benzidine ⁎
N,N-Dimethyl aniline
Diphenyl amine
N-Ethyl aniline
Ethyl morpholine
1-Methyl-2-naphthylamine
Morpholine
1-Naphthylamine
2-Napthylamine ⁎
Nicotine
p-Phenylenediamine
Phenylethanolamine
Phenyl-2-napththylamine
Picolines
Pyridine
Quinaldine
Quinoline
8-Quinolinol
4-Stilbenamine
Strychnine
Toluidines
Xylidines

⁎ Carcinogenic

▲6

Aromatic Halogenated Amines and Nitro Compounds

Wear:

Butyl rubber gloves, protective laboratory coat; self-contained breathing apparatus, protective shoes.

Spills:

On skin — Wash with strong soap solution immediately. Rinse well.

Contaminated gloves, clothing, shoes — Remove and clean at once or destroy by burning.

Small spills on tables or floor — Absorb liquid spills on paper towels or vermiculite; sweep solid spills onto paper. Put on an iron pan in the fume hood and allow to evaporate. Burn the paper or vermiculite in the absence of other flammables. Wash the site thoroughly with strong soap solution.

Large spills — Absorb or mix with vermiculite, odium bicarbonate or sand. Package this in a paper carton and burn in an open pit. Use fuel such as crumpled paper and wood splinters. Wash site thoroughly as above.

Package lots:

(Choice of Procedures) ⁎ ⁎ ⁎

1 • Pour or sift onto sodium bicarbonate or a sand-soda ash mixture (90-10). Mix and package in heavy paper cartons with plenty of paper packing to serve as fuel. Burn in an incinerator. Fire may be augmented with scrap wood.

2 • The packages of #1 may be burned more effectively in an incinerator with afterburner and scrubber (alkaline).

3 • The waste may be mixed with a flammable solvent (alcohol, benzene, etc.) and sprayed into the fire chamber of an incinerator with afterburners and scrubber.

Examples:

Brucine
Carbazole
1-Chloro-2,4-dinitrobenzene
Chloro-2-napthylamine
Chloro-nitroanilines
Chloro-nitrobenzene
Chlorophenols
2,6-Dibromo-N-chloro-p-benzoquinonimine
2,5-Dichloroaniline
Dichlorobenzene
3,3′-Dichlorobenzidine ⁎
1,3-Dichloro 5,5-dimethylhydantoin
2,4-Dichlorophenol
2-Dimethylaminofluorene
9,10-Dimethyl-1,2-benzanthracene
N,N-Dimethyl-4-biphenylamine
Dinitroaniline
m-Dinitrobenzene ⁎ ⁎
o-Dinitrobenzene ⁎ ⁎
p-Dinitrobenzene ⁎ ⁎
4,6-Dinitro-o-cresol
2,7-Dinitrofluorene
2,4-Dinitrophenol ⁎ ⁎
1,4-Dinitropiperazine
2,4-Dinitrotoluene ⁎ ⁎
Elon
Endrin
4-Ethoxy-2-nitroaniline
N-2-Fluorenylacetamide
4-Fluoro-4-biphenylamine
2′-Fluoro-4′-phenylacetanilide
4‴-Fluoro-4′-phenylacetanilide
Methylene bi-phenylisocyanate
Methyl isothiocyanate
N-Methyl-N-nitrosoacetamide
N-Methyl-N-nitrosoallylamine
N-Methyl-N-nitrosoaniline
N-Methyl-N-nitrosobenzylamine
1-Methyl-1-nitrosourea
N-Methyl-N-nitrosovinylamine
1-Methyl pyrole
N-Methyl-N-2,4,6-tetranitroaniline
3-Nitroacetophenone
m,o-,p-Nitroanilines
Nitrobenzene
Nitrobiphenyl
2-Nitrofluorene
α-Nitronaphthalene
Nitrophenols
4-Nitroquinoline-N-oxide
N-Nitroso-N-methylaniline
4-Nitrosomorpholine
1-Nitrosopiperazine
N-Nitrosopiperidine
m-,o-,p-Nitrotoluenes
Picric acid ⁎ ⁎
Piperidine
Tetrachloronaphthalene
N,N,N′,N′-Tetramethyl-3,3′-dimethoxybenzidine
N,N,N′,N′-Tetramethylenediamine
Toluene-2,4-diisocyanate
Trinitrobenzene ⁎ ⁎
Trinitrotoluene ⁎ ⁎

⁎ Carcinogenic.
⁎ ⁎ Explosive. Other nitro compounds may also be unstable.
⁎ ⁎ ⁎ Destruction by chemical decomposition is recommended for dinitro, trinitro and other compounds with explosive potential.
Add the material slowly, while stirring, to 30 times its weight of a solution prepared by dissolving 1 part sodium sulfide ($Na_2S.9H_2O$) in 6 parts of water.
For unstable acidic materials (e.g. Picric acid), dissolve in 25 times its weight of a solution made from 1 part sodium hydroxide and 21 parts sodium sulfide in 200 parts of water. Some H_2S and NH_3 is evolved.

▲7a

Aliphatic Amines

Wear:

Butyl rubber gloves, face shield or all-purpose canister respirator, laboratory coat.

Spills:

Liquid or solid — Cover with sodium bisulfate. Spray with water and wash into drain with large excess of water.

Package lots:

(Choice of Procedures)

1 • Add the contaminated amine to a layer of sodium bisulfate in a large evaporating dish. Spray with water. Make neutral and wash into the drain with large excess of water.

2 • Dissolve in a flammable solvent (e.g., waste alcohols). Burn in an open pit by means of an excelsior train. Stay on the upwind side.

3 • Solution of #2 may be sprayed into the fire box of an incinerator with afterburner and scrubber.

Examples:

Allyl amine
Amyl amine
Aminoethylethanolamine
Butyl amine
iso-Butyl amine
Tert-Butyl amine
Cyclohexylamine
Dibutyl amine
Dicyclohexylamine
Diethanolamine
Diethylamine
2-Diethyl aminoethanol
Diethylenetriamine
Diisopropylamine
Dimethylamine
Ethanolamine
Ethylamine
Ethylene diamine
N-Ethyl-N-nitroso-N-butylamine
N-Ethyl-N-N nitrosovinylamine
n-Heptylamine
Hexamethylenetetramine
1-6-Hexanediamine
Hydroxylamine
Hydroxylamine hydrochloride
Lutidine
N-Methylbutylamine
Monomethylamine
N-Nitrosodiethanolamine
N-Nitrosodimethylamine *
1,3-Propanediamine
Propyl amines
Propylene imine
Pyrrolidine
Tetraethylenepentamine
Triamylamine
Tri-n-butylamine
Tri-ethylamine
Triethanolamine
Triethylene tetramine
Trimethylamine
Tripropylamine

* *Carcinogenic.*

▲7b

Organic Phosphates and Related Compounds

Wear:

Rubber gloves, self-contained breathing apparatus, laboratory coat.

Spills:

Absorb with vermiculite or paper towels. Scoop the mixture into a plastic bag. Take bag outside to incinerator or pad and burn. If an incinerator is not available, set the bag in a pan of waste flammable solvent and burn.

Package lots:

(Choice of Procedures)

1 • Take packages to an open incinerator. Stay on upwind side and mix with equal parts of sand and pulverized limestone. Wet down with a flammable solvent (benzene or alcohol). Ignite from a safe distance with an excelsior train.

