1. **Policy and Purpose**
   - A. Policy 3
   - B. Purpose 3
   - C. Hazardous Chemical Definitions 3

2. **Responsibility, Authority and Resources**
   - A. Chief Executive Officer 5
   - B. University Chemical Hygiene Officer 6
   - C. Departmental Chemical Hygiene Officer 7
   - D. Laboratory Supervisors (Faculty, PI's) 9
   - E. Employees, Staff, and Students 11
   - F. Safety Committees 11
   - G. Environmental Health & Safety Staff in Risk Management 13
   - H. Oversight, Annual Review, Recordkeeping, Compliance and Enforcement 14

3. **Chemical Hygiene Plan: Laboratory Standard Operating Procedures**
   **A. Laboratory Specific Information and Signatures** 15
   **B. Preparation, Approval, Annual Review and Update** 16
   **C. Standard Operating Procedures and Work Practices for Chemicals or Classes, Including Personal Protective Equipment** 17
   **D. Elimination or Substitution** 18
   **E. Enclosure, Isolation and Regulated Areas** 19
   **F. Exposure Control Procedures** 20
   **G. Personal Hygiene and Sanitation** 22

4. **Chemical Hygiene Plan Standards**
   - A. Education and Training (including Biological, Radiation and Laser Safety) 23
   - B. Personal Protective Equipment 24
   - C. Ventilation, Fume Hoods, and Proper Operations 27
   - D. Housekeeping, Maintenance and Inspections 28
   - E. Signs and Labels, Material Safety Data Sheets 29
   - F. Monitoring and Employee Assessment 33
   - G. Waste Disposal 34
   - H. Medical Surveillance 38

5. **Emergency Procedures and Exposure Reporting**
   - A. Emergency Procedures and Exposure Reporting 41

6. **Emergency Response**
   - A. Emergency Response 42
   - Accidents 42
   - Chemical Spills 42

7. **First Aid**
   - Splash to the Eye 46
8. **Fire Safety** 50

9. **Electrical Safety** 52

10. **Appendixes** 53

A. [OSHA Lab Standard 29 CFR 1910.1450](#)
B. [Living With The Laboratory Standard A Guide for Chemical Hygiene Officers](#)
C. [Incompatibility of Common Laboratory Chemicals](#)
D. [Common Laboratory Flammable and Combustible Chemicals](#)
E. [Flammable and Combustible Liquid Containment and Storage Requirements](#)
F. [Common Laboratory Corrosives](#)
G. [Common Laboratory Oxidizers](#)
H. [Classes of Peroxidizable Chemicals](#)
I. [Shock Sensitive and Explosive Chemicals](#)
J. [Carcinogens](#)
K. [Industrial Toxicology Overview](#)
L. [Respirator Program](#)
M. [Laboratory Exhaust Hood Annual Surveillance Data & Certificate](#)
N. [Air Monitoring Results](#)
O. [Recordkeeping Forms, Annual Audit Forms](#)
P. [Glossary](#)

Note: ** Departmental Chemical Hygiene Officer or Laboratory Supervisor will prepare.

1 Living With The Laboratory Standard, American Chemical Society, 1998
A. Policy

It is the policy of Brown University to provide a safe and healthy workplace in compliance with the Occupational Safety and Health Act of 1970 and regulations of the Department of Labor including 29 CFR 1910.1450 "Occupational Exposure to Hazardous Chemicals in Laboratories". The full standard is in Appendix A.

B. Purpose

This document presents the Chemical Hygiene Plan required by the above regulation. The purpose of the Plan is to describe proper practices, procedures, equipment and facilities for employees, students, visitors, or the persons working in each laboratory at the University in order to protect them from potential health hazards presented by chemicals used in the laboratory workplace, and to keep exposures below specified limits. It is the responsibility of faculty, administration, research and supervisory personnel to know and to follow the provisions of this Plan. The University Chemical Hygiene Officer (UCHO) will be designated from the Environmental Health & Safety staff in the Risk Management Office. The UCHO is qualified by training or experience, to provide technical guidance in the development and implementation of the written Chemical Hygiene Plan. Each Department Chair is the appointed Departmental Chemical Hygiene Officer, who is responsible for developing, implementing, monitoring and updating his/her plan annually. Affected departments are all those maintaining laboratories containing toxic chemicals, as defined by law.

C. Hazardous Chemical Definitions

A hazardous chemical is defined as any chemical, chemical compound, or mixture of compounds which is a physical and/or health hazard.

**A chemical is a physical hazard if there is scientifically valid evidence that it is:**

- A flammable or combustible liquid
- A compressed gas
- An organic peroxide
- An explosive
- An oxidizer
- A pyrophoric
- An unstable material (reactive)
- A water reactive material

**A chemical is a health hazard if there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. Included are:**

- allergens
- embryotoxicants
- carcinogens
- toxic or highly toxic agents
Particularly hazardous substances are carcinogens, reproductive toxicants and chemicals with a high degree of acute and chronic toxicity. Select carcinogens are chemicals listed by the National Toxicology Program (NTP) as “known to be carcinogens” and by the International Agency for Research on Cancer (IARC) as Group 1 carcinogens. Also included are chemicals or processes listed in either Group 2A or 2B by IARC or under the category “reasonably anticipated to be carcinogens” by NTP and that cause statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

- After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m³.
- After repeated skin application of less than 300 mg/kg of body weight per week.
- After oral dosages of less than 50 mg/kg of body weight per day.

IARC Group 1, 2A and 2B as well as the NTP carcinogens, are listed in App. J

Reproductive toxicants are defined as any chemical, which affects the reproductive capabilities of males or females, including chromosomal damage (mutagenesis) and effects on fetuses (teratogenesis). Information on reproductive effects will be listed on the MSDS.

Chemicals with a high degree of acute and chronic toxicity are not defined in the Laboratory Standard.

The following sources have established lists of hazardous chemicals based on substantiated tests:


American Conference of Governmental Industrial Hygienists (ACGIH), “Threshold Limit Values for Chemicals Substances and Physical Agents in the Work Environment.” Threshold Limit Values can be found in the Hazardous Ingredients section of the material’s MSDS.

The hazard(s) of a chemical may also be listed on its container label. Additionally, if the hazard of a chemical is not evident from the container...
Use the MSDS to address chronic toxicity.
A. Chief Executive Officer

The Chief Executive Officer has the ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene.
DEFINITION:

The University Chemical Hygiene Officer (UCHO) will be designated from the Environmental Health & Safety staff in the Risk Management Office. The UCHO is qualified by training or experience, to provide technical guidance in the development and implementation of the written Chemical Hygiene Plan. In this capacity, the UCHO works with the Departmental Chemical Hygiene Officers (DCHO), Laboratory Supervisors and staff to develop and implement appropriate chemical hygiene policies and practices and to continually seek to improve the chemical hygiene program.

DUTIES:

1. Periodically inspect, at least annually, laboratory facilities to ensure compliance with the provisions of the Chemical Hygiene Plan (CHP).

2. Monitor health and safety conditions at laboratory facilities and investigate accidents/exposures.

3. Arrange for industrial hygiene monitoring as appropriate and inform employees of results.

4. Update the University Chemical Hygiene Plan as necessary.

5. Remain abreast of regulatory and legal requirements associated with the use of hazardous chemicals.

6. Review incident reports submitted by Departmental CHO’s and determine those which should be brought to the attention of the University Laboratory Safety Committee.

7. Ensure that safety devices (i.e. safety showers, eyewashes, fire extinguishers and fume hoods) are working properly.

8. Receive and review all laboratory CHPs and advise DCHO’s and Laboratory Supervisors of deficiencies in their Standard Operating Procedures.

9. Maintain current copies of all CHPs, as provided by the DCHOs, in the Risk Management Office.

RESOURCES:

The University Chemical Hygiene Officer may call upon Departmental Administrative Officers for administrative support and upon Departmental
information concerning their laboratories.
REQUIREMENTS:

Within Brown University, it has been determined by the Laboratory Safety Committee that each Department Chair is the Departmental Chemical Hygiene Officer (DCHO). Each department which is involved in the laboratory use of hazardous chemicals is responsible for the adaptation and implementation of the Chemical Hygiene Plan within the laboratories under its administrative control.

DUTIES:

The Departmental Chemical Hygiene Officer will assist the responsible Laboratory Supervisor to accomplish the following:

1. Work with students and staff to monitor safe procurement, use, and disposal of chemicals.

2. Assist responsible Laboratory Supervisor with safety audits to ensure compliance with the provisions of the Chemical Hygiene Plan.

3. Ensure that laboratory workers have been properly trained and follow chemical hygiene policies and practices.

4. Ensure that control measures selected for use with any material in the laboratory are employed.

5. Inform the UCHO of any accidents involving: exposure to hazardous chemicals, significant property damage, fire, personal injury or significant potential for personal injury.

6. Advise Laboratory Supervisor concerning adequate facilities and procedures under the regulation.

7. Seek ways to improve the Chemical Hygiene Program.

8. Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices.

In addition, the Departmental Chemical Hygiene Officer will be responsible for knowing the contents of the relevant regulation (Occupational Exposures to Hazardous Chemicals in Laboratories, 29 CFR 1910.1450) see appendix A.
RESOURCES:

The Departmental Chemical Hygiene Officer may call upon Departmental Administrative Officers for administrative support and upon Brown University’s Chemical Hygiene Officer who may provide information concerning their laboratories.
D. **Laboratory Supervisor (Faculty, PI’s, etc)**

**REQUIREMENTS:**

The OSHA laboratory standard requires designation of a Laboratory Supervisor. Within Brown University, it has been agreed upon by the Laboratory Safety Committee that each Principal Investigator is the Laboratory Supervisor.

**DUTIES:**

The Supervisor's duties, as defined in the OSHA Laboratory Standard, are the responsibility of the Principal Investigator. For laboratories with no Principal Investigator, the Supervisor's duties are assumed by the person with authority over all laboratory functions. That person shall be appointed by the Department Chairperson.

The primary responsibility of the supervisor is to institute the Chemical Hygiene Plan (CHP) and ensure compliance with the OSHA Laboratory Standard. The duties include the following:

1. Ensure that all work is conducted in accordance with the CHP.

2. Make copies of the CHP available to employees, staff and students.

3. Define the location of work areas where toxic substances and potential carcinogens will be used, and ensure that the inventory of these substances is properly maintained.

4. Define the Standard Operating Procedures, (S.O.P.) detailing all aspects of proposed research activities that involve hazardous agents and designating safe practices, and selecting protective equipment. (see section 3)

5. Prepare a S.O.P for use of test substances when this use involves alternate procedures not specified in these guidelines. The S.O.P. shall include a description of the alternate procedure and an assessment of alternate controls that will be used.

6. Ensure that employees receive instructions and training in safe work practices, use of personal protective equipment, and in procedures for dealing with accidents involving toxic substances (Contact Environmental Health & Safety staff in Risk Management at x3-3353).

7. Ensure that employees understand the training received.
equipment necessary for the safe performance of their job.

9. Monitor the safety performance of the staff to ensure that the required safety practices and techniques are being employed.

10. Request workplace air samples, swipes, or other tests to determine the amount and nature of airborne and/or surface contamination, inform employees of the results, and use data to aid in the evaluation and maintenance of appropriate laboratory conditions. Contact Risk Management with monitoring requests.

11. Assist the University Laboratory Safety & Chemical Hygiene Officer, Radiation & Biological Safety Officer and other Environmental Health & Safety employees when necessary.

12. **Immediately investigate accidents and report them to your Departmental Chemical Hygiene Officer and the University Chemical Hygiene Officer at x3-3353. Include procedures that will prevent future accidents.**

13. Ensure that action is taken to correct work practices and conditions that may result in the release of toxic chemicals.

14. **Properly dispose of unwanted and/or hazardous chemicals and materials (Contact the Environmental Health and Safety (EH&S) staff at x3-1610 or x3-3353).**

15. Document and maintain compliance with all local, state, and federal regulatory requirements.
Employees, as defined by the Brown University Chemical Hygiene Plan, are those staff under the direction of the Supervisor, as defined by the Plan. Employees not under the direction of the Supervisor, but who are in an area under the direction of the Supervisor, are also subject to the Brown University Chemical Hygiene Plan and Standard Operating Procedures in effect in that area. Non-employees, such as students, are equally subject to the plan, as described below.

The primary responsibility of the employee is to follow the procedures outlined in the Brown University Chemical Hygiene Plan and all Standard Operating Procedures developed under that plan. These would include the following:

1. Understand and follow all Standard Operating Procedures and the Chemical Hygiene Plan.

2. Attend training and understand materials covered in training or ask for clarification or more information.

3. Understand the function and proper use of all personal protective equipment. Wear personal protective equipment when mandated or necessary.

4. Report, in writing, to your supervisor any significant problems arising from the implementation of the Standard Operating Procedures.

5. Report to your supervisor all facts pertaining to every accident that results in the exposure to toxic chemicals and any action or condition that may exist and could result in an accident or exposure.

6. Contact your supervisor, the Departmental Chemical Hygiene Officer, or the Environmental Health and Safety staff in the Office of Risk Management if any of the above procedures are not clearly understood.

F. Safety Committee

The establishment of a Safety Committee shall be instituted by each department to implement and enforce all aspects of the Chemical Hygiene Plan.

Purpose and Authority
The Laboratory Safety Committee and its Chairperson are appointed by the President and advise him/her in all matters relating to laboratory safety concerns (recognizing that other Committees and offices have responsibilities in specific areas of safety). The Committee is responsible for recommending to the
related activities are conducted to safeguard the health and safety of Brown University students, faculty, staff and the community, and to assure compliance with appropriate laws, regulations, and guidelines. The Committee will address, among other things, laboratory safety concerns relevant to facilities, procedures, emergency response and education.

The Committee shall establish the mechanisms whereby issues concerning laboratory safety are identified, prioritized and systematically addressed. Inherent to this charge is the requirement that the committee work closely with departmental safety committees in developing appropriate building safety standards. For information concerning the Brown University Radiation Safety Committee and the BioSafety Committee please consult the respective safety manuals.

Membership

Ex-officio members

Dean of Research – Chairperson
Associate Dean of Research – Vice Chairperson
University Laboratory Safety & Chemical Hygiene Officer - Secretary
Radiation & Biological Safety Officer
Director of the Center for Environmental Studies
Associate Vice President for Facilities Management
Director of Risk Management

Other members

No fewer than five faculty members and at least one member representing laboratory technical staff.

Departmental Safety Committees

Purpose and Authority

There are departmental safety committees in each Brown University departments in which there are laboratories or art studios. These committees work closely with the Laboratory Safety Committee and with the Environmental Health & Safety staff in the Office of Risk Management. Their primary functions are to audit laboratories and studios to ensure safe practices and conditions, and to provide mechanisms to respond to emergencies and to safety concerns of building occupants.

The specific means of accomplishing these objectives varies from department to
approved by the Laboratory Safety Committee. All faculty, staff and students should be aware of the functions of the committee in their department.
Responsibility
The Environmental Health and Safety staff (EH&S) in the Office of Risk Management (ORM) is charged with responsibility for control, review, monitoring and advice with respect to exposure to chemical, radiological, and biological agents used in research and teaching. EH&S staff is also responsible for oversight and control of physical hazards in the workplace, including fire protection, electrical and other safety hazards, and chemical waste disposal arising from work at the University.

Authority
The EH&S staff has the authority to stop any activity which is immediately hazardous to life or health (IDLH) in their judgment. In addition, the Radiation Safety Officer has regulatory authority as part of Brown's license with the State of Rhode Island Radiation Control Agency. Apart from these conditions, the EH&S staff acts in an advisory capacity to the individual Departments, etc., to help them provide a safe and healthful workplace.

Resources
The EH&S staff can be called upon for advice and help on safety and environmental health problems. The staff offers the following services to the University:

The EH&S staff evaluates and implements safety policies and reviews new and existing equipment and operating practices to minimize hazards to the University community and visitors from fire, electricity, explosion, pressure, and machinery. EH&S staff conducts accident investigations and suggests remedial measures and procedures. Training and assistance in conducting special accident prevention programs are available as required.

The services of the EH&S staff are available both in emergency situations and in an advisory capacity to answer questions from anyone at the University. However, procedures for safe use and disposal of chemicals or radioactive substances start in the laboratory; therefore, students, post-doctoral fellows and technicians must be informed about their responsibilities and the procedures to be followed by the Chemical Hygiene Officer/Supervisor.

Emergencies
The Environmental Health and Safety staff in ORM provides 24-hour on-call personnel to respond to needs. They can be reached through Campus Police (x3-4111).
For non-emergencies contact X3-3353.
H. Oversight, Annual Review, Recordkeeping, Compliance, Enforcement

The Laboratory Supervisor (or appointed personnel) is responsible for establishing and maintaining records for employee training, employee and environmental monitoring and an inventory of chemicals stored in the work place. In practice, the Departmental Chemical Hygiene Officer may assist with this work.

The Laboratory Supervisor (or appointed personnel) should enforce the Chemical Hygiene Plan by making sure the Chemical Hygiene rules are known, and followed. The Departmental Chemical Hygiene Officer advises and assists in this work and helps with documentation.

The Departmental Chemical Hygiene Officer will assist with chemical hygiene and housekeeping inspections. When there are significant changes in existing policies or work practices, an inspection and training should be conducted soon after the new process is implemented.

The Environmental Health and Safety staff in Risk Management is available to assist the Departmental Chemical Hygiene Officer in the inspection process and in all related matters.

The Laboratory Supervisor will review and update the Chemical Hygiene Plan annually. The Departmental Chemical Hygiene Officer will review, sign and send a copy of the annual updates to Risk Management Attn: University Laboratory Safety & Chemical Hygiene Officer, Box 1914.
3. Chemical Hygiene Plan: Laboratory Standard Operating Procedures

A. Laboratory Specific Information and Signatures

The Chemical Hygiene Plan: Laboratory Standard Operating Procedures (section 3 only), after being reviewed and signed by the Laboratory Supervisor, Departmental Chemical Hygiene Officer and affected personnel, will be sent to Risk Management Attn. University Chemical Hygiene Officer Box 1914. Please send section 3 only to Risk Management. Updates are due at least annually. Do not change/alter other sections of the plan. If you have any questions, please contact the University Chemical Hygiene Officer at X3-1737.

This plan is for the Department of ______________________________________
Building ____________________________________________________________
Rooms covered by plan ____________________________________________

The Departmental Chemical Hygiene Officer for this laboratory is;

Print Name ____________________________________
Signature ______________________________________
Date   ________________________

The Laboratory Supervisor for this laboratory is;

Print Name ____________________________________
Signature ______________________________________
Date   ________________________

Signature and Title of persons covered by this plan (including students and staff);

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<th>Print Name</th>
<th>Signature</th>
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B. **Preparation, Approval, Annual Review and Update**

1. The Departmental Chemical Hygiene Officer will oversee the preparation of the Chemical Hygiene Plans by the Laboratory Supervisor for *his/her department*;

2. He/she is responsible for seeing that the plan meets requirements set forth in 29 CFR 1910.1450.
   a. Assistance in creating the Chemical Hygiene Plan will be provided by the University Chemical Hygiene Officer in Risk Management (x3-1737).

3. The Departmental Chemical Hygiene Officer is responsible for seeing that the Chemical Hygiene Plan is reviewed on an annual basis and updated to accommodate changes in the 29 CFR 1910.1450, departmental procedures, personnel Brown policies and other pertinent materials.
   a. The Departmental Chemical Hygiene Officer and the Laboratory Supervisor will also see that the Chemical Hygiene Plan is updated to include procedures regarding new hazards and processes as they are introduced.

4. The Laboratory Supervisor will see that the Chemical Hygiene Plan and updates are distributed to or made available to those who are affected by it during all working hours.

5. The **Chemical Hygiene Plan: Laboratory Standard Operating Procedures** and updates, after being reviewed and signed by the Laboratory Supervisor, Departmental Chemical Hygiene Officer and affected personnel, will be sent to Risk Management, Attn. University Chemical Hygiene Officer, Box 1914. Updates are due at least annually.
Including Personal Protective Equipment

Include a brief description of research, recommendation and location of personal protective equipment, location of spill equipment, and location of material safety data sheets (MSDS). Consult with Appendices. A & B.

Environmental Health & Safety staff in Risk Management has developed generic procedures relevant to safety and health considerations when laboratory work involves the use of hazardous chemicals. Where the scope of hazards are not adequately addressed by this general document, the Laboratory Supervisor or Departmental Chemical Hygiene Officer must develop written standard operating procedures for work area specific operations. This document must be provided to all affected laboratory employees. This document specifies minimum regulations and recommendations.
D. Elimination or Substitution

The first step in evaluating a new experiment, process or operation should be to investigate the possibility of eliminating the use of hazardous materials or substituting a less hazardous material. For example, instead of using an organic solvent or chromic acid based material for washing glassware, one should substitute an aqueous based detergent. Aromatic compounds (i.e., benzene) and chlorinated hydrocarbons (i.e., methylene chloride) in some experiments should be replaced with aliphatic compounds or non-chlorinated hydrocarbons, if possible.

The particular process, experiment or operation may also be modified to reduce the quantity of the hazardous material(s) necessary or limit the potential emission release rate or exposure time. For example, the use of microscale techniques may be applicable in measuring boiling points of a material. Another example is the substitution of closed systems for open vessels.

The use of a secondary containment device such as a pan can be helpful in preventing or minimizing the effects of chemical spills.

Please list any measures that you have taken in regards to elimination or substitution.
Designated Areas

Reducing the potential for exposure to particularly hazardous chemicals is achieved by restricting the use of the material to a designated area equipped with the proper control devices. This designated area can be a glove box, fume hood, bench, or an entire laboratory depending on the manipulations required. Particularly hazardous substances are stored, used, and prepared for disposal only in designated areas. The boundaries of a designated area are defined by the researcher in the special provisions written for the specific particularly hazardous substance. The designated area is identified by signs so those entering the area are aware a particularly hazardous material may be present.

For example:

"ACRYLAMIDE BALANCE" over balance area

“DANGER! HIGHLY REACTIVE MATERIAL” in storage area

"AFLATOXIN IN USE" on glove box

Radiation and Biohazard signs are available from the Radiation and Biological Safety staff in Risk Management at x3-1738.

In addition to establishing the physical boundaries which define the designated area, the procedures used in a designated area should be described under special provisions by the laboratory supervisor, (see below). These include storage, use of protective equipment, use of containment, equipment disposal and decontamination procedures.

Special Provisions for Particularly Hazardous Substances.

Including reproductive hazards, carcinogens, acutely toxic, blood and body fluids, radioactive isotopes and any other special hazards. Please include the regulated areas for this laboratory. Consult with Appendices. A & B.

NOTE: To be done by the Laboratory Supervisor or Departmental Chemical Hygiene Officer for each plan
Please include any designated areas for this laboratory.
Including proper chemical storage, proper use, disposal, and other procedures to control hazards.

**NOTE:** To be done by the Laboratory Supervisor for each plan. Please add any items specific to your lab.

The decision to use a hazardous chemical should be a commitment to handle and use the chemical properly from initial receipt to proper disposal.

**EXAMPLE:**

**Chemical Handling and Storage**
- Information on proper handling, storage and disposal of chemicals and access to related Material Safety Data Sheets should be made available to all laboratory employees prior to the use of the chemical.
- Always purchase the minimum amount necessary to maintain operations.
- Chemical containers with missing or defaced labels or that violates appropriate packaging regulations should not be accepted.
- Chemicals utilized in the laboratory must be appropriate for the laboratory’s ventilation system.
- Chemicals should not be stored on high shelves and large bottles should be stored no more that two feet from floor level.
- No chemicals should be stored on the floor.
- Chemicals shall be segregated by compatibility.
- Chemical storage areas must be labeled as to their contents.
- Storage of chemicals at the lab bench or other work areas shall be kept to a minimum.
- Any chemical mixture shall be assumed to be as toxic as its most toxic component.
- Substances of unknown toxicity shall be assumed to be toxic.

**Transferring Chemicals**
- Carry glass containers in specially designed bottle carriers or a leak resistant, unbreakable secondary container.
- When transporting chemicals on a cart, use a cart that is suitable for the load and one that has high edges to contain leaks or spills.
- When possible, transport chemicals in freight elevators to avoid the possibility of exposing people on passenger elevators.

**Compressed Gasses**
- Special systems are needed for handling materials under pressure. Cylinders pose mechanical, physical and/or health hazards, depending on the compressed gas in the cylinder.
- Cylinders **must be secured** in an upright position at all times. Use suitable racks, straps, chains, or stands to support cylinders against an immovable object, such as a bench or a wall, during use and storage. Do not allow cylinders to fall or lean against one another.
- Use an appropriate cart to move cylinders.
Do not lubricate an oxygen regulator or use a fuel gas regulator on an oxygen cylinder. Use an oxygen-approved regulator.