2 • Shovel mixture of #1 into a paper box and drop into an incinerator with an efficient afterburner. Alkaline scrubbing will prevent escape of any oxides of phosphorous and arsenic.

Examples:

o-Chlorophenyl diphenyl phosphate
Dibutyl phosphate
Dibutyl phosphite
Dichlorophenyl phosphine
Diethyl ethyl phosphate
Diisopropyl fluorophosphate
Dimethyl-1,2-dibromo-2,2-dichloroethyl phosphate
Grain fumigants
Hydroxy dimethyl arsine oxide
Malathion
Methyl parathion
1-Napthylisothiocyanate
Parathion
Phosdrin
Ronnel
Systox
Tetraethyldithionopyrophosphate
Tetraethylpyrophosphate
Tributyl phosphate
Triphenyl phosphate
Triphenyl phosphine
Tritolyl phosphate

▲8

Azides and Azo-Compounds

The organic azides and heavy metal azides are explosive. Alkali and alkaline earth azides are not considered explosive under normal laboratory conditions.

Keep stock of all azides very low. Stamp date and receipt on package.

Wear:

Leather gloves, heavy face shield, laboratory coat. Work from behind a barricade (body shield or wall). Avoid unnecessary heat, friction or impact.

Small spills:

Absorb the liquid on paper or with vermiculite. If it is a solid, dampen and brush onto paper with great care. Place in plastic bag and take outside for burning.

OR

Sponge up with water, followed by decontamination with a 10% ceric ammonium nitrate solution.

Large spills or Package lots:

(Choice of Procedures)

"Kill" by adding to a greater-than-stoichiometric amount of ceric ammonium nitrate solution (without acid) and agitation sufficient to provide suspension of all solids. Cool the reaction.

Examples:

2,2′-Azonaphthalene
Azoxybenzene
Diazo methane
Dimethyl amino azo benzene-2-napthalene
2,3-Dimethylazobenzene
Hydrazoic acid
3-Methyl-4-dimethyl amino-azobenzene
1-Phenylazo-2-naphthol
1-Ortho-tolylazo-2-naphthol
Sodium azide

▲9

Carbon Disulfide

Wear:

Rubber gloves, safety glasses, laboratory coat. If hood is not available wear self-contained breathing apparatus. Carbon dioxide fire extinguisher should be available.

Spills:

Eliminate flammables and all sources of ignition. Allow to evaporate or absorb with paper towels and evaporate in hood on an iron pan or glass dish. Burn the paper.

Package lots:

All equipment or contact surfaces should be grounded to avoid ignition by static charge. Absorb on vermiculite, sand, or ashes and cover with water. Transfer under water in buckets to an open area. Ignite from a distance with an excelsior train. If quantity is large, carbon disulfide may be recovered by distillation and repackaged for use.

▲10

Caustic Alkali and Ammonia

Wear:

Rubber gloves, large face shield (wear all-purpose or special canister respirator for NH_3 ∗), Laboratory coat.

Spills:

Solid — Sweep up, dilute and neutralize with 6M-HCl in a large bucket. Wash down drain with large excess of water.
Solution — Neutralize and mop up — or use water-vac. Discharge to sewer with large excess of water.

Package lots:

Pour into large tank of water and neutralize. Transfer to sewer with large excess of water.

Examples:

Ammonia, anhydrous
Ammonia, aqua
Calcium hydroxide (slaked lime)
Calcium oxide (quick lime)
Potassium hydroxide (caustic potash)
Sodium hydroxide (caustic soda)

▲11

Inorganic Salts

Wear:

Rubber gloves, safety glasses, laboratory coat.

Spills:

1 • Solutions — Cover with soda ash, mix and scoop into a beaker of water. Neutralize with 6M-HCl and wash down drain with excess water.
2 • Solids — Collect in a beaker. Dissolve in large amount of water. Add soda ash, mix and treat as above. If spill contains a fluoride, add slaked lime in addition to the above treatment.

Package lots:

Add slowly to a large container of water. Stir in slight excess of soda ash. If fluoride is present add slaked lime also. Let stand 24 hours. Decant or siphon into another container and neutralize with 6M-HCl before washing down drain with large excess of water. The sludge may be added to land fill.

Examples:

Alums
Aluminum chloride, hydrate
Aluminum nitrate, hydrate
Aluminum sulfate, hydrate
Ammonium fluoride
Ammonium nitrate
Ammonium thiocyanate
Chromic (III) salts, hydrates
Cobaltous nitrate
Copper nitrate
Cuprous chloride
Ferrous Ammonium sulfate
Ferrous chloride
Ferrous sulfate
Lithium carbonate
Magnesium nitrate
Manganese sulfate
Molybdenum compounds
Nickel nitrate
Nickel sulfate
Potassium acetate
Potassium carbonate
Potassium ferrocyanide
Potassium fluoride
Potassium hydrogen difluoride
Potassium nitrate
Sodium acetate
Sodium benzoate
Sodium fluoride
Sodium formate
Sodium hydrogen difluoride
Sodium iodide
Sodium nitrate
Sodium propionate
Sodium silicate
Sodium tetraborate
Stannic chloride, hydrate
Zinc acetate
Zinc chloride (sol.)

▲12a

Oxidizing Agents

Wear:

Rubber gloves, face shield, laboratory coat. Body shield should be available for the more active agents. Replace face shield with self-contained breathing apparatus for such agents as chlorine and bromine.

Spills:

1 • Gas leak: If the valve is leaking because it cannot be closed (a common occurrence). the gas can be bubbled through a reducer (sodium sulfite) and excess sodium bicarbonate solution. Be sure to include a trap in the line to prevent the solution being sucked back into the cylinder. If this cannot be done, the cylinder should be placed in or adjacent to a fume hood and left to bleed off.

For fluorine gas do not use a solution. Use a scrubber filled with solid bicarbonate, soda lime or granulated charcoal.

2 • If the oxidizer is a liquid or a solid — Cover with a reducer (hypo, a bisulfite, or a ferrous salt but not carbon, sulfur or strong reducing agents). Mix well and spray with water. A sulfite or a ferrous salt will require addition of some $3M-H_2SO_4$ to promote rapid reduction. Scoop slurry into a container of water and nuetralize with soda ash. Wash down the drain with excess water. Wash site thoroughly with a soap solution containing some reducer.

Package lots:

Add to a large volume of concentrated solution of reducer (hypo, a bisulfite or a ferrous salt and acidify with $3M-H_2SO_4$). When reduction is complete add soda ash or dilute hydrochloric acid to neutralize the solution. Wash into drain with large excess of water.

Examples:

Ammonium dichromate
Ammonium perchlorate
Ammonium persulfate
Barium chlorate
Bromic acid
Bromine
tert-Butyl chromate
Bromic acid
Bromine
Calcium chlorate
Calcium hypochlorite
Chloric acid
Chlorine
Chlorine dioxide
Cleaning solution (acid dichromate)
Chromium oxide
Chromium oxychloride
Fluorine
Iodine
Magnesium chlorate
Magnesium perchlorate
Nitrogen trifluoride
Nitrosyl chloride
Nitrosyl sulfuric acid
Peracetic acid
Perchloric acid
Potassium and sodium perchlorates, chlorates, chlorites, dichromates, hypochlorites, per-manganates, persulfates
Zinc chlorate

▲12b

Reducing Substances

Wear:

Rubber gloves, safety glasses, laboratory coat. Work in hood or wear a respirator.

Spills:

Gas leak — Eliminate all sources of ignition. If the valve is leaking because it cannot be closed, the gas can be bubbled through a calcium hypochlorite solution. Be sure to include a trap in the line to prevent the solution being sucked back into the cylinder.