- Always wear goggles or safety glasses with side shields when handling compressed gases.
- Always use appropriate gauges, fittings and materials compatible with the particular gas being handled.
- When work with a toxic, corrosive or reactive gas is planned, EH&S staff in Risk Management X3-3353 should be contacted for information concerning specific handling requirements. Generally, these gases will need to be used and stored with local exhaust ventilation such as a lab hood or a gas cabinet designed for that purpose.
- Cryogenic Liquefied Gases (liquid argon, nitrogen and oxygen) are transported and stored in special, insulated containers designed to keep them from warming up. Coming in contact with them can rapidly freeze and destroy skin tissues. Appropriate gloves should always worn when transferring these materials.
G. Personal Hygiene and Sanitation

NOTE: To be done by the Laboratory Supervisor for each plan. Please add any items specific to your lab.

EXAMPLE:
• Avoid eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present.
• Avoid storage, handling or consumption of food or beverages in all laboratories.
• Do not wear lab coats in an area where food is consumed.
• Be aware that open packages of tobacco products can absorb chemical vapors.
• Wash areas of exposed skin well before leaving the laboratory.
• Avoid direct contact with any hazardous chemical.
• Confine long hair and loose clothing and wear footwear that fully covers the feet.
• Never mouth pipette.
4. **Chemical Hygiene Plan Standards**

A. **Education and Training**

Employees shall be informed of the presence of hazardous chemicals when assigned to a work area and prior to new exposure situations. This information must include contents of the OSHA Lab Standard, the applicable details and location of the Chemical Hygiene Plan, emergency and personal protective equipment training, physical and chemical properties of hazards used in the work place along with proper handling to minimize exposure, signs and symptoms of exposure associated with appropriate chemicals plus location and availability of reference material. Below is a list of the training requirements.

<table>
<thead>
<tr>
<th>Training Type</th>
<th>Requirements</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory Safety</td>
<td>Initial training require for anyone working in a laboratory and annual retraining required every 5 years.</td>
<td>Chemical Hygiene Officer &amp; Laboratory Safety Specialist X3-1737 or X3-3353</td>
</tr>
<tr>
<td>Hazardous Waste Management</td>
<td>Initially and annually thereafter for anyone who generates hazardous waste.</td>
<td>Environmental Specialist X3-1610 or X3-3353</td>
</tr>
<tr>
<td>Radioactive Materials</td>
<td>Initial training required for anyone working with radioactive materials. Biennial refresher training recommended.</td>
<td>Radiation &amp; Biological Safety Officer X3-1738 or X3-3353</td>
</tr>
<tr>
<td>X-ray Safety</td>
<td>Initial training required for anyone working with X-rays.</td>
<td>Radiation &amp; Biological Safety Officer X3-1738 or X3-3353</td>
</tr>
<tr>
<td>Laser Safety</td>
<td>Initial training required for anyone working with lasers.</td>
<td>Radiation &amp; Biological Safety Officer X3-1738 or X3-3353</td>
</tr>
<tr>
<td>Biosafety</td>
<td>Training provided by the Principal Investigator for anyone working with biological agents.</td>
<td>Radiation &amp; Biological Safety Officer X3-1738 or X3-3353</td>
</tr>
<tr>
<td>Bloodborne Pathogen</td>
<td>Initial training required for anyone working with human blood and bodily fluids.</td>
<td>Radiation &amp; Biological Safety Officer X3-1738 or X3-3353</td>
</tr>
</tbody>
</table>

The Laboratory supervisor shall provide information and training concerning the handling of hazardous chemicals in their specific laboratory. The Environmental Health and Safety (EH&S) staff in Risk Management is available to assist the Laboratory Supervisor in developing and implementing training policies and procedures.

**Visual Arts and Theatres**

Arrangements should be made through the EH&S staff in Risk Management for the training of faculty, staff and students in Visual Arts and the Theatres. A wide variety of topics can be covered, including but not limited to chemical handling and toxicity, fire safety, accident prevention, machine guarding, hazardous waste management and electrical safety.
B. **Personal Protective Equipment**

The use of personal protective equipment shall be included in all Standard Operating Procedures (see section 3). The type and level of equipment can be determined with the aid of Environmental Health & Safety (EH&S) staff in Risk Management (RM). Any use of personal protection equipment should only be considered after the options of reducing the hazards including improved engineering controls. The laboratory worker should ensure that all personal protection material to be used is compatible with the chemicals to be used.

**RESPIRATORS**

Respirators are not required nor recommended for most research activities at the University. All work involving hazardous materials should be performed in an approved fume hood, which should minimize the potential exposure.

Any respirator use at the University must be pre-approved by Risk Management and will require:

- Medical examination by a Physician prior to use.
- Annual training and fit testing by Risk Management.

A copy of the University’s written Respiratory Protection Policy is available from Risk Management. Information concerning the EH&S written Respirator Program appears in Appendix L.
GLOVE SELECTION

The use of gloves should be based on a chemical resistance chart. Different glove materials resist different chemicals. A glove that is suited well for one application may prove dangerous for another. When reading a chemical resistance chart it is important to become familiar with the terminology. The following is a chart taken from EZFACTS by Laboratory Safety Supply (http://www.labsafety.com).

Chemical Compatibility
Glove Material: NITRILE

<table>
<thead>
<tr>
<th>Challenge Chemical</th>
<th>Degradation</th>
<th>Breakthrough Time</th>
<th>Permeation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isopropanol</td>
<td>E</td>
<td>&gt;480 min</td>
<td>.001</td>
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</tbody>
</table>

**Breakthrough Time:** The elapsed time between initial contact of the chemical on the glove surface and the analytical detection on the inside of the glove. Typically expressed as a greater than symbol (>), the example shows the test was run for 480 minutes and then stopped. Also may be expressed as “ND” for none detected.

**Degradation:** A change in one or more of the physical properties of a glove due to contact with a chemical. Can appear as a swelling, softening, shrinkage or cracking of the material. Rating example is “E” for excellent, meaning the glove has little or no signs of degradation when exposed to the challenge chemical. *A good degradation rating does not guarantee an acceptable breakthrough time.*

**Permeation Rate:** The rate at which a chemical passes through a glove material. This process involves absorption on the glove surface, the diffusion of the chemical through the material, and the desorption on the glove’s inside surface. This is a complex measurement: ug/cm²/min (micrograms per square centimeter per minute). This measurement is also limited to the “LDL” or Lower Detection Limit of the equipment used. The example given is .001, but is sometimes expressed as “E” or “P” for excellent or poor, respectively.

Consult with the MSDS for the chemicals that will be used and request a chart through the glove manufacturer.

EYE PROTECTION

The use of eye protection should be determined by the employee, lab supervisor, and Environmental Health & Safety staff in Risk Management.

Eye protection shall be worn in the laboratory at all times unless the Standard Operation Procedure specifically excludes their use.
Standard Operation Procedure, see Section III B.
PROTECTIVE CLOTHING
The use of protective clothing, including gloves, shall be determined by the employee, lab supervisor, and Environmental Health & Safety (EH&S) staff in Risk Management (RM).

The Standard Operating Procedure shall include whether protective clothing is required. See Section III B.

Protective clothing shall be chosen, with the aid of EH&S staff, on the potential of the chemical exposure and medical condition of the user.

Contaminated protective clothing shall be disposed of properly.

Open-toed shoes, sandals, or open-toed sneakers shall not be worn in laboratories.

Contaminated lab coats shall not be worn. Please consult with your laboratory supervisor for information and replacement.

OTHER PERSONAL PROTECTIVE EQUIPMENT

Other personal protective equipment shall be used, if needed. Its use shall be included in the Standard Operating Procedure.

EMERGENCY SHOWERS AND EYEWASH STATIONS

Emergency showers are located at no more than 10 seconds away from laboratory hazards. Access to emergency showers should not be inhibited or obstructed for any reason. Eyewash stations are typically located at or near laboratory sinks, or in the hallway. Laboratory personnel should flush the eyewash stations weekly to keep them clean. Access to the eyewash should be kept clear at all times.

All laboratory staff should be familiar with the location of emergency showers and eyewash stations.
Local exhaust ventilation is the primary method used to control inhalation exposures to hazardous substances in University research buildings. The laboratory fume hood is the most common local exhaust method used in laboratories. Other types of local exhaust include vented enclosures for large pieces of equipment or chemical storage, and snorkel types of exhaust for capturing contaminants near the point of release. Local exhaust systems consist of some type of hood, ductwork, and a fan located on the roof. Some systems are equipped with air cleaning devices (HEPA filters).

A laboratory fume hood should be used when working with hazardous substances. A properly operating and correctly used fume hood will control the vapors released from volatile liquids as well as dust and mists.

Do not make any modifications to hoods or ductwork without calling Environmental Health & Safety (EH&S) staff in Risk Management (RM) first (x3-3353). It is University policy that any changes made to local exhaust systems must be approved by EH&S staff and Facilities Management.

Do not use a fume hood for large pieces of equipment unless you intend to dedicate the fume hood for this use, since it will change the airflow patterns and may render the fume hood unsafe for other uses. It is generally more effective to install a specially designed enclosure for large equipment so the fume hood can be used for its intended purpose.

Do not use a fume hood for chemical storage. Store chemicals in a chemical storage cabinet since a hood cluttered with bottles may not contain releases effectively.

The EH&S staff in RM conducts the fume hood survey program. Before you begin using a fume hood, check to see that the hood is labeled as appropriate for use with toxic chemicals and has been re-certified within the last year. If this is not the case or you have any doubts about the fume hood operation, contact EH&S staff in RM at x3-3353. Also use the proper work practices listed below:

1. Setup your work at least six inches behind the plane of the sash.
2. Never put your head inside an operating fume hood to check an experiment. The plane of the sash is the barrier between contaminated and uncontaminated air.
3. Work with the sash in the lowest position possible. The sash will then act as a shield.
4. Do not clutter your hood with bottles or equipment. Keep it clean and clear. Only materials actively in use should be in the fume hood. This will provide optimal containment and reduce risk of extraneous chemicals being involved in fire or explosions which may occur in the hood.
5. Clean the grill along the bottom slot of the hood regularly so it does not become clogged with papers and dirt.
6. Do not dismantle or modify the physical structure of your hood or exhaust system in any way without first consulting EH&S staff and Facilities Management.
D. Housekeeping, Maintenance and Inspections

EXAMPLES:

Inspections:

* Formal housekeeping and chemical hygiene inspections should be held semiannually, informal inspections should be continual.

Maintenance:

• Eye wash stations should be flushed weekly by laboratory personnel.
• Gas cylinder regulators should be inspected and their tags completed every 6 mos.
  Regulators should have a tag on them from Risk Management that gives direction on how to inspect the regulator and a place to sign the tag indicating that the inspection has been performed.
• All safety equipment should be inspected regularly (every 3-6 months).
• Procedures to prevent restarting of out-of-service equipment should be established.
  For information; http://www.osha-slc.gov/dts/osta/lototraining/index.htm
• Stairways and hallways should not be used as storage areas. Access to exits, emergency equipment, and utility controls should never be blocked. If a second exit from a laboratory exists, it cannot be blocked by equipment.
E. Signs and Labels, Material Safety Data Sheets

Signs

**Emergency Notification Sign**

The Environmental Health and Safety (EH&S) staff in Risk Management (RM) requires that each laboratory post a current Emergency Laboratory Information Sign on or near its entrance(s). The Brown Emergency Response Team and the Providence Fire Department need current information. Late night, weekend and holiday fires, chemical incidents and other emergencies can be dealt with more effectively and safely if the occupants can be contacted quickly and appropriate hazard warning signs have been posted.

List the following information on this sign:

1. Building-Room number(s).
2. Department
3. Supervisor's name
4. The names of the persons (including supervisors) who should be contacted in an emergency.
   
   **At least two people should be reachable by home phone or pager.**

Brown office telephone extensions and room numbers are helpful but after hours home numbers are necessary.

5. Date posted or revised (update at least annually).
6. Classes and locations of chemicals and other hazards.

Ready-to-mount signs are available from EH&S staff in RM.

Radioactive or Biohazardous substances used in laboratories also require special signs. Hood certification labels are discussed in section C.

Entrances to laboratories, storage areas, and associated facilities must have signs, as necessary, to warn emergency personnel and custodians of unusual or severe hazards therein that are not directly related to combustibility of the contents.

Examples of severe or unusual hazards that may require signs are; unstable chemicals, toxic or carcinogenic materials, chemical spills, high-powered lasers, water reactive chemicals, and radioactive materials. Signs warning of these and for many other uses are available through the EH&S staff in RM.
All containers must be labeled as to content. Chemicals received from outside vendors or from stockrooms of lab supplies will have labels indicating the name with other physical and chemical data. Toxicity warning signs or symbols should be prominently visible on the labels.

All containers of chemicals, which have been decanted from original container, must be labeled with the chemical name, primary hazard(s), person responsible and dated.

All containers of chemical waste must be labeled with the full chemical name, hazard identification, and equipped with the orange waste disposal tag (available from EH&S staff in RM at x3-1610).