Solid — Cover spill with soda ash or sodium bicarbonate. Mix and spray with water. If effervescent wait until reaction is complete. Scoop into a large beaker and cautiously add equal volume of calcium hypochlorite (reaction may be vigorous). Add more water, stir, and allow to stand for one hour. Dilute and neutralize* the oxidized solution and transfer to the drain with excess of water.

* Test with litmus. Neutralize with 6M-HCl or 6M-NaOH as required.

Package lots:

If a gas,** bubble into soda ash solution. If a solid, mix with equal volume of soda ash and add water to form a slurry in a large container. In either case add calcium hypochlorite. Add more water if necessary and let stand two hours. Neutralize* the oxidized solution. Wash down drain with large excess of water.

Examples:

Chromous salts
Sodium bisulfite
Sodium nitrite
Sodium sulfite
Sodium thiosulfate
Stannous chloride
Sulfur dioxide

** If a tank or reducing gas has developed a permanent leak lower it upside down into a drum filled with water. Add a mixture of soda ash and calcium hypochlorite. Continue the treatment until the tank is empty and the drum contains a solution of stable element or compound.

▲13

Mercaptans-and Organic Sulfides

Wear:

Rubber gloves, self-contained breathing apparatus, laboratory coat.

Spills:

Eliminate all sources of ignition. Cover with calcium hypochlorite and mix. Scoop into a large beaker. After 12 hours, neutralize* if necessary. Wash to sewer with excess water. Wash site of spill with strong soap solution to which has been added some hypochlorite.

Package lots:

1 • As for spills.
2 • Dissolve in waste alcohol or other flammable solvent. Burn in an incinerator with an afterburner and scrubber to neutralize the SO_2.

* Test with litmus. Neutralize with 6M-HCl or 6M-NH_4OH as required.

Examples:

Allyl propyl disulfide
Amyl mercaptan
Benzyl mercaptan
Butyl mercaptan
Carbonyl sulfide * *
Crag 974
Dimethyl sulfide
Diphenyl sulfide
Ethanethiol
Ferbam
2-Mercaptoethanol
Methyl mercaptan * *
Perchloromethyl mercaptan
Thioacetamide
2,2-Thiodiethanol
Thioglycolic acid
Thiophene
Thiourea
Tetramethylthiuram disulfide (Thiram)

* * If quantity is large, seal and return container to the supplier. If small, allow it to dissipate in a fume hood.

▲14

Cyanides and Nitriles

Wear:

Long rubber gloves, self-contained breathing apparatus, laboratory apron or coat.
Evacuate the laboratory and isolate the area during decontamination.

Spills:

Eliminate all sources of ignition and flammables.
1 • General treatment:
(a) Absorb liquid with vermiculite or on paper towel (sweep solid onto paper). Place on an iron or glass dish in a hood. Evaporate and burn paper.
(b) On skin — Wash away immediately with much soap and water.
2 • Hydrocyanic acid (HCN) leak: *
Turn on fume hood. Allow gas to leak into a container of sodium hydroxide solution while stopping leak. * * Add excess calcium hypochlorite to the alkali cyanide. Discharge the cyanate into the drain with excess water.

* If the leak cannot be stopped set the tank upside down in a drum filled with a strong solution of sodium hydroxide and calcium hypochlorite. Continue the treatment until the tank is empty.
* * Avoid possibility of suck back of alkaline material into liquid HCN.

3 • Cyanides:
(a) Scoop into a larger beaker and make alkaline with sodium hydroxide solution. Add to the slurry an excess of ferrous sulfate solution. After one hour, flush down the drain with excess water.
OR
(b) Add excess sulfur to the alkaline slurry of the cyanide. Heat to convert to thiocyanate. Flush down drain with excess water.
4 • Nitriles:
Add excess of sodium hydroxide and calcium hypochlorite solution to produce a cyanate. Scoop slurry into a large beaker. After one hour flush down the drain with excess water. Wash site with soap solution containing some hypochlorite.

Package lots:

(Choice of Procedures)
1 • Add the cyanide with stirring to strong alkaline solution of calcium hypochlorite. Maintain an excess sodium hydroxide and calcium hypochlorite. Let stand 24 hours. Flush the cyanate down drain with large excess of water.
2 • Nitriles are more effectively converted to soluble sodium cyanate by treating with excess alcoholic sodium hydroxide. After about one hour evaporate the alcohol and then add calcium hypochliorite. Maintain an excess of the hydroxide and hypochlorite. After 24 hours flush the cyanate down the drain with a large excess of water.

Examples:

Acetone cyanohydrin
Acetonitrile
Acrylonitrile
Adiponitrile
Benzonitrile
Benzyl cyanide
Butyl nitrile
n-Butyronitrile
Calcium cyanide
Chloroacetonitrile
Crotononitrile
Cuprous cyanide
Cyanamide
Cyanoacetamide
Cyanogen
Cyanogen chloride
Ethyl cyanoacetate
Hydrocyanic acid
Lactonitrile
Potassium cyanide
Propionitrile
Sevin
Sodium cyanide
Succinonitrile
Tetramethyl-succinonitrile
Trichloroacetonitrile

▲15

Ethers

Wear:

Rubber gloves, large heavy face shield (if in doubt use body shield also). Self-contained breathing apparatus.

Spills:

Eliminate all sources of ignition and flammables. Absorb on paper towel. Evaporate from an iron pan in a hood. Allow time for vapors to completely escape the hood vents, then burn the paper.
If large spill, absorb on much more paper or vermiculite and allow complete evaporation from all surfaces. Use same precaution before burning paper.

Package lots:

1 • Pour on ground in open area. Allow evaporation or ignite from a distance by means of a long fuse or excelsior train.
2 • Dissolve waste in higher alcohol (e.g., butyl), benzene, or petroleum ether. Incinerate.
3 • Peroxide Formation. Ether of long standing in contact with air and exposed to light may contain

peroxides, especially if stored in clear glass. Explosions have occurred when caps or stoppers were turned. Transport cans or bottles to an isolated area (e.g., deserted quarry). Each container should be wrapped in padding material or packed in sawdust. At site uncover containers and arrange an excelsior train. From a safe distance puncture the cans near bottom with rifle fire. Ignite excelsior train. Local regulations must be observed.

Examples:

Allyl glycidyl ether
n-Amyl ether
Anisole
n-Butyl glycidyl ether
Butyl vinyl ether
Di-n-butyl ether
Chloromethyl ether
2,2-Dichloroethyl ether
1,1-Diethoxyethane
Diethylene glycol monoethyl ether
Diglycidyl ether
Diisopropyl ether
Dimethoxy ethane
Dimethoxy methane
Dimethoxy propane
Dipropylene glycol methyl ether
1,2-Epoxy-3-phenoxy-propane
1,2-Epoxy-propane
Ethoxy acetylene
Ethyl ether
Ethyl vinyl ether
Ethylene oxide
Glycidol
Guaiacol
Hydroquinone monomethyl ether
Methyl ether
Methyl ethyl ether
Methyl vinyl ether
Phenyl ether
Phenyl ether-biphenyl mixture
iso-Propyl ether
iso-Propyl glycidyl ether
Tetrahydrofuran
Vinyl ether

▲16

Hydrazines

Wear:

Rubber gloves, self-contained breathing apparatus. Impervious clothing recommended. Body shield should be available.

Spills:

Eliminate all sources of ignition and flammables.

1 • On skin or clothing — Wash skin immediately. Remove contaminated clothing at once.

2 • Absorb liquid with vermiculite or paper towels. Scoop mixture, paper or solids into a plastic bag and take to a burning pit or incinerator for burning.

3 • Large spills — Collect the liquid with an aspirator such as used for recovering spilled mercury. Empty into a large beaker and neutralize with dilute sulfuric acid. Wash to drain with excess water. Wash site with soap and water.

Package lots:

(Choice of Procedures)

1 • Dilute to at least 40% and neutralize with dilute sulfuric acid. Flush to sewer with excess water.

OR

2 • Dissolve in large volume of waste alcohol or other flammable solvent and burn in an open pit. Ignite from a distance with an excelsior train.

Examples:

1,1-Dimethyl hydrazine (UDMH)
Hydrazine
Hydrazine salts
Methyl hydrazine
Phenyl hydrazine

▲17

Hydrides

Wear:

Rubber gloves, fire proof clothing, face shield. Work from behind body shield where possible. Keep available pulverized dolomite or dry graphite for fire fighting.

Spills:

Eliminate all sources of ignition. Scoop in dry plastic bag which has first been purged to inert gas. Remove to the outside for burning. Flood the burned residues with water to ensure complete destruction of hydrides.

Package lots:

(Choice of Procedures)

1 • Mix with dry sand to avoid or stop fire. Scoop into bucket and remove to open area. Slowly spray with dry butyl alcohol. Later add water by fogging until last of hydride is destroyed. Scoop the solid into a large container. Neutralize* with 6M-HCl. Let settle. Decant and flush to sewer with excess of water. Send sand residue to land fill. If the hydride is a gas (e.g. diborane, silane, germanium hydride), dispose of it by controlled burning.

2 • Burn in iron pan or in open pit.

Examples:

Aluminum borohydride
Calcium hydride
Decaborane
Diborane
Germanium hydride
Lithium aluminum hydride
Lithium borohydride
Lithium hydride
Pentaborane
Potassium borohydride
Potassium hydride
Silane
Sodium amide
Sodium borohydride
Sodium hydride

* Test with litmus — neutralize with 6M HCl if necessary.

▲18

Hydrocarbons, Alcohols, Ketones, and Esters.

Wear:

Rubber gloves, face shield, laboratory coat. Have all-purpose canister mask available.

Spills:

Eliminate all sources of ignition and flammables.

1 • A gas leak from a faulty tank — Keep

concentration of gas below the explosive mixture range by forced ventilation. Remove tank to an open area and allow dissipation to the atmosphere. Attempt to cap the valve outlet and return tank to the supplier.

2 • A liquid — Abosrb on paper. Evaporate on an iron pan in a hood. Burn the paper.

3 • A solid — Sweep onto paper and place in an iron pan in the hood. Burn the paper and compounds.

Package lots:

1 • A gas — Pipe the gas into the incinerator. Or lower into a pit and allow it to burn away.

2 • A liquid — Atomize into an incinerator. Combustion may be improved by mixing with a more flammable solvent.

3 • A solid — Make up packages in paper or other flammable material. Burn in the incinerator. Or the solid may be dissolved in a flammable solvent and sprayed into the fire chamber.

Examples:

Acenaphthene
Acetone
Acetylene
Alizarin dye
Allene
Allyl acetate
Allyl alcohol
n-Amyl acetate
iso-Amyl acetate
sec-Amyl-acetate
n-Amyl-alcohol
iso-Amyl alcohol
tert-Amyl alcohol
Amylene
iso-Amyl formate
Anthracene
Anthraquinone
1,2-Benzanthracene
Benzene
Benzyl acetate
Butyl methacrylate
iso-Butyl methyl ketone
p-tert-Butyl toluene
1-Butyne
2-Butyrolactone
Camphor
Carbon monoxide
Cellosolve
Cellosolve acetate
Cresols
Creosote
Croton oil
Crude oil
Cumene
Cycloheptanone
Cyclohexane
Cyclohexanol
Cyclohexanone
Cyclohexene
Cylohexyl benzene
Cyclopentadiene
Cyclopentane
Cyclopentanone
Cyclopropane
p-Cymene
3,4,8,9-Dibenzpyrene
Dibutyl tin dilaurate
Dibutyl oxalate
Dibutyl phthalate
Dicyclopentadiene
Diethyl adipate
Diethyl carbonate
Diethylene glycol
Diethyl ketone
Diethyl malonate
Diethyl phthalate
3,4-Dihydropyran
Diisobutyl ketone
2,2-Dimethyl butane
Dimethyl carbonate
1,2-Dimethyl chrysene
Dimethyl fumarate
Dimethyl naphthalene
Dimethyl propane
Dimethyl phthalate
Di-n-octyl phthalate
Di-sec-octyl phthalate
1,4-Dioxane
Dipentene
Dipentene monoxide
Diphenyl methane
Dodecane
Ethane
Ethanol
Ethyl acetate
Ethyl acetoacetate
Ethyl acrylate
Ethyl alcohol
Ethyl-sec-amyl ketone
Ethyl benzene
Ethyl benzoate
Ethyl butyl ketone
Ethyl butyrate
Ethyl crotonate
Ethylene
Ethylene glycol
Ethyl formate
2-Ethyl hexanol
Ethyl lactate
Ethyl oxalate
p-Ethyl phenol
Ethyl silicate
Decahydronaphthalene
n-Decane
n-Decyl alcohol
Diacetone alcohol
1,2,5,6-Dibenzanthracene
1,2,5,6-Dibenzofluorene
Benzyl alcohol
Benzyl benzoate
Biphenyl
Borneol
Butadiene
n-Butane
iso-Butane
1-Butene
2-Butene
n-Butyl acetate
iso-Butyl acetate
sec-Butyl acetate
tert-Butyl acetate
n-Butyl alcohol
iso-Butyl alcohol
sec-Butyl alcohol
tert-Butyl alcohol
Butyl cellosolve
n-Butyl formate
iso-Butyl formate
Furfuryl alcohol
Gasoline
Glycerol
Greases
Heptane
Hexane
n-Hexanol
1-Henene
2-Hexene
sec-Hexyl acetate
p-Hydroquinone
5-Indanol
Industrial gases (LHG)
Isoprene
Jet fuels
Kerosene
Ketene
Lacquer diluent
Ligroin
Liquefied petroleum gas
p-Mentha-1,8-diene
Mesityl oxide
Methane
Methyl acetate
Methyl acrylate
Methyl alcohol
Methyl amyl alcohol
Methyl-n-amyl ketone
6 Methyl-1,2-benzanthracene
10 Methyl-1,2-benzanthracene
Methyl benzoate
1,2,3,4-Dibenzophenanthrene
Octane
1-Octanol
2-Octanol
Oil, cocoanut
Oil, fuel
Oil, lubricating
Oil, mineral
Oil, olive
Oil, peanut
Oil, soybean
Furan
Phenanthrene
Phenol
Phenyl acetate
Phenyl isocyanate
o-Phenyl phenol
Phorone
iso-Phorone
Phosgene solutions in benzene
Pindone (Pival)
2-Pinene
Piperylene
Polyvinyl acetate emulsion
Propane
1,2-Propanediol
Propargyl alcohol
iso-Propenyl acetate
iso-Propyl acetate
n-Propyl acetate
n-Propyl alochol
iso-Propyl alochol
Propyl benzene
iso-Propyl benzoate
Propylene
Propylene carbonate
Porpyl formate
iso-Propyl formate
Propyne
Methyl benzyl alcohol
2-Methyl-1-butene
2-Methyl-2-butene
3-Methyl-1-butene
Methyl butyl ketone
Methyl butyrate
Methyl cellosolve
Methyl cellosolve acetate
3-Methyl cholanthrene
Methyl cyclohexane
2-Methyl cyclohexanol
2-Methyl cyclohexanone
4-Methyl cyclohexene
Methyl ethyl ketone
Methyl formate
2-Methyl furan
Methyl isobutyl ketone
Methyl isobutyrate
Methyl isocyanate
Methyl methacrylate
1-Methyl naphthalene
Methyl-n-propyl ketone
Methyl salicylate
Methyl styrenes
Methyl-toluene sulfonate
Naphthas
Naphthalene
1-Napthol
2-Naphthol
Natural gas
Nickel carbonyl
Nonyl phenol
Oil, vegetable
Paraffin
n-Pentane
iso-Pentane
1,5-Pentanediol
2,4-Pentandeione
2-Pentanol
Petroleum ether
Propyne-allene mixture
Quinone