All containers of chemicals prepared in the laboratory must be marked with the full chemical name, primary hazard(s), person responsible and dated. Labeling must be provided for chemicals synthesized in the laboratory or prepared by other processes such as distillation or extraction.

Chemicals developed in the laboratory must be assumed to be toxic if no data on toxicity are available, and suitable handling procedures must be prepared and implemented, including training of users in controls necessary to handle safely. If the substance is produced for another user outside of the laboratory, a Material Safety Data Sheet and labels must be prepared and provided to such users (in accordance with provision of OSHA regulation (29 CFR 1910.1200).

Material Safety Data Sheets (M.S.D.S.)

Material Safety Data Sheets (MSDS) are bulletins prepared by manufacturers to summarize the health and safety information about their products. MSDSs are provided for each chemical by its supplier. A file of MSDSs for chemicals, substances, or materials used at Brown is kept by Risk Management, University Chemical Stockrooms and vendor databases. These are accessible to any laboratory employee, student, staff or visiting professional by calling x3-3353.

Material Safety Data Sheets come in many formats and present the information in different ways. Regardless of the format, the information that is required by OSHA includes:

- Product Identity
- Hazardous Ingredients
- Physical/Chemical Properties
- Fire and Explosion Hazards
- Health Hazard

- Reactivity Hazards
- Spill Clean-Up
- Protective Equipment
- Special Precautions

A User's Guide to Material Safety Data Sheets follows. Consult with EH&S staff in RM to apply this general information to your work situation.
USER'S GUIDE TO MATERIAL SAFETY DATA SHEETS

Material Safety Data Sheets (abbreviated MSDS) are prepared by manufacturers to summarize the health and safety information about their products.

TO OBTAIN MSDS's:

- Ask your Supervisor or Departmental Safety Committee representative if your laboratory or department has an MSDS file.
- Or, call the Environmental Health and Safety (EH&S) staff in Risk Management (RM) (x3-3353).
- Or, call the manufacturer.

Vendor Web Sites for frequently used chemical vendors;

VWR Scientific- (JT Baker, Alfa Aesar, Burdick & Jackson, ICN, EM Science, Mallincrodt, VWR brand.
   http://www.vwrsp.com/refine_msdss.html

Fisher Scientific- (Acros, Fisherbrand)
   http://www.fisher.com

Sigma Aldrich- (Sigma, Aldrich, Fluka, Supelco)
   http://www.sigma.com

- Below is the most important information that OSHA requires to be on an MSDS.

- For assistance with interpreting and applying this information to your experiment or work situation, consult with the EH&S staff in RM (x3-3353).

SECTION ONE/IDENTITY

- Trade name used on the label and inventory list
- Manufacturer's name, address, and emergency telephone number
- Preparation and revision dates
*CHEMICAL and COMMON NAMES of all the hazardous components

*MAXIMUM OCCUPATIONAL LIMITS OF EXPOSURE
 : ACGIH TLV
 : OSHA PEL

These are not proven safe levels of exposure. If the exposure limit is not listed, don't assume that a chemical is safe. Contact the EH&S staff in RM (x3-3353).

*Percentage of the mixture (optional) The percentages do not usually add up to 100% since only the hazardous ingredients have to be listed. This is NOT a trade secret recipe.

PHYSICAL/CHEMICAL CHARACTERISTICS

*VAPOR PRESSURE-a measure of a liquid's tendency to evaporate.
*VAPOR DENSITY-vapor or gas lighter or heavier than air.

*APPEARANCE and ODOR-depending upon your senses to detect or identify hazardous materials is like playing russion roulette

The EH&S staff in RM consider these properties as well as how you work with a hazardous material to evaluate the risks, which vary greatly depending on how a material is used.

FIRE AND EXPLOSION HAZARD DATA

*FLASH POINT--the lowest temperature at which a liquid gives off enough vapors, which when mixed with air, can be easily ignited by a spark. The lower the flash point, the greater the risk of fire or explosion. Remember it's the vapors that burn, not the liquid.

REACTIVITY DATA

- Reactivity, in this context, is the tendency for a material to chemically change or breakdown and to become more dangerous. Precautions include:

*CONDITIONS TO AVOID--such as light or heat

*MATERIALS TO AVOID--for example: sodium and water will react vigorously to generate hydrogen, creating a fire hazard

HEALTH HAZARD DATA

- If you need health hazard information that is not on an MSDS, contact the EH&S staff in RM (x3-3353).

*ROUTES OF ENTRY--How a hazardous material can enter your body:
  Inhalation, Skin Absorption, Injection and Ingestion
*LONG-TERM HEALTH EFFECTS (CHRONIC)--symptoms may be felt after repeated contact with the same hazardous material over a long period of time

- References that list a chemical as a carcinogen or potential carcinogen
- Signs and Symptoms of Exposure
- Medical Conditions Generally Aggravated by Exposure
- Emergency and First-aid Procedures

PRECAUTIONS FOR SAFE HANDLING AND USE

*SPILL AND LEAK PROCEDURES--The EH&S staff in RM can advise you on specific procedures and recommend protective equipment. For spills of 100 ml’s or more of non-acute hazardous chemicals or any quantity of an acute hazard please contact EH&S staff at X3-3353. If you are concerned about any spill clean-up procedures contact EH&S staff immediately.

Waste Disposal- Contact EH&S staff, at x3-1610 or x3-3353 for hazardous waste information.

The EH&S staff in RM can answer specific questions regarding ventilation and personal protective equipment for normal working conditions and emergencies. Suitable control measures are based on how a material is used.

F. Monitoring and Employee Assessment

1. The EH&S staff in RM will perform exposure monitoring in accordance with paragraph (d) of 29 CFR 1910.1450, upon request from researchers or in response to complaints.
2. Employee exposure determination shall be done in accordance with paragraph (d) of the 29 CFR 1910.1450.

a. Employee exposure determination.
   (i) Initial monitoring will be performed if there is reason to believe that exposure levels for a substance routinely exceed the action level (or in the absence of an action level, the PEL).
   (ii) Periodic monitoring.
        If the initial monitoring performed discloses employee exposure over the action level (or in the absence of an action level, the PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.
   (iii) Monitoring may be terminated in accordance with the relevant standard.
   (iv) Within 15 working days after the receipt of any monitoring results, the employee will be notified of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.
3. Anyone with a "reason to believe that exposure levels for a substance routinely exceed the action level, or in the absence of an action level, the PEL" may initiate the monitoring process.
   a. Requests for monitoring can be made to the EH&S staff.
   b. The Chemical Hygiene Officer must be notified of monitoring requests.
4. Monitoring may be requested at any time.
5. It will be the responsibility of the Chemical Hygiene Officer to insure that periodic monitoring requirements are satisfied, when necessary.

7. The EH&S staff in RM will maintain exposure monitoring records.

a. **Recordkeeping.**
   (1) The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.
   (2) The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.20.

G. **Waste Disposal**

**Policy**

The proper disposal of waste chemicals at the University is of serious concern and proper disposal is required. The responsibility for the identification and handling of waste chemicals within each laboratory necessarily rests with the individuals who have created the waste. It is the responsibility of the Risk Management staff to assign all EPA hazardous waste codes. Contact Environmental Health & Safety (EH&S) staff in Risk Management (RM) at x3-1610 or x3-3353 with any questions.

**Identification**

All waste chemicals must be identified by full chemical name, including the proportions of a mixture. Do not use symbols or abbreviations. All containers must be labeled prominently because the safe transportation of chemicals is possible only when everyone who handles the containers knows the identity of the contents.

**Unknown Waste Chemicals**

Unknown waste cannot be accepted for disposal. Disposal contractors cannot accept or ship unknown waste. It is the responsibility of the department involved to identify all chemicals and this may require polling laboratory personnel, students and faculty members to ascertain the owner of such unknown waste and its identity. Ultimately it may require the services of an analytical
Identify and label all wastes and project products with a chemical name. In order to properly dispose, unknown wastes can cost more than ten times the normal rate.

**Orange Tags**

All containers of hazardous waste must have a "Orange Hazardous Waste Label" attached to them. This "Orange Hazardous Waste Label" identifies the type of waste, the associated hazards and the laboratory or department that created the waste. The Orange Hazardous Waste Labels are available from all stockrooms and the EH&S staff in RM at x3-1610 or x3-3353.

**Storage**

1. Waste chemicals stored in containers of one gallon or larger size should be break-resistant, whenever possible.

2. All waste chemicals stored in breakable containers shall be kept within approved secondary containers.

**Break-Resistant** shall mean a container made of metal, plastic, plastic-coated glass or metal overpack of glass.

**Approved Secondary Container** must be compatible with the waste that it is holding.

**Packaging**

Wastes must be packaged and containerized in a manner which will allow them to be transported without the danger of spillage, explosion, or hazardous vapors escaping. Wastes, which have not been properly packaged and identified, will not be accepted for disposal.

**Storage Area**

**Guidelines for Waste Reduction**

Plan a procedure for waste disposal before you start on a project. Label waste properly. It is up to each department, group, or experimenter to identify waste materials properly before disposal. Inadvertent mixing of incompatible materials could have serious consequences.

Protection of the environment makes the disposal of large quantities of chemical and solid wastes a difficult problem. It is in everyone's best interest to keep quantities of waste to a minimum.

The following suggestions may help:

1. Order only the amount of material you need for your project or experiment even if you can get twice as much for the same money.

2. Use only the amount of material that is needed for conclusive results.
because you may want it in the future.

4. Before disposing of unwanted, unopened, uncontaminated chemicals check with others in your department who may be able to use them.

5. On termination of a research project or completion of a thesis, all unused chemicals to be kept by the laboratory shall be labeled properly.

6. Make sure all samples and products to be disposed of are properly identified, labeled with its chemical name and containerized. Do not leave them for others to clean up after you.

Types and Procedures

Organic solvents must not be put down the drain. Federal and State regulations which apply to Brown’s sewer system prohibit the discharge of organic solvents to the sewer system. This applies to all organic solvents whether flammable or nonflammable, miscible or non-miscible with water. Organic solvents should be placed in suitable containers where there is no danger that vapors or the liquid will escape. Containers shall be capped tightly, labeled prominently and placed in your hazardous waste chemical storage area.

Mixtures of organic solvents that are compatible and combined in one container must be identified with an estimated proportion in percentages of each solvent in the mixture.

Acids and alkaline solutions should be collected. Do not pour down the drain. All acids and caustics should be placed in the hazardous waste storage area of your laboratory in proper containers tightly capped and labeled. Acids and caustics should be segregated in separate secondary containment trays.

Inorganic and organic solids in their original containers that are designated as waste because they are contaminated, old, or of questionable purity may be placed in the hazardous waste secondary containment storage area in each laboratory.

Mercury must be removed from lab apparatus and put into jars or bottles before placing it in the hazardous waste storage area. Broken mercury thermometers must be put into a jar or secondary container. Clean up materials from a mercury spill may be containerized, labeled and placed in the hazardous waste secondary containment storage area.

Cyanide compounds, arsenic, lead, and heavy metal wastes should be placed in bottles and containers, sealed tightly, labeled, and placed in the hazardous waste secondary containment chemical storage area.

The EH&S staff in RM x3-1610 may be consulted if there is any question concerning the toxicity or packaging of any toxic wastes.

Alkali metals such as sodium and potassium should be placed in a suitable container, covered with Nujol (mineral oil), labeled properly, sealed so that there is no possibility of their coming in contact with water, and placed in your hazardous waste storage area.
and fine powders should be placed in a metal container, sealed tightly, labeled, and placed in your hazardous waste storage area.

**Waste Oil - Small Quantities** of vacuum pump oil or lubricating oils in 1 gallon containers or less may be placed in your hazardous waste storage area. For larger quantities please see guidelines below.

Large quantities of waste chemicals to be removed from a laboratory may be more than a normal amount for the EH&S staff to pick up. The department may be financially responsible for the disposal.

**OTHER TYPES-SPECIAL PROCEDURES REQUIRED**

Gas cylinders are to be returned to the proper vendor. Some small lecture bottles are the non-returnable type, which become a disposal problem when empty or near empty with a residual amount of gas. Disposal costs can exceed $1,000.00. Call the EH&S staff x3-3353 for information on the disposal of non-returnable cylinders. **When ordering gases in lecture bottle size be sure to order the gases in a returnable cylinder.**

Controlled drugs to be disposed of, as waste must not be sent to the hazardous waste chemical storage area. The handling, records, and disposal of controlled drugs are the responsibility of the department involved operating within the Drug Enforcement Agency (DEA) Regulations. The Animal Care Facility should be contacted directly.

Radioactive material disposal is handled in accordance with procedures established by the Radiation Safety Office (x3-1738).

Biological Waste and Physically Dangerous Waste (Sharps) must not be sent to the waste chemical storage area. These wastes are deactivated and disposed of according to procedures set forth by EH&S staff in RM (x3-1738).