Resorcinol
Rotenone
Stoddard solvent
Styrene
Tall oil
Tallow
Terphenyis
Tetradecane
Tetrahydronaphthalene
1-Tetralone
Toluene
Tridecanol
Triethylene glycol
Triethyl-ortho-formate
5,9,10-Trimethyl-1,2-benzanthracene
6,9,10-Trimethyl-1,2-benzanthracene
Trimethyl borate
2,2,4-Trimethyl pentane
2,4,4-Trimethyl-2-pentene
1,3,5-Trioxane
Turpentine
Varnish
Vinyl acetate
Warfarin
Xylenes
Xylenois

▲19

Inorganic Amides and Derivatives

Wear:

Rubber gloves, large face shield, protective laboratory coat. A large body shield should be available.

Spills:

Eliminate all sources of ignition. Sweep up solid amide onto dry paper. Cautiously add to cold water in small portions with agitation. Neutralize* and discharge into drain with large excess of water.

Package lots:

Sift slowly into a large container of cold water, with agitation. When all has reacted, neutralize* and pour into drain with large excess of water.

Examples:

Ammonium sulfamate
Monochloroamine
Sulfamic acid
Sulfamide

* Test with litmus. Neutralize with 3M-HCl or 6M-NH_4OH as required.

▲20

Organic Amides

Wear:

Rubber gloves, safety glasses, laboratory coat.

Spills:

Scoop into a plastic bag or onto a paper towel. Remove to the outside, add alcohol and burn in a safe place.

Package lots:

Add to a flammable solvent (alcohol or benzene). Pour into an iron pan in an open pit. Ignite.

OR

Spray into an incinerator. Oxides of nitrogen may be scrubbed out with alkaline solution.

Examples:

Acetamide
Chloroacetamide
N,N-Dimethylacetamide
Dimethylformamide
Ethyl Acetanilide
Formamide
2-Phenanthreneacetamide
3-Phenanthreneacetamide

▲21

Inter Non-Metallic Compounds

Wear:

Long rubber gloves, safety glasses or goggles, self-contained breathing apparatus, laboratory coat. Recommended that work be done in an effective hood from behind a body shield or in an open barricaded area out of doors. NOTE — Some suppliers will collect unwanted cylinders of compressed gases on request.

Spills:

Eliminate all sources of ignition.

Gas leak (e.g., boron trichloride, chlorine trifluoride). Allow gas to flow into a mixed solution of caustic soda and slaked lime. If possible, keep in a hood until cylinder is emptied.

Liquid or solid — Cover with vermiculite, sodium bicarbonate or a mixture of soda ash and slaked lime (50-50). Mix and spray water cautiously from an atomizer. Scoop up and add slowly to a large container of water (if too active continue spraying). When reaction is complere neutralize* and wash down the drain with a large excess of water. Wash site with soap solution.

Package lots:

Sprinkle or sift onto a thick layer of mixed dry soda ash and slaked lime (50-50) from behind a body shield. Mix and spray water cautiously with an atomizer. Scoop up and sift cautiously into a large volume of water. Neutralize* and wash down the drain with large excess of water.

Examples:

Boron fluoride-ethyl ether complex
Boron tribromide
Boron trichloride
Boron trifluoride
Boron trifluoride complexes with acetic acid and methanol
Bromine pentafluoride
Bromine trifluoride
Carbonyl Fluoride
Chlorine trifluoride
Iodine chloride
Iodine pentafluoride
Iodine trichloride
Nitric oxide
Nitrogen dioxide
Oxygen difluoride
Perchloryl fluoride
Phosgene
Phosphorus oxychloride
Phosphorus pentachloride
Phosphorus pentasulfide
Phosphorus sesquisulfide
Phosphorus tribromide
Phosphorus trichloride
Silicon tetrafluoride
Sulfur decafluoride
Sulfur dichloride
Sulfur monochloride
Sulfuryl chloride
Sulfuryl fluoride
Thionyl chloride
Thionyl fluoride

* Make litmus test. Neutralize with 6M-NH_4OH or 6M-HCl as required.

▲22a

Peroxides, Inorganic

Wear:

Rubber gloves, large face shield, laboratory coat. A body shield should be available.

Spills:

Cover with at least double volume of sand-soda ash mixture (90%-10%). Mix thoroughly and break up any lumps of peroxide. With a plastic scoop add slowly to a large beaker of sodium sulfite solution (3 or 4 liters) with stirring. Neutralize with dilute sulfuric acid. When settled decant the sulfate solution into drain with excess water. The sand can be sent to the landfill.

Hydrogen Peroxide (spill or package lots): Dilute and wash down drain with excess of water.

Package lots:

Use the above method for the encrusted impure peroxide. Repackage any recovered pure granular peroxide in glass containers with rubber stoppers.

Examples:

Hydrogen peroxide (3% to 90%)
Potassium peroxide
Sodium peroxide

▲22b

Peroxides, Organic

CAUTION: Keep stock low and date each container as received. Never transfer to glass stoppered containers or screw cap bottles which can cause dangerous friction. See Procedure 15.

Wear:

Rubber gloves, large heavy face shield, laboratory coat. Work from behind heavy body shield in hood.

Spills:

Eliminate all sources of ignition.

1 • Liquid peroxide spills may be absorbed in large quantity of vermiculite or sand. Using a soft plastic scoop, carefully place the mixture in a plastic container. Spread on a steel pan or in a deep pit. Ignite from a distance with an excelsior train or a long torch. Wash the scoop and container with 30% $FeSO_4H_2O$. Burn the original cartons and bags.

2 • Solid peroxide spills should be mixed with a large volume of vermiculite or sand. Cautiously transfer as above and burn.

3 • A very small quantity of #1 or #2 may be destroyed by adding 10 volumes of 20% NaOH. After 24 hours, neutralize* and pass into drain with large excess of water.

Package lots:

Absorb or mix in small portions on vermiculite or sand. Wet down with 10% NaOH. Scoop up with plastic scoops and take to open-incinerator pit. When dry, ignite from a distance with an excelsior train.