Polychlorinated Biphenyls (PCB's) - Capacitors, transformers, equipment and oil that contain PCB's are considered hazardous waste in Rhode Island. Contact EH&S at (x3-1610) for procedures on the management of PCBs.

Waste Oil - Bulk Quantities of waste oil stored are the responsibility of the department involved. See "Guidelines for Handling Waste Oil in Bulk Quantities," at the end of this section.

**GUIDELINES FOR HANDLING WASTE OIL IN BULK QUANTITIES**

Identification

Drums of waste oil need to be identified with the Orange Hazardous Waste Label.

Drum
that are not in good condition.

Inside Storage

The area where the drums are to be stored should be a suitable inside area that is preferably cool and dry. Secondary containment of 110% is required.

Secure Area

The storage area should be secured or locked to ensure that the contents of the drums are as identified and belong to the department involved. The department may want to have an individual assigned responsibilities for this area so that persons cannot dump waste oil without authorization.

Paperwork

EH&S staff in RM at x3-1610 or x3-3353 will arrange for the disposal and sign all hazardous waste manifests.
Programs:

a. Medical surveillance is available to employees or students exposed routinely to the following hazards:

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos</td>
<td>4-Aminodiphenyl</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Ethylenimine</td>
</tr>
<tr>
<td>Lead</td>
<td>beta-propiolactone</td>
</tr>
<tr>
<td>4-Nitrobiphenyl</td>
<td>2-acetylaminofluorene</td>
</tr>
<tr>
<td>Alpha-Naphthylamine</td>
<td>N-Nitrosodimethylamine</td>
</tr>
<tr>
<td>Methyl Chloromethyl Ether</td>
<td>Vinyl Chloride</td>
</tr>
<tr>
<td>3,3”-Dichlorobenzidine</td>
<td>Inorganic arsenic</td>
</tr>
<tr>
<td>bis-chloromethyl ether</td>
<td>Benzene</td>
</tr>
<tr>
<td>beta-naphthylamine</td>
<td>Cotton Dust</td>
</tr>
<tr>
<td>benzidine</td>
<td>1,2-dibromo-3-chloropropane</td>
</tr>
<tr>
<td>Acrylonitrile</td>
<td>Ethylene Oxide</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>Methyleneedianiline</td>
</tr>
<tr>
<td>1,3 – Butadiene</td>
<td>Methylene Chloride</td>
</tr>
<tr>
<td>Inonizing radiation</td>
<td></td>
</tr>
</tbody>
</table>

and the following materials;

Recombinant DNA

and to individuals in contact with potential sources of infectious diseases (Such as animal handlers)

and to individuals working with ionizing radiation in the event of exposures.

b. In addition, employees or students who wish to discuss workplace risks, reproductive hazards, allergies, workplace illnesses, or other workplace exposure matters may do so by contacting Environmental Health & Safety (EH&S) staff in Risk Management (RM) at X3-3353.

Charges:

There are no charges for persons performing duties in a laboratory who need these services. If you are in need of services please contact EH&S staff in RM X3-3353.
Purpose:

a. The purpose of medical surveillance is, as a secondary means of prevention, to detect early failures of primary means of workplace protection that may result in workplace illness.

b. Enrollment

Enrollment in ongoing routine medical surveillance is initiated by the EH&S staff at x3-3353.

Enrollment and Compliance Responsibility:

a. Identification of individuals at potential risk.

   i. It is the responsibility of supervisors to identify new employees/students who are exposed to hazards, and to provide names, work addresses, and social security numbers to EH&S staff at x3-3353.

   ii. Individuals not otherwise identified but who believe that they incur hazardous exposures may request enrollment themselves by calling x3-3353.

   iii. EH&S staff may identify individuals or populations of individuals at risk and invite their participation.

Compliance with Scheduled Doctor Appointments:

a. It is the responsibility of individuals to appear promptly for scheduled appointments.

b. The departments or other administrative entities may, as a matter of written policy, require enrollment and participation in medical surveillance provided that such requirements apply equally to all affected individuals.

Right To Privacy:

Your medical surveillance results are private. They are part of a medical record, which is kept within Health Services. The only individual who can initiate the dissemination of this information outside of the medical department is you.
Right To Information:

You have the right to be informed of the results of your medical surveillance, and this will happen normally as a matter of course.

a. **Physician Visit**
   If your surveillance involves a physician or other provider visit, you will be informed of findings at the time of your visit.

b. **Laboratory Results only, or Incomplete Information At Time of Physician Visit**
   If complete surveillance information is not given to you at the time of provider visits, because surveillance involved lab work only, or because the full information was not yet available at the time of the visit, you will receive a letter informing you of results.

c. **Questions About Results or Incomplete Reporting**
   If you have not received complete information about an encounter within one month from the time of the visit, or if you have questions about the information received, please call EH&S staff at x3-3353 to obtain additional information.

Rights Of Supervisors:

Supervisors have a right, and sometimes a legal duty, to know if individuals are medically fit to perform certain kinds of work (such as wearing respirators on the job).

Supervisors are not entitled to know diagnoses, medical findings, or other personal information in the medical record.

**When supervisors need information, the information given to supervisors is in one of three categories:**

a. Fit to perform the operation

b. Not fit to perform the operation
Additional information can be given to supervisors only with the patient’s written approval.

5. **Emergency Response and Exposure Reporting**

Any employee who believes they have had an exposure should contact Environmental Health & Safety (EH&S) staff in Risk Management (RM) (x3-3353) for evaluation.

If any employee exhibits adverse health effects they should report to Health Services immediately. EH&S staff will evaluate the situation and conduct air sampling if necessary to help determine actual exposures. The results of all hazard evaluations and any area air sampling data will be available to all occupants of the affected areas. EH&S staff can be contacted directly for information. In addition, the results of any personal air sampling conducted will be given to the individual as well as kept by EH&S in RM records. EH&S staff cannot divulge results of personal sampling without the consent of the employee. (Results will also be added to the individual's medical records, which are kept in Health Services).

Emergencies that can occur in a laboratory include fire, explosion, chemical spill or release, medical or other health threatening accidents. General procedures to be followed in any emergency are:

1. Render assistance to person(s) involved and remove them from exposure to further injury if necessary and if this can be done safely.

2. Notify nearby persons who may be affected and call x3-4111 to report the emergency and seek assistance. (Note that EMS and the EH&S staff are on-call 24 hours per day and can be reached through Police & Security at x3-4111.

3. Evacuate the area until help arrives. If necessary, pull the fire alarm to evacuate the entire building.

4. Wait for emergency responders and assist them in handling the emergency.

5. Assist in the follow-up investigation of the emergency.
6. **Emergency Response**

**EMERGENCY RESPONSE**

**Accidents**

If an accident or medical emergency occurs anywhere in the University, the following procedure should be followed:

- Medical and first aid assistance should be the first priority in any accident. Contact Police & Security at X3-4111 to get medical attention for injured personnel. See the First Aid section of this manual for response to specific incidents.

- If an accident results in an injury or exposure to any member of the University Community, an accident report must be completed and sent to the Office of Risk Management Box 1914. A copy is available at the end of this section.

- If the injured person is an employee and the accident occurred during the work shift, the supervisor should fill out the accident report. Accident report forms are available from the Office of Risk Management, and there is a copy at the end of this section.

**Chemical Spills**

1. **EVACUATE ROOM.**

2. **REMOVE CONTAMINATED CLOTHING ASAP. TAKE SHOWER FOR LARGE BODILY CONTAMINATION.**

3. **GET MEDICAL ATTENTION FOR INJURED PERSONNEL, Call Police & Security x3-4111.**

4. If you feel comfortable with the material and the spill is less than 100 ml, clean by using an available laboratory spill kit.

- **YOU SHOULD BE ABLE TO CLEAN UP THE SPILL SAFELY ON YOUR OWN UNDER THE FOLLOWING CIRCUMSTANCES.**

  1. The type and quantity of spilled material presents a low-level health and safety hazard.

     a) The spill involves a nonvolatile liquid, or liquid which gives off vapors that are not harmful when inhaled over a short period of time.

     b) The spill involves an inert solid.

     c) The spilled material is not highly reactive, radioactive, or likely to cause a fire.

     d) The quantity of spilled liquid is no greater than one liter.

     e) The quantity of spilled reactive, poisonous, or explosive solid material is no greater than one kilogram.

     f) The spill has occurred inside a laboratory building.
2. Appropriate spill clean up material and equipment are readily available. Make sure that you use a commercially prepared clean-up kit appropriate for the type of chemical spilled. Do not use shovels or brooms that will create sparks when cleaning up flammables.

3. Personal protective equipment is readily available. Always wear appropriate gloves when cleaning up a spill. If you need respiratory protection equipment, you should not be attempting the clean up yourself.

4. You have sufficient knowledge of what to do. If you are not sure how to clean up the spill properly, you should not attempt to do so.

How to safely clean a spill

CHEMICALS
1. Extinguish open flame.
   If there is no fire, turn off all Bunsen burners, hot plates and other sources of ignition to avoid a resultant fire.
2. Leave hood/room exhaust on.
3. For large spills follow instructions from the Emergency Response Team in Risk Management.
4. For small spills follow instructions on spill kit and training procedures.
5. Wear necessary personal protective clothing. At a minimum: Gloves, Lab Coat, and Safety Glasses.
6. Only after RISK MANAGEMENT confirms area is safe, ask custodial services to wash spill area.
7. All exposed personnel should be checked by Health Services X 3-3953.
8. Contact Risk Management at X3-3353. For weekend, holidays, and off-hours, call Police and Security at X3-4111.

BIOHAZARDS
1. Allow aerosols to settle 30 minutes.
2. Put on protective clothing and assemble clean-up material.
3. Personal protective clothing should include: Lab Coat, Gloves, Safety Glasses, Dust/Mist Respirator.
4. Pick up broken glass with forceps.
5. Pour concentrated disinfectant around spill; let sit 15 minutes.
6. Dispose of all contaminated material in autoclave container; and autoclave.
7. For any exposure to blood and/or body fluids, contact the Biological Safety Officer at X: 3353. For weekend, holidays, and off-hours, call Police and Security at X3-4111.

RADIOACTIVE
1. Notify all personnel to vacate the area.
2. For large spills, call the Radiation Safety Office X3-3353 immediately. For small spill follow the procedures below.
3. Put on protective clothing (lab coat, gloves).
4. Blot any spilled liquid with absorbent paper. Do not wipe or use a wiping motion. Wipe from the outside to the inside of the spill.
5. Avoid stepping in the spilled liquid.
6. Once the affected area has been blotted dry, scrub the contaminated area with soap and water. Blot water from the surface with absorbent paper.
to the bag.
8. Monitor the area with a geiger counter or wipe test as appropriate.
9. Contact the Radiation Safety Officer at X3-3353. For weekend holidays, and off-hour call Police and Security at X3-4111.

IF YOU CANNOT CLEAN UP THE SPILL SAFELY ON YOUR OWN:

1. Notify Police & Security at x3-4111 for assistance. Be prepared to supply the following information;
   a. Your name and extension at which you can be reached while waiting for assistance.
   b. Location of the spill.
   c. Names of the chemicals, biologic agents, or radioactive materials involved.
   d. Estimate of amount spilled.
   e. Name of the person in charge.
2. If the spill is in a hood, close the sash completely.
3. Leave the room where the spill has occurred and post a sign on the door to prevent entry.
4. Wait for help to arrive.

• Once the spill has been cleaned up, submit an accident report to the Office of Risk Management. Accident report forms are available from the Office of Risk Management and there is a copy at the end of this section.

CHEMICAL RELEASE TO THE ENVIRONMENT

Whenever a spill, fire, or uncontrolled reaction results in a release of a chemical to the environment, including releases to the air, soil, or sewer, you must notify Police and Security as well as your building safety contact. Federal and State regulations require notification of various government agencies when such incidents occur. In order to ensure compliance with these regulations it is extremely important for Police and Security to be informed immediately so that EH&S staff can be informed and initiate appropriate agency notification.

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**BROWN UNIVERSITY ACCIDENT REPORT FORM**

Employees who are injured while working must notify their supervisor immediately and complete this form. Supervisors must ensure completion of form, proper signatures, and delivery to Risk Management within 48 hours of injury.

Fax · 863-7676 Campus Box · 1914

**Personal Information:**
mame of injured employee________________________________________________________ Sex M♂ F♀ Date_____________________
home address (local for student workers)_________________________________________ Telepho
student: Did mishap occur as direct result of course of study or employment? Please check one.

Occupation____________________________________Department____________________________________ Date of hire__________

Supervisor’s name____________________________________ Campus phone number __________________________ Box number__________

Pay type: Weekly  Student  Miscellaneous  Semi-Monthly  Monthly  Faculty

Medical Information:

Did the mishap occur as a direct result of employment at Brown University? Yes No

Did you go to University Health Services? Yes No

Did University Health Services refer you to another medical provider? Yes No If yes

Did you see any medical provider (i.e. emergency room, private physician)? Yes No If yes

Did you (or will you) miss any days from work? Yes No If yes, List date

Incident Information:

When did the mishap occur? Date Time AM PM

Time work day started? Time AM PM

Days normally worked each week: Sunday Monday Tuesday Wednesday Thursday Friday Saturday

Where did the mishap occur? (Please be specific)_____________________________________________________________________________

Witnesses? (Please indicate the name of anyone who was with you when you were injured or witnessed your jury)__________________________

OH did the mishap occur? (Please be specific)_____________________________________________________________________________

What injuries were sustained, if any? (Example: cut-left hand, bruise-right knee)_____________________________________________________________________________

Employee’s Signature

Signed or incomplete reports will be returned causing delay in processing

Supervisor Information:

Corrective measures taken announced.________________________________________________________________________________________

_____________________________________________________________________________________________________________

_____________________________________________________________________________________________________________

_____________________________________________________________________________________________________________
7. **FIRST AID**

The first aid administered to injured laboratory personnel shall be limited to procedures necessary to stabilize an protect the person from further injury. It is critical to summon medical help at X3-4111 as soon as possible. The instructions that follow are intended as guidelines for untrained individuals and should be executed while waiting for medical assistance. It is preferable to have a person trained in first aid and cardio-pulmonary resuscitation (CPR) provide assistance during the first few minutes. The Environmental Health & Safety (EH&S) staff in Risk Management (RM) urges employee involvement in first aid and C.P.R. training and will assist in arranging such training sessions.

**Never attempt a rescue that will endanger your own safety!**

**RESPONSE TO SPECIFIC INCIDENTS**

**Splash to the eye**

Note: Contact lenses are not recommended in a laboratory. If necessary they should not be worn without splash goggles.

**Chemical**

1. Immediately flush the eye with a gentle stream of clean, temperate water for at least 15 minutes. Hold the eyelids open. Be careful not to wash the contaminant into the other eye. Use an emergency eyewash if one is accessible.

2. Notify your Supervisor of any incident/accident. If medical attention is needed, call Police and Security at x3-4111 for Emergency Medical Services.

**Biological**

1. Immediately flush the eye with a gentle stream of clean, temperate water for at least 15 minutes. Hold the eyelids open. Be careful not to wash the contaminant into the other eye. Use an emergency eyewash if one is accessible.

2. Notify your Supervisor of any incident/accident. If medical attention is needed, call Police and Security x3-4111 for Emergency Medical Services. Notify the Biological Safety Officer at x3-3353.

**Radioactive**

1. Immediately flush the eye with a gentle stream of clean, temperate water for at least 15 minutes. Hold the eyelids open. Be careful not to wash the contaminant into the other eye. Use an emergency eyewash if one is accessible.

2. Notify your Supervisor of any incident/accident. If medical attention is needed, call Police and Security x3-4111 for Emergency Medical Services. Notify the Radiation Safety Officer x3-3353.

**Contamination to the body**

**Chemical**
1. Immediately drench skin with water and remove contaminated clothing. Flush the area for at least 15 minutes. Use an emergency drench shower if one is accessible.

2. Notify your Supervisor of any incident/accident. If medical attention is needed, call Police and Security x3-4111 for Emergency Medical Services (EMS).

**Biological**

1. Immediately drench skin with water and remove contaminated clothing. Flush the area for at least 15 minutes. Use an emergency drench shower if one is accessible.

2. Notify your Supervisor of any incident/accident. If medical attention is needed, call Police at Security x3-4111 for Emergency Medical Services (EMS). Notify the Biological Safety Officer at x3-3353.

**Radioactive**

1. Immediately drench skin with water and remove contaminated clothing. Flush the area for at least 15 minutes. Use an emergency drench shower if one is accessible.

2. Notify your Supervisor of any incident/accident. If medical attention is needed, call Police at Security x3-4111 for Emergency Medical Services (EMS). Notify the Radiation Safety Officer at x3-3353.

**Thermal burns**

1. If skin is unbroken, submerge the burned area in clean water.

   **Important:** if the skin IS broken, do NOT submerge the burned area in water.

2. Do not break any blisters.

3. Do not use any medications.

4. Notify your Supervisor of any incident/accident. If medical attention is needed, call Police at Security x3-4111 for Emergency Medical Services (EMS).

**Cold Liquid Frostbite**

1. Flood area with lukewarm water (not hot or cold)

2. Clothing should not be removed as it may be frozen to the skin and may remove layers with it, if removed, cover with dry sterile dressings.

3. Any affected areas should be handled VERY gently.

4. Rewarming should only be attempted by medical professionals in a stable, sterile, medical environment.
If the victim is conscious:

1. Notify your Supervisor of any incident/accident. If medical attention is needed, call Police at Security X3-4111 for Emergency Medical Services (EMS).
   **POISON CONTROL CENTER: 444-5727**

2. Save the label or the container for vital information for medical treatment.

If the victim is unconscious: **Call EMS X3-4111**

1. Maintain open airway for adequate breathing.

2. Save the label or container for vital information for medical treatment.

**Poisoning by inhalation**

1. **Do not become a victim yourself by exposure to the same poison while rescuing the victim.** Be sure the hazard no longer exists before entering area. If a dangerous/hazardous atmosphere exists, The Emergency Response Team in Risk Management (RM) needs to respond for any rescue attempts. It is important to communicate the potential presence of a dangerous/hazardous atmosphere to Risk Management and any other responding teams.

2. Move the victim to uncontaminated air immediately.


4. Notify your Supervisor of any incident/accident. If medical attention is needed, call Police at Security x3-4111 for Emergency Medical Services (EMS).

If the victim is unconscious: **Call EMS x3-4111**

**Cuts and abrasions**

1. Immediately cleanse the wound and surrounding skin with soap and warm water, wiping away from the wound.

   **It is important that you take proper precautions to protect yourself from the victim’s potentially infectious body fluids by using Universal Precautions which include gloves, face shield etc.**

2. Hold a sterile or clean pad firmly over the wound and apply pressure directly to the wound.

3. If the person is bleeding profusely, **Call EMS x3-4111.**

4. Keep the victim lying down and raise the bleeding part higher than the rest of the body if the cut is severe.

5. Notify your Supervisor of any incident/accident. If medical attention is needed, call Police at Security x3-4111 for Emergency Medical Services (EMS).

**Clothing fire**

If your clothing should catch on fire, immediately **DROP TO THE FLOOR AND ROLL.** In case of ignition of another person’s clothing, immediately knock that person to the floor and roll that person around to smother the
Fire blankets are of secondary importance. They should be used only when immediately at hand. Rolling on the floor smothers the fire, helps keep flames out of the victim's face and reduces inhalation of smoke. Improper use of fire blankets can increase the severity of smoke and injuries if the blanket is not removed after the flames have been extinguished.

**Electrical Shock**

1. NEVER approach or touch a person who is in contact with live electrical equipment!
2. Shut off power source as soon as possible.
3. Administer CPR if necessary.

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8. **FIRE SAFETY**

**Components of a Fire**

1. Oxygen
2. Fuel
3. Heat, spark, or other source of ignition

A fire cannot take place without the proper combination of all three of these components. Thus the easiest means of fire prevention is to eliminate one or more of these components.

**Precautions**

- Minimize fuel
  1. Keep flammable and combustible chemical storage to a minimum.
  2. Do not accumulate combustible trash in laboratories, especially near exits and corridors.
  3. Solvent saturated refuse (e.g. oily rags) should be collected as hazardous waste. Dry rags should be disposed of in the trash unless it contains other elements such as heavy metals etc.
  4. Never pour volatile liquids down the sink.
  5. Keep containers of flammable liquids capped when not in use.

- Minimize ignition sources
2. Install explosion-proof electrical equipment in areas where flammable liquids are used or may generate vapor concentrations at ignitable levels.

3. Report damaged or defective electrical equipment to Facilities Management. If extension cords are used they should be UL approved and no less than 15 amps.

4. Do not use space heaters in laboratories or other chemical storage areas.

5. Avoid using open flames whenever possible.

All University personnel and students should be aware of the steps to be taken in case of fire. It is expected that any member of the community attempt to extinguish a fire if this will endanger his/her own safety. Action by the occupants of a building, however, can often minimize damages to health and property. Fire extinguisher use training is available upon request from Risk Management’s Fire Safety Office X3-3462.

**Be Prepared**

- Know the location of emergency exits and keep them clear of debris.

- Know the location of fire extinguishers and fire blankets.

- Understand the different types of fires and extinguishers and know what types of extinguishers are available in your area.

  1. Class A fires involve paper, wood, and non-volatile combustible materials. These may be extinguished with water (type A extinguisher) or with a multipurpose ABC extinguisher.

  2. Class B fires involve flammable liquids. **DO NOT USE WATER ON A CLASS B FIRE.** Use a CO₂, dry chemical, or multipurpose ABC extinguisher.

  3. Class C fires are fires that are near energized electrical equipment. **DO NOT USE WATER ON A CLASS C FIRE.** Use a CO₂, dry chemical, or ABC extinguisher. CO₂ is best for class C fires since it will cause the least amount of damage to equipment.

  4. Class D fires involve alkali earth metals and alkaline metals such as sodium, potassium, magnesium. **DO NOT USE WATER OR AN ABC EXTINGUISHER.** This will create very dangerous conditions. Always use a type D extinguisher which is identified by a five point star. You may also extinguish burning metals with sand.

**Response to Fire**

- If the fire is small and does not involve hazardous materials, you may attempt to extinguish the fire with an extinguisher. Use good judgment. Do not attempt to extinguish a fire if you are not certain you can control it. Pull the alarm so that help will be on the way.

- If the fire is too large for you to control, or if there are hazardous substances involved, pull the fire alarm and evacuate the building.

- If you know what is burning, indicate this to the University Fire Safety Officer, Police at Security, or the Providence Fire Department when they arrive on the scene.

- The University Fire Safety Officer conducts fire drills in dormitories in compliance with State regulations. Fire drills are conducted in other buildings on campus as needed or upon request. If you would like to schedule a fire drill in your building, contact the University Fire Safety Officer in Risk Management X3-3462.

- When an alarm goes off for any reason, it is required that all occupants leave the building even if a false alarm is suspected. Students and employees may be penalized for failure to evacuate.

**False Alarms**
• If you will be doing work that may accidentally set off the fire alarm in a building because you will be generating substantial amounts of dirt, dust, or fumes, you should notify the University Fire Safety Officer at X3-3462 or X3-3353.

9. **Electrical Safety**

**General Guidelines**
The following guidelines should be followed in laboratories and in other places on campus to reduce the risk of electrical accidents.

• Operate all equipment on grounded circuits, or ground the equipment itself.
• Do not use portable space heaters in laboratories or other areas where chemicals are present.
• Extension cord use should be kept to a minimum. Use only UL approved three prong extension cords, at least 15 amps, that are no longer than nine feet long.
• Do not use three to two prong adaptor plugs. Make sure the grounding prong is present.
• Do not overload circuits!
• If different voltages are available in your area, mark your equipment so incorrect connections are not made.
• Conduct regular inspections of electrical equipment.
  1. Look for loose connections or broken parts.
  2. Replace worn out power cords and plugs.
  3. Protect wires from traffic.
  4. Mark fuse and circuit boxes indicating what equipment is covered.
  5. Make sure there are signs indicating high voltage usage.
• Do not attempt to repair or clean the insides of electrical equipment.

**Electrical Shock Prevention**

• Follow all of the guidelines listed above.
• Never use electrical equipment in wet locations.
• Never operate electrical equipment while touching a metal object, especially plumbing.
• An extension cord cannot be used as a permanent installation (>30 days). If additional Electrical circuits are necessary contact Facilities Management X3-7800.
• Always Lockout/Tagout equipment during installation, maintenance and repair. Contact Environmental Health & Safety (EH&S) staff in Risk Management (RM) for more information X3-3353.
Appendix A: OSHA Laboratory Standard

29 CFR 1910.1450—Occupational Exposure to Hazardous Chemicals in Laboratories

(a) Scope and application.

(1) This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.

(2) Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR part 1910, subpart Z, except as follows:

(i) For any OSHA health standard, only the requirement to limit employee exposure to the specified permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.

(ii) Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

(iii) Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements, paragraphs (d) and (g)(1)(ii) of this section shall apply.

(3) This section shall not apply to:

(i) Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart Z, even if such use occurs in a laboratory.