Examples:

Acetyl peroxide
Benzoyl peroxide
Butyl hydroperoxide
tert-Butyl peracetate
tert-Butyl perbenzoate
tert-Butyl peroxy pivalate
Cumene hydroperoxide * *
3,4-dichlorobenzoyl peroxide
Diisopropyl peroxy dicarbonate
Di-tert-butyl peroxide
Lauroyl peroxide
Methyl ethyl ketone peroxide

* Neutralize with 6M-HCl

* * For CHP — mix the hydroperoxide with 10 vols. of 30% solution of $FeSO_4$—H_2O. Remix intermittently for 2 hours and the CHP should be completely converted to the corresponding alcohol. Flush to sewer with large excess of water.

▲23

Sulfides, Inorganic

Wear:

Rubber gloves, safety glasses. Work in hood or wear self-contained breathing apparatus, laboratory coat.

Spills:

Eliminate all sources of ignition. Add $FeCl_3$ solution. Stir until FeS formation is complete. Add slight excess of soda ash. Scoop up and wash into drain with excess water. Wash site with soap solution.

OR

Absorb with vermiculite or sodium bicarbonate and scoop into plastic bag or wide-mouthed glass jar. Close tightly, remove to safe place outside and add $FeCl_3$ solution. Stir until reaction is complete. Add slight excess sodium bicarbonate and wash into drain with excess water.

Package lots:

Add to a large volume of $FeCl_3$ solution with stirring. Add more $FeCl_3$ if necessary. Add soda ash with stirring until neutral. Scoop up and wash down the drain with excess water.

Note: If a gas (e.g., H_2S) seal the cylinder and return to supplier. If the valve is leaking the gas can be bubbled through a $FeCl_3$ solution. Be sure to include a trap in the line to prevent the solution being sucked back into the cylinder. If this cannot be done, the cylinder should be placed in or adjacent to a fume hood and left to bleed off.

Examples:

Ammonium polysulfide
Ammonium sulfide
Calcium sulfide
Hydrogen sulfide
Potassium sulfide
Sodium sulfide

▲24a

Acids, Organic (Limited to C, H, and O Compositions)

Wear:

Rubber gloves, face shield, laboratory coat. Body shield and self-contained breathing apparatus should be available.

Spills:

Eliminate all sources of ignition.

1 • Cover contaminated surfaces with soda ash or sodium bicarbonate. Mix and add water if necessary. Scoop up slurry and wash neutral* waste down drain with excess water. Wash site with soda ash solution.

Package lots:

(Choice of Procedures)

1 • Liquid acid may be injected at base of incinerator or after mixing with a flammable solvent. Afterburner is suggested for complete combustion.

2 • A solid acid may be dissolved in a flammable solvent and burned as above.

3 • Solid acid may be packaged in paper or other flammable material and burned in an incinerator.

Examples:

Acetic acid
Acetic anhydride
Acrylic acid
Adipic acid
Benzoic acid
n-Butyric acid
iso-Butyric acid
n-Butyric anhydride
Caproic acid
Citraconic anhydride
Citric acid
Formic acid
Fumaric acid
Gallic acid
Glutaric anhydride
Glycolic acid
Hydracylic acid-β-lactone * *
Lauric acid
Maleic acid
Maleic anhydride
Methacrylic acid
Octanoic acid
Oleic acid
Oxalic acid
Phthalic anhydride
Pimelic acid
Propionic acid
Pyrogallic acid
Pyruvic acid
Salicylic acid
Stearic acid
Succinic acid
Succinic anhydride
Tannic acid
Valeric Acid

▲24b

Acids, Inorganic

Wear:

Rubber gloves, self contained breathing apparatus, laboratory coat. Have body shield available.

Spills:

1 • Cover the contaminated surface with sodium bicarbonate or a soda ash — slaked lime mixture (50-50). Mix and add water if necessary to form a slurry. Scoop up slurry and wash down the drain with excess water. Wash site with soda ash solution.

Package lots:

Add slowly to large volume of agitated solution of soda ash and slaked lime. Add neutralized solution to excess running water. As an added precaution, the sink can be lined with protective matting and filled with coarse chipped marble.

Examples:

Boric acid
Boron oxide
Fluoroboric acid
Fluorosilicic acid
Hydriodic acid
Hydrobromic acid
Hydrochloric acid
Hydrofluoric acid
Iodic acid
Mixed acids
Nitric acid
Phosphoric acid
Phosphoric anhydride
Sulfuric acid
Sulfur trioxide

▲25

Carbides

Wear:

Rubber gloves, safety glasses, laboratory coat.

Spills:

Cover with dry vermiculite, scoop into a dry bucket or plastic bag and transfer to a safe open area. Dispose of the material cautiously by adding it slowly to a large volume of water. Burn the hydrocarbon gas using a pilot burner. Allow to stand for 24 hours and run to sewer with excess water.

Package lots:

Take to a safe open area and add slowly to a large container of water. Burn off the hydrocarbon gas with a pilot flame. Allow to stand for 24 hours. Siphon off the liquid and transfer the precipitate to a landfill.

Examples:

Aluminum carbide
Calcium carbide

▲26

Wastes to be dumped into landfills or released to air

Wear:

Heavy work gloves, safety glasses.

Properly assembled waste ready for pick-up trucks may be used as fill in reclaiming low areas or may be dumped into a landfill.

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* Make litmus test. Neutralize with 6M-NH_4OH or 6M—HCl as required.

* * Carcinogenic.

Examples:

Argon
Asphalt
Batteries, dry cell
Boron
Bromochloromethane
Bromotrifluoromethane
Calcium carbonate
Calcium oxide
Carbon black
Carbon tetrafluoride
Chlorobromomethane
1-Chloro-1,1-difluoroethane
Chloropentafluoroethane
Chlorotrifluoroethylene
Chromium
Crude lime
1,2-Dibromotetrafluoroethane
Dichlorodifluoromethane
Dichloromethane
Dichloromonofluoromethane
Dichlorotetrafluoroethane
Epoxy resin systems
Ferrosilicon
Ferrovanadium dust
Fluorotrichloromethane
Helium
Hexachloroethane
Hexafluoroethane
Hydrogen
Lamp bulbs
Latex
Magnesium oxide
Metal scrap
Molybdenum, insoluble
  compounds
Neon
Nitrogen
Nitrogen fertilizers
Nitrogen trioxide
Octafluorocyclobutane
Osmium tetroxide
Oxygen
Ozone
Paint
Pyrethrum
Resins
Rubber
Scrap glass
Scrap stoneware
Silica
Sludges
Stone, alberine
Sulfur
Sulfur hexafluoride
Tar
Tetrabromoethane
1,1,1,2-Tetrachloro-2,2-difluoroethane
1,1,2,2-Tetrachloro,1,2-difluoroethane
Tetramethyl silane
Transite
Tin, organic compounds
Titanium oxide
Tremolite
1,1,1-Trichloroethane
1,1,2-Trichloro-1,2,2-trifluoroethane
Trifluoromethane
Urea
Xenon
Yttrium
Zinc Oxide
*Zirconium
*Zirconium-hafnium
  powders

* Clean dry material may be burned on steel plate. Ignite from distance. To dispose of 2 lbs of moist or contaminated material, add, with water, to 10 lbs. cement mix. Allow to set for 2 days and dump into landfill.

▲27a

Recovery Scrap metal in the form of sheets, rods, wire, tubes

Wear:

Heavy gloves, safety glasses, laboratory coat.

1 • Larger pieces of less expensive metals can be salvaged profitably for use in local shops, or can be sold as scrap metal — e.g., aluminum, copper, brass.

2 • The more expensive metals are worth salvaging, even in small pieces — e.g., platinum wire, silver foil.

Metal should be sorted, classified, and placed in boxes, properly labelled. Turnings, shot, cuttings or the cheaper metals may be assigned to landfill. (See 26.)