(ii) Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:

(A) Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is
chart supplied by the manufacturer of the test strip; and

(B) Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

(b) Definitions-"Action level" means a concentration designated in 29 CUR part 1910 for a specific substance calculated as an eight (8)-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U. Department of Labor, or designee. "Carcinogen" (see "select carcinogen").

"Chemical Hygiene Officer" means an employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not intended to place limitations on the position description job classification that the designated individual shall hold within the employer's organizational structure.

"Chemical Hygiene Plan" means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section. "Combustible liquid" means a liquid having a flashpoint at or above 100 deg. F (37.8 deg. C), but below 200 deg. F (93.3 deg. C), except a mixture having components with flashpoints of 200 deg. F (93.3 deg. C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

"Compressed gas" means: (i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 4 psi at 70 deg. F (21.1 deg. C); or (ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 deg. F (54.4 deg. C) regardless of the pressure at 70 deg. F (21.1 deg. C); or (iii) liquid having a vapor pressure exceeding 40 psi at 100 deg. F (37.8 deg. C) as determined by ASTM D-323-72.

"Designated area" means an area which may be used for work with "select carcinogens," reproductive toxins substances which have a high degree of acute toxicity. A designated area may be the entire laboratory, such as laboratory hood.

"Emergency" means any occurrence such as, but not limited to, equipment failure, rupture of containers failure of control equipment which results in an uncontrolled release of a hazardous chemical into the workplace.

"Employee" means an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.

"Explosive" means a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

"Flammable" means a chemical that falls into one of the following categories:

(i)"Aerosol, flammable" means an aerosol that, when tested by the method described in 16 CFR 1500.4
(ii) "Gas, flammable" means: (A) A gas that at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or (B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the low limit.

(iii) "Liquid, flammable" means any liquid having a flashpoint below 100 deg F (37.8 deg C), except a mixture having components with flashpoints of 100 deg C or higher, the total of which makes up 99 percent more of the total volume of the mixture.

(iv) "Solid, flammable" means a solid, other than blasting agent or explosive as defined in 1910, that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retains heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

"Flashpoint" means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

(i) Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24-1979 (ASTM D 56-79))-for liquids with a viscosity of less than 45 Saybolt Universal Second (SUS) at 100 deg. F (37.8 deg. C), that do not contain suspended solids and do not have a tendency to form surface film under test; or

(ii) Pensky-Martens Closed Tester (See American National Standard Method of Test for Flashpoint by Pensky-Martens Closed Tester, Z11.7-1979 (ASIM D 93-79))-for liquids with a viscosity equal to or greater than 45 SUS at 100 deg. F (37.8 deg. C), or that contain suspended solids, or that have a tendency to form surface film under test; or

(iii) Setaflash Closed Tester (see American National Standard Method of Test for Flash Point by Setaflash Closed Tester (ASTM D 3278-78)). Organic peroxides, which undergo autoaccelerating thermal decomposition are excluded from any of the flashpoint determination methods specified above.

"Hazardous chemical" means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or high toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxic agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes. Appendices A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for purposes of this standard.

“Laboratory" means a facility where the "laboratory use of hazardous chemicals" occurs. It is a workplace where relatively small quantities of hazardous chemicals used on a non-production basis.
“Laboratory scale” means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person.

“Laboratory scale” excludes those workplaces whose function is to produce commercial quantities of material.

“Laboratory-type hood” means a device located in a laboratory, enclosure on five sides with a movable sash fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

Walk-in hoods with adjustable sashes meet the above definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

“Laboratory use of hazardous chemicals” means handling or use of such chemicals in which all of the conditions are met:

(i) Chemical manipulations are carried out on a "lab-scale;"

(ii) Multiple chemical procedures or chemicals are used;

(iii) The procedures involved are not part of a production process, nor in any way simulate a production process; and

(iv) “Protective laboratory practices and equipment” are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

“Medical consultation” means a consultation which takes place between an employee and a licensed physician for the purpose of determining what medical examinations or procedures, if any, are appropriate in cases where a significant exposure to a hazardous chemical may have taken place.

"Organic peroxide" means an organic compound that contains the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms have been replaced by an organic radical.

"Oxidizer" means a chemical other than a blasting agent or explosive as defined in 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

"Physical hazard" means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer pyrophoric, unstable (reactive) water-reactive.

"Protective laboratory practices and equipment" means those laboratory procedures, practices and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, minimizing the potential for employee exposure to hazardous chemicals.

"Reproductive toxins" means chemicals which affect the reproductive capabilities including chromosomal
"Select carcinogen" means any substance which meets one of the following criteria:

(i) It is regulated by OSHA as a carcinogen; or

(ii) It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or

(iii) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC) (latest editions); or

(iv) It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria: (A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m^3; (B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or (C) After oral dosages of less than 50 mg/kg of body weight per day.

"Unstable (reactive)" means a chemical which in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure, or temperature. "Water-reactive" means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

(c) Permissible exposure limits. For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in 29 CFR part 1910, subpart Z.

(d) Employee exposure determination

(1) Initial monitoring. The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level, the PEL).

(2) Periodic monitoring. If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over the action level (or in the absence of an action level, the PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.

(3) Termination of monitoring. Monitoring may be terminated in accordance with the relevant standard.

(4) Employee notification of monitoring results. The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.

(e) Chemical hygiene plan-General. (Appendix A of this section is non-mandatory but provides guidance to assist employers in the development of the Chemical Hygiene Plan.)

(1) Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall...
(i) Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and

(ii) Capable of keeping exposures below the limits specified in paragraph (c) of this section.

(2) The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the Assistant Secretary.

(3) The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection:

(i) Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;

(ii) Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;

(iii) A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;

(iv) Provisions for employee information and training as prescribed in paragraph (f) of this section;

(v) The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;

(vi) Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;

(vii) Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer, and, if appropriate, establishment of a Chemical Hygiene Committee; and

(viii) Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:

(A) Establishment of a designated area;

(B) Use of containment devices such as fume glove boxes;

(C) Procedures for safe removal of contaminated waste; and

(D) Decontamination procedures.

(4) The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually at
(f) Employee information and training.

(1) The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.

(2) Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.

(3) Information. Employees shall be informed of:

(i) The contents of this standard and its appendices which shall be made available to employees;

(ii) The location and availability of the employer's Chemical Hygiene Plan;

(iii) The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable standard;

(iv) Signs and symptoms associated with exposures to chemicals used in the laboratory; and

(v) The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets received from the chemical supplier.

(4) Training.

(i) Employee training shall include:

(A) Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);

(B) The physical and health hazards of chemicals in the work area; and

(C) The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.

(ii) The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

(g) Medical consultation and medical examinations.

(1) The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:
employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.

(ii) Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.

(iii) Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

(2) All medical examinations and consultations shall be performed by or under the direct supervision of licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.

(3) Information provided to the physician. The employer shall provide the following information to the physician:

(i) The identity of the hazardous chemical(s) to which the employee may have been exposed;

(ii) A description of the conditions under which the exposure occurred including quantitative exposure data, available; and

(iii) A description of the signs and symptoms of exposure that the employee is experiencing, if any.

(4) Physician's written opinion.

(i) For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:

(A) Any recommendation for further medical follow-up;

(B) The results of the medical examination and any associated tests;

(C) Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous workplace; and

(D) A statement that the employee has been informed by the physician of the results of the consultation medical examination and any medical condition that may require further examination or treatment.

(ii) The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

(h) Hazard identification.

(1) With respect to labels and material safety data sheets:

(i) Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed
(ii) Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.

(2) The following provisions shall apply to chemical substances developed in the laboratory:

(i) If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.

(ii) If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph (e) of this section.

(iii) If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.120) including the requirements for preparation of material safety data sheets and labeling.

(i) Use of respirators. Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of 29 CFR 1910.134.

(j) Recordkeeping.

(1) The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.

(2) The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.20.

(k) Dates.

(1) Effective date. This section shall become effective May 1, 1990.

(2) Start-up dates.

(i) Employers shall have developed and implemented a written Chemical Hygiene Plan no later than January 3, 1991.

(ii) Paragraph (a)(2) of this section shall not take effect until the employer has developed and implemented a written Chemical Hygiene Plan.

(1) Appendices. The information contained in the appendices is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.
Appendix A to 1910.1450—National Research Council Recommendations Concerning Chemical Hygiene in Laboratories (Non-Mandatory)

Table of Contents

Foreword

Corresponding Sections of the Standard and This Appendix

A. General Principles

1. Minimize All Chemical Exposures
2. Avoid Underestimation of Risk
3. Provide Adequate Ventilation
4. Institute a Chemical Hygiene Program
5. Observe the PELs and TLVs

B. Responsibilities

1. Chief Executive Officer
2. Supervisor of Administrative Unit
3. Chemical Hygiene Officer
4. Laboratory Supervisor
5. Project Director
6. Laboratory Worker

C. The Laboratory Facility

1. Design
2. Maintenance
3. Usage
4. Ventilation

D. Components of the Chemical Hygiene Plan

1. Basic Rules and Procedures
2. Chemical Procurement, Distribution, and Storage
3. Environmental Monitoring
4. Housekeeping, Maintenance and Inspections
5. Medical Program
6. Personal Protective Apparel and Equipment
7. Records
8. Signs and Labels
10. Training and Information
11. Waste Disposal

E. General Procedures for Working with Chemicals

1. General Rules for All Laboratory Work with Chemicals
2. Allergens and Embryotoxins
3. Chemicals of Moderate Chronic or High Acute Toxicity
4. Chemicals of High Chronic Toxicity
5. Animal Work with Chemicals of High Chronic Toxicity

F. Safety Recommendations

G. Material Safety Data Sheets

Foreword

As guidance for each employer's development of an appropriate laboratory Chemical Hygiene Plan, the following non-mandatory recommendations are provided. They were extracted from "Prudent Practices for Handling Hazardous Chemicals in Laboratories" (referred to below as "Prudent Practices"), which was published in 1981 by the National Research Council and is available from the National Academy Press, 210 Constitution Ave., NW, Washington DC 20418.

"Prudent Practices" is cited because of its wide distribution and acceptance and because of its preparation by members of the laboratory community through the sponsorship of the National Research Council. However, none of the recommendations given here will modify any requirements of the laboratory standard. This appendix merely presents pertinent recommendations from "Prudent Practices," organized into a format convenient for quick reference during operation of a laboratory facility and during development and application of a Chemical Hygiene Plan. Users of this appendix should consult "Prudent Practices" for a more extended presentation and justification for each recommendation.

"Prudent Practices" deals with both safety and chemical hazards while the laboratory standard is concerned primarily with chemical hazards. Therefore, only those recommendations directed primarily toward control of toxic exposures are cited in this appendix, with the term "chemical hygiene" being substituted for the word "safety." However, since conditions producing or threatening physical injury often pose toxic risks as well, page references concerning major categories of safety hazards in the laboratory are given in section F. The recommendations from "Prudent Practices" have been paraphrased, combined, or otherwise reorganized and headings have been added. However, their sense has not been changed.

Corresponding Sections of the Standard and this Appendix

The following table is given for the convenience of those who are developing a Chemical Hygiene Plan which will satisfy the requirements of paragraph (e) of the standard. It indicates those sections of this appendix which are most pertinent to each of the sections of paragraph (e) and related paragraphs.

<table>
<thead>
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### Section (e)(3)

| (e)(3)(i) Standard operating procedures for handling toxic chemicals. | C, D, E |
| (e)(3)(ii) Criteria to be used for implementation of measures to reduce exposures. | D |
| (e)(3)(iii) Fume hood performance. | C4b |
| (e)(3)(iv) Employee information and training (including emergency procedures). | D10, D9 |
| (e)(3)(v) Requirements for prior approval of laboratory activities. | E2b, E4b |
| (e)(3)(vi) Medical consultation and medical examinations. | D5, F4f |
| (e)(3)(vii) Chemical hygiene responsibilities | B |
| (e)(3)(viii) Special precautions for work with particularly hazardous substances. | F2, E3, E4 |

In this appendix, those recommendations directed primarily at administrators and supervisors are given in sections A-D. Those recommendations of primary concern to employees who are actually handling laboratory chemicals are given in section E. (References to page numbers in "Prudent Practices" are given in parentheses.)

### A. General Principles for Work with Laboratory Chemicals

In addition to the more detailed recommendations listed below in sections B-E, "Prudent Practices" express certain general principles, including the following:

1. It is prudent to minimize all chemical exposures. Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted, rather than specific guidelines for particular chemicals (2,10). Skin contact with chemicals should be avoided as a cardinal rule (198).

2. Avoid underestimation of risk. Even for substances of no known significant hazard, exposure should be minimized; for work with substances which present special hazards, special precautions should be taken (10,37,38). One should assume that any mixture will be more toxic than its most toxic component (30, 103) and that all substances of unknown toxicity are toxic (3, 34).