Examples:

Sheet, rods, wire, tubes,
  foil, etc.
Aluminum
Antimony
Batteries, wet cells
Beryllium
Bismuth
Bronze
Cadmium
Cobalt
Copper
Gold
Lead
Magnesium
Manganese
Molybdenum
Nickel
Paladium
Platinum
Rhodium
Silver
Steel, carbon
Steel, stainless
Tantalum
Tin
Titanium
Zinc

▲27b

Recovery * —Mercury

Wear:

Rubber gloves, self-contained breathing apparatus, laboratory coat.

CAUTION: The toxicity of mercury is such that the element and its compounds should not be allowed to contaminate air or water.

Spills and package lots:

Metal — Collect all droplets and pools at once by means of suction pump and aspirator bottle with a long capillary tube. Cover fine droplets in nonaccessible cracks with calcium polysulfide and excess sulfur. Combine all contaminated mercury in a tightly stoppered bottle. Hold it for purification or sale.

Compounds — Dissolve all water soluble contaminated compounds. Convert other contaminated compounds to the soluble nitrates. Adjust the acidity and precipitate as mercuric sulfide. Wash and dry the precipitate.

Examples:

Mercuric nitrate, chloride and thiocyanate
Mercurous nitrate and chloride
Mercury
Mercury fulminate * *
Organic mercury compounds

* In procedures 27b to 27m, recovery is essential because of high toxicity of all elements and compounds — e.g. the American Conference of Governmental Industrial Hygienists' threshold limit values (1968) expressed as mg/M^3 (miligrams per meter cubed) for mercury = 0.1, for arsenic = 0.5, antimony = 0.5, selenium = 0.2, beryllium 0.002, lead 0.2, cadmium 0.2, barium 0.5, uranium 0.05, vanadium 0.1 — as opposed to hydrogen cyanide 11, and hydrogen sulfide 15.

* * Readily destroyed by reaction with 20% sodium thiosulfate. Ventilate process to avoid cyanogen exposure.

▲27c

Recovery — Phosphorus, Yellow and Red

Wear:

Rubber gloves, large face shield.

Yellow Phosphorus

Spills:

Cover with wet sand. Spray with water to keep sand wet. Scoop into a bucket of water. After standing overnight, recover and repackage.

OR

If quantity is very small (e.g., fragments of sticks of yellow phosphorus), cover with water and remove to an open area. Pour onto the ground or a steel pan. The water will evaporate and dry yellow phosphorus will ignite spontaneously in air and burn away.

Red Phosphorus

Spills:

Sweep up and burn on an iron pan in the hood.

▲27d

Recovery — Arsenic, Antimony and Bismuth *

Wear:

Rubber gloves, safety glasses, respirator, laboratory coat. Work in fume hood.

Waste:

Dissolve in minimum hydrochloric acid (concentrated, reagent). Filter if necessary. Dilute with water until white precipitates form (SbOCl and BiOCl). Add just enough 6M-MCl to redissolve. Saturate with hydrogen sulfide. Filter, wash the precipitate and dry.

OR

If the waste is of very little value, use Procedure 11.

Examples:

Antimony pentasulfide
Antimony trioxide
Arsenic acid
Arsenic trichloride
Arsenic trioxide
Arsenous acid
Calcium arsenate
Lead arsenate
Metals (arsenic, antimony and bismuth)
Nitrates and chlorides of arsenic, antimony and bismuth
Stibine

▲27e

Recovery — Selenium and Tellurium

Wear:

Rubber gloves, safety glasses, respirator (or work in hood), laboratory coat.

Spills:

Absorb on paper and place in wide mouth stoppered bottle for later recovery. Wash site with soap solution.

Package lots and recovered spills:

Liquid or solid — Make a solution strongly acidic with hydrochloric acid. Slowly add sodium sulfite to the cold solution with stirring, thus producing sulfur dioxide, the reducer.

Upon heating dark grey selenium and black tellurium form. Let stand overnight. Filter and dry.

Examples:

Hydrogen selenide
Selenium hexafluoride
Selenium oxides
Selenium oxychloride
Selenium tetrachloride
Tellurium hexafluoride
Tellurium oxides

▲27f

Recovery — Lead and Cadmium Compounds

Wear:

Rubber gloves, safety glasses, respirator (or work in hood).

Package lots and recovered spills:

Convert to nitrates with a minimum of nitric acid (concentrated, reagent). Evaporate in a fume hood to a thin paste. Add about 500 ml. water and saturate with hydrogen sulfide. Filter, wash, and dry the precipitate.

OR

If the waste is of small volume use Procedure 11.

Examples:

Cadmium oxide
Cadmijm salts
Lead oxides
Lead salts

▲27g

Recovery — Beryllium Compounds

Wear:

Rubber gloves, self-contained respirator, laboratory coat (wash after each job).

Spills:

Absorb on paper towels and place in large stoppered wide-mouth bottle. Save for recovery. Wash site with soap solution.

Package lots and recovered spills:

Dissolve in minumum of 6M-HCl. Filter and treat filtrate with slight excess of 6M-NH_4OH (use litmus). Boil and allow coagulated precipitate to settle for about 12 hours. Filter and dry.

Examples:

Beryllium salts

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* Although bismuth is much less toxic than arsenic or antimony it is included here because the recovery procedure is similar

▲27h

Recovery — Strontium and Barium Compounds

Wear:

Rubber gloves, safety glasses, laboratory coat.

Package lots and recovered spills:

Dissolve waste in 6M-HCl and filter. Neutralize the filtrate with 6M-NH_4OH (use litmus) and precipitate with excess sodium carbonate. Filter, wash, and dry the precipitate.

OR

If the waste is of small volume, use Procedure 11.

Examples:

Oxides and salts of strontium and barium

▲27i

Recovery — Vanadium Compounds

Wear:

Rubber gloves, large face shield, laboratory coat. (Wear self-contained respirator if spill is large.)

Spills:

Cover with powered ammonium carbonate. Add a layer of crushed ice and spray with 6M-NH_4OH while stirring. Scoop slurry into a wide mouth bottle, save for salvage. Wash site with soap water.

Package lots:

(Work in a fume hood).

Add (e.g., $VOCl_3$) slowly to a thick layer of powered ammonium carbonate in a large evaporating dish. Spray with 6M-NH_4OH while stirring. Add a layer of crushed ice and continue stirring and spraying. Add more 6M-NH_4OH if necessary. May add more waste vanadium compound with stirring. Pour into large beaker and let stand overnight. Filter off the crude ammonium vanadate and dry.

Examples:

Ammonium vanadate
Sodium vanadate
Vadadium chlorides
Vanadium oxychlorides
Vandyl sulfate

▲27j

Recovery — Halogenated Solvents

Wear:

Rubber gloves, self-contained respirator (or work in hood), laboratory coat.

Spills:

Absorb on paper towels and allow to evaporate in the fume hood. Burn the paper. Wash site with soap solution.

Package lots:

The toxic liquid compounds concerned here are insoluble in water and cannot be burned. Purify the contaminated liquids by distillation and place the pure distillate back on the shelf.

Examples:

Bromoform
Carbon tetrabromide
Carbon tetrachloride
Chloroform
Tetrachloroethylene
1,1,1-Trichloroethane
Trichloroethylene

▲27k

Recovery — Miscellaneous

The elements and their compounds listed below should be dealt with separately. If the quantity justifies recovery get in touch with the supplier for special instructions.