3. Provide adequate ventilation. The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices (32, 198).

4. Institute a chemical hygiene program. A mandatory chemical hygiene program designed to minimize exposures is needed; it should be a regular, continuing effort, not merely a standby or short-term activity (6,11). Its recommendations should be followed in academic teaching laboratories as well as by full-time laboratory workers (13).
B. Chemical Hygiene Responsibilities

Responsibility for chemical hygiene rests at all levels (6, 11; 21) including the:

1. Chief executive officer, who has ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene (7, 11).

2. Supervisor of the department or other administrative unit, who is responsible for chemical hygiene that unit (7).

3. Chemical hygiene officer(s), whose appointment is essential (7) and who must:
   
   (a) Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices (7).
   
   (b) Monitor procurement, use, and disposal of chemicals used in the lab (8);
   
   (c) See that appropriate audits are maintained (8);
   
   (d) Help project directors develop precautions and adequate facilities (10);
   
   (e) Know the current legal requirements concerning regulated substances (50); and
   
   (f) Seek ways to improve the chemical hygiene program (8, 11).

4. Laboratory supervisor, who has overall responsibility for chemical hygiene in the laboratory (21) including responsibility to:

   (a) Ensure that workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided (21, 22);

   (b) Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment (21, 171);

   (c) Know the current legal requirements concerning regulated substances (50, 231);

   (d) Determine the required levels of protective apparel and equipment (156, 160, 162);

   and

   (e) Ensure that facilities and training for use of any material being ordered are adequate (215).

5. Project director or director of other specific operation, who has primary responsibility for chemical hygien
6. Laboratory worker, who is responsible for:

(a) Planning and conducting each operation in accordance with the institutional chemical hygiene procedures (19, 21, 22, 230); and

(b) Developing good personal chemical hygiene habits (22).

(C) Laboratory Facility

1. Design. The laboratory facility should have:

(a) An appropriate general ventilation system (see C4 below) with air intakes and exhausts located so as to avoid intake of contaminated air (194);

(b) Adequate, well-ventilated stockrooms / storerooms (218, 219);

(c) Laboratory hoods and sinks (12, 162);

(d) Other safety equipment including eyewash fountains and drench showers (162, 169); and

(e) Arrangements for waste disposal (12, 240).

2. Maintainance. Chemical hygiene-related equipment (hoods, incinerator, etc.) should undergo continual appraisal and be modified if inadequate (11, 12).

3. Usage. The work conducted (10) and its scale (12) must be appropriate to the physical facilities available and, especially, to the quality of ventilation (13).

4. Ventilation

(a) General laboratory ventilation. This system should: provide a source of air for breathing and for input to local ventilation devices (199); it should not be relied on for protection from toxic substances released into the laboratory (198); ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day (194); direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194).

(b) Hoods. A laboratory hood with 2.5 linear feet of hood space per person should be provided for every worker if they spend most of their time working with chemicals (199); each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use (200, 209). If this is not possible, work with substances of unknown toxicity should be avoided (13) or other types of local ventilation devices should be provided (199). See pp. 201-206 for a discussion of hood design, construction and evaluation.

(c) Other local ventilation devices. Ventilated storage cabinets, canopy hoods, snorkels, etc. should be provided as needed (199). Each canopy hood and snorkel should have a separate exhaust duct (207).

(d) Special ventilation areas. Exhaust air from glove boxes and isolation rooms should be passed through scrubbers or other treatment before release into the regular exhaust system (208). Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of electrical failure (209).

(e) Modifications. Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate (12, 193, 204).

(f) Performance. Rate: 4-12 room air changes/hour is normally adequate general ventilation if local exhaus
Quality. General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas (194, 195); airflow into and within the hood should not be excessively turbulent (200); hood face velocity should be adequate (typically 60-100 lfm) (200, 204).

(h) Evaluation. Quality and quantity of ventilation should be evaluated on installation (202), regularly monitored (at least every 3 months) (6, 12, 14, 195), and reevaluated whenever a change in local ventilation is made (12, 195, 207). See pp. 195-198 for methods of evaluation and for calculation of estimated airborne contaminant concentrations.

D. Components of the Chemical Hygiene Plan

1. Basic Rules and Procedures
(Recommendations for these are given in section E, below.)

2. Chemical Procurement, Distribution, and Storage

(a) Procurement. Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved (215, 216). No container should be accepted without adequate identifying label (216). Preferably, all substances should be received in a central location (216).

(b) Stockrooms/storerooms. Toxic substances should be segregated in a well-identified area with local exhaust ventilation (221). Chemicals which are highly toxic (227) or other chemicals whose containers have been opened should be in unbreakable secondary containers (219). Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity (218-19). Stockrooms/storerooms should not be used as preparation or repackaging areas, should be open during normal working hours, and should be controlled by one person (219).

(c) Distribution. When chemicals are hand carried, the container should be placed in an outside container bucket. Freight-only elevators should be used if possible (223).

(d) Laboratory storage. Amounts permitted should be as small as practical. Storage on bench tops and hoods is inadvisable. Exposure to heat or direct sunlight should be avoided. Periodic inventories should be conducted, with unneeded items being discarded or returned to the storeroom/storeroom (225-6, 229).

3. Environmental Monitoring

Regular instrumental monitoring of airborne concentrations is not usually justified or practical in laboratories but may be appropriate when testing or redesigning hoods or other ventilation devices (12) or when a high toxic substance is stored or used regularly (e.g., 3 times/week) (13).

4. Housekeeping, Maintenance, and Inspections

(a) Cleaning. Floors should be cleaned regularly (24).

(b) Inspections. Formal housekeeping and chemical hygiene inspections should be held at least quarterly (6, 21) for units which have frequent personnel changes and semiannually for others; informal inspections should be continual (21).

(c) Maintenance. Eye wash fountains should be inspected at intervals of not less than 3 months (6). Respirators for routine use should be inspected periodically by the laboratory supervisor (169). Other safety equipment should be inspected regularly (e.g., every 3-6 months) (6, 24, 171). Procedures to prevent restarting of out-of-service equipment should be established (25).

(d) Passageways. Stairways and hallways should not be used as storage areas (24). Access to exits, emergency equipment, and utility controls should never be blocked (24).
5. Medical Program

(a) Compliance with regulations. Regular medical surveillance should be established to the extent required by regulations (12).

(b) Routine surveillance. Anyone whose work involves regular and frequent handling of toxicological significant quantities of a chemical should consult a qualified physician to determine on an individual basis whether a regular schedule of medical surveillance is desirable (11, 50).

(c) First aid. Personnel trained in first aid should be available during working hours and an emergency room with medical personnel should be nearby (173). See pp. 176-178 for description of some emergency first aid procedures.

6. Protective Apparel and Equipment

These should include for each laboratory:

(a) Protective apparel compatible with the required degree of protection for substances being handled (15161);
(b) An easily accessible drench-type safety shower (162, 169);
(c) An eyewash fountain (162)
(d) A fire extinguisher (162-164);
(e) Respiratory protection (164-9), fire alarm and telephone for emergency use (162) should be available nearby; and
(f) Other items designated by the laboratory supervisor (156, 160).

7. Records

(a) Accident records should be written and retained (174).

(b) Chemical Hygiene Plan records should document that the facilities and precautions were compatible with current knowledge and regulations (7).

(d) Inventory and usage records for high-risk substances should be kept as specified in section E3e below.
(e) Medical records should be retained by the institution in accordance with the requirements of state and regulations (12).

8. Signs and Labels

Prominent signs and labels of the following types should be posted:

(a) Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers (28).
(b) Identity labels, showing contents of containers (including waste receptacles) and associated hazards (27, 48);
(c) Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits (2) and areas where food and beverage consumption and storage are permitted (24); and
(d) Warnings at areas or equipment where special or unusual hazards exist (27).

9. Spills and Accidents

(a) A written emergency plan should be established and communicated to all personnel; it should include procedures for ventilation failure (200), evacuation, medical care, reporting, and drills (172).

(b) There should be an alarm system to alert people in all parts of the facility including isolation areas su
A spill control policy should be developed and should include consideration of prevention, containment, cleanup, and reporting (175).

All accidents or near accidents should be carefully analyzed with the results distributed to all who might benefit (8, 28).

10. Information and Training Program

(a) Aim: To assure that all individuals at risk are adequately informed about the work in the laboratory, risks, and what to do if an accident occurs (5, 15).

(b) Emergency and Personal Protection Training: Every laboratory worker should know the location and use of available protective apparel and equipment (154, 169). Some of the full-time personnel of the laboratory should be trained in the proper use of emergency equipment and procedures (6).

Such training as well as first aid instruction should be available to (154) and encouraged for (176) everyone who might need it.

(c) Receiving and stockroom/storeroom personnel should know about hazards, handling equipment, protective apparel, and relevant regulations (217).

(d) Frequency of Training: The training and education program should be a regular, continuing activity—simply an annual presentation (15).

(e) Literature/Consultation: Literature and consulting advice concerning chemical hygiene should be readily available to laboratory personnel, who should be encouraged to use these information resources (14).

11. Waste Disposal Program

(a) Aim: To assure that minimal harm to people, other organisms, and the environment will result from the disposal of waste laboratory chemicals (5).

(b) Content (14, 232, 233, 240): The waste disposal program should specify how waste is to be collected, segregated, stored, and transported and include consideration of what materials can be incinerated. Transportation from the institution must be in accordance with DOT regulations (244).

(c) Discarding Chemical Stocks: Unlabeled containers of chemicals and solutions should undergo prompt disposal; if partially used, they should not be opened (24, 27). Before a worker's employment in the laboratory ends, chemicals for which that person was responsible should be discarded or returned to storage (226).

(d) Frequency of Disposal: Waste should be removed from laboratories to a central waste storage area at least once per week and from the central waste storage area at regular intervals (14).

(e) Method of Disposal: Incineration in an environmentally acceptable manner is the most practical disposal method for combustible laboratory waste (14, 238, 241). Indiscriminate disposal by pouring waste chemicals down the drain (14, 231, 242) or adding them to mixed refuse for landfill burial is unacceptable (14). Hoods should not be used as a means of disposal for volatile chemicals (40, 200). Disposal by recycling (233, 243) or chemical decontamination (40, 230) should be used when possible.

E. Basic Rules and Procedures for Working with Chemicals

The Chemical Hygiene Plan should require that laboratory workers know and follow its rules and procedures. In addition to the procedures of the subprograms mentioned above, these should include the rules listed below.
(a) Accidents and Spills-Eye Contact: Promptly flush eyes with water for a prolonged period (15 minutes) and seek medical attention (33, 172).
Ingestion: Encourage the victim to drink large amounts of water (178).
Skin Contact: Promptly flush the affected area with water (33, 172, 178) and remove any contaminated clothing (172, 178). If symptoms persist after washing, seek medical attention (33).
Clean-up: Promptly clean up spills, using appropriate protective apparel and equipment and proper disposal (24, 33). See pp. 233-237 for specific clean-up recommendations.

(b) Avoidance of "routine" exposure: Develop and encourage safe habits (23); avoid unnecessary exposure chemicals by any route (23).
Do not smell or taste chemicals (32). Vent apparatus which may discharge toxic chemicals (vacuum pump, distillation columns, etc.) into local exhaust devices (199).
Inspect gloves (157) and test glove boxes (208) before use.
Do not allow release of toxic substances in cold rooms and warm rooms, since these have contained recirculated atmospheres (209).

(c) Choice of chemicals: Use only those chemicals for which the quality of the available ventilation system is appropriate (13).
(d) Eating, smoking, etc: Avoid eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present (22, 24, 32, 40); wash hands before conducting these activities (23, 24).
Avoid storage, handling, or consumption of food or beverages in storage areas, refrigerators, glassware or utensils which are also used for laboratory operations (23, 24, 226).

(e) Equipment and glassware: Handle and store laboratory glassware with care to avoid damage; do not use damaged glassware (25). Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur (25). Use equipment only for its designed purpose (23, 26).

(f) Exiting: Wash areas of exposed skin well before leaving the laboratory (23).

(g) Horseplay: Avoid practical jokes or other behavior which might confuse, startle or distract another worker (23).
(h) Mouth suction: Do not use mouth suction for pipeting or starting a siphon (23, 32).

(i) Personal apparel: Confine long hair and loose clothing (23, 158). Wear shoes at all times in the laboratory but do not wear sandals, perforated shoes, or sneakers (158).

(j) Personal housekeeping: Keep the work area clean and uncluttered, with chemicals and equipment being properly labeled and stored; clean up the work area on completion of an operation or at the end of each day (24).

(k) Personal protection: Assure that appropriate eye protection (154-156) is worn by all persons, including visitors, where chemicals are stored or handled (22, 23, 33, 154). Wear appropriate gloves when the potential for contact with toxic materials