Examples:

Deuterium
Erbium
Gadolinium
Gallium
Germanium
Germanium dioxide
Hafnium
Holmium
Indium
Lanthanum
Lutecium
Niobium
Osmium
Osmium oxide
Praseodymium
Rubidium
Ruthenium
Samarium
Silver nitrate
Terbium
Thallium
Thallous sulfate
Thorium*
Uranium*

* These materials as well as all other naturally radioactive materials, elements or substances must be disposed of in accordance with regulations of the U.S. Atomic Energy Commission or those of the local or state departments of health. This may usually be done by turning them over to the radiation safety officer or a commercial disposal agency handling radioactive materials.

▲28

Cellulose Nitrate, Collodion, Celluloid

Wear:

Rubber gloves and face shield. Note: Outside disposal is preferred but can be done in the hood.

Spills:

Cellulose Nitrate

Eliminate all sources of ignition. Gather up the nitrocellulose and dampen with an alcohol. Spread out in a thin layer (2 inches deep max.) in an outside open area on top of papers or other combustible material. Ignite from a distance with an excelsior train or a long torch. When disposal by burning must be done in a hood, the quantity of nitrocellulose burned at any one time should be limited to 250 ml or less. This small quantity of nitrocellulose can be placed in a shallow pyrex dish and ignited after it has been dampened with an alcohol.

OR

Eliminate all sources of ignition. Gather up the nitrocellulose and dampen with water. Squeeze out excess water and place nitrocellulose (250 ml or less) in a large stainless steel beaker (2500 ml or larger), and place beaker in a large pyrex dish. Add an equal amount of 10% caustic (no stronger) to the beaker. Most of the nitrocellulose should be consumed in 20 minutes. Remove beaker (Caution: beaker will be hot from the heat of reaction) and pour remaining contents into drain with large excess of water.

Spills:

Collodion (Nitrocellulose Lacquer)

Eliminate sources of ignition. Wipe up spilled material with paper towels or rags. Remove to an outside open area, spread on the ground and ignite with an excelsior train or a long torch.

Package lots:

Small quantities of collodion (250 ml or less) may be disposed of in a hood by igniting it in a pyrex dish. Larger quantities should be disposed of in an outside open area by pouring into a steel pan and igniting with an excelsior train or a long torch.

Celluloid (Nitrocellulose Plastic)

Celluloid disposal should be done outside in an open area. Eliminate sources of ignition. Spread the waste celluloid on top of paper or other combustible material. Ignite from a distance with an excelsior train or a long torch.

WARNING: Whenever cellulose nitrate, collodion or celluloid is burned or decomposed, oxides of nitrogen are released. Avoid direct breathing of vapors.

▲29

Direct Burning

Wear:

Heavy leather gloves, safety glasses.

Disposal:

Materials should be properly packed for safe handling, and placed in a prescribed site for daily pick-up. Burning can be done in an open or closed incinerator with afterburners.

Examples:

Materials: Wood scraps, packing boxes, etc.
Bags, paper and cloth Bags, paper and cloth
Biological wastes — animal remains, bedding, feed wastes
Clothing, discarded or contaminated
Excelsior
Paper wastes, packing boxes, etc.

Toxicity Data

The information in this chart is provided in the interest of laboratory safety. The chemicals in PART ONE which have been tested for toxicity carry one or more of these symbols. For expansion of this data, please refer to NIOSH: "Registry of Toxic Effects of Chemical Substances, 1976 ed." Any comments of information you could add regarding toxicity of chemicals would be welcomed by our staff at MCB.

Key to Abbreviations

C — continuous
cat — cat
chd — child
ckn — chicken
ctl — cattle
D — day
dck — duck
dog — dog
dom — domestic
frg — frog
gm — gram
gpg — guinea pig
grb — gerbil
H — hour
ham — hamster
hmn — human
I — intermittent
idr — intradermal
idu — intraduodenal
ihl — inhalation
imp — implant
ims — intramuscular
inf — infant
ipc — intraplacental
ipl — intrapleural
ipr — intraperitoneal
irn — intrarenal
isp — intraspinal
itr — intratracheal
ivn — intravenous
kg — kilogram (one thousand grams)
LC50 — lethal concentration 50 percent kill
LCLo — lowest published lethal concentration
LD50 — lethal dose 50 percent kill
LDLo — lowest published lethal dose
mam — mammal (species unspecified)
man — man
M — minute
m^3 — cubic meter
mg — milligram (one thousandth of a gram)
mky — monkey
mus — mouse
ng — nanogram (one billionth of a gram)
ocu — ocular
orl — oral
par — parenteral
pgn — pigeon
pig — pig
ppb — parts per billion (v/v)
pph — parts per hundred (v/v) (percent)
ppm — parts per million (v/v)
ppt — parts per trillion (v/v)
rat — rat
rbt — rabbit
rec — rectal
scu — subcutaneous
skn — skin
sql — squirrel
TXLo — lowest published toxic concentration
TDLo — lowest published toxic dose
trk — turkey
TXDS — qualifying toxic dose
μg — microgram (one millionth of a gram)
unk — unreported
W — week
wmn — woman
Y — year

APPENDIX H

Selected Seminars/Workshops and Memberships

Membership is available for a small fee in The American Chemical Society's (ACS) Division of Chemical Health and Safety. Non-ACS members may join as affiliates having the privileges of ACS members with the exceptions of voting and holding office.

For further information, contact:

Dr. Douglas Walters
Secretary
Division of Chemical Health & Safety
C/O National Toxicity Program - NIEHS
P.O. Box 12233
Research Triangle, NC 27709

J.T. Baker Chemical Company presents two-day seminars and workshops at various locations several times a month, year-round, entitled Managing the Hazardous Chemical Safety Training Program and Management and Disposal of Hazardous and Chemical Wastes. J.T. Baker is a member of the:

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The Office of Safety Training
J.T. Baker Chemical Company
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APPENDIX I

Code of Federal Regulations, Title 40, Part 265.316 Disposal of Small Containers of Hazardous Waste in Overpacked Drums (Lab Packs)

Small containers of hazardous waste in overpacked drums (lab packs) may be placed in a landfill if the following requirements are met:

(a) Hazardous waste must be packaged in non-leaking inside containers. The inside containers must be of a design and constructed of a material that will not react dangerously with, be decomposed by, or be ignited by the waste held therein. Inside containers must be tightly and securely sealed. The inside containers must be of the size and type specified in the Department of Transportation (DOT) hazardous materials regulations (49 CFR Parts 173, 178 and 179), if those regulations specify a particular inside container for the waste.

(b) The inside containers must be overpacked in an open head DOT-specification metal shipping container (49 CFR Parts 178 and 179) of no more than 416-liter (110 gallon) capacity and surrounded by, at a minimum, a sufficient quantity of absorbent material to completely absorb all of the liquid contents of the inside containers. The metal outer container must be full after packing with inside containers and absorbent material.

(c) The absorbent material used must not be capable of reacting dangerously with, being decomposed by, or being ignited by the contents of the inside containers, in accordance with Section 265.17(b).

(d) Incompatible wastes, as defined in Section 260.10(a) of this chapter, must not be placed in the same outside container.

(e) Reactive waste, other than cyanide- or sulfide-bearing waste as defined in Section 261.23(a)(5) of this chapter, must be treated or rendered non-reactive prior to packaging in accordance with paragraphs (a) through (d) of this section without first being treated or rendered non-reactive.

[46 FR 56596, November 17, 1981]

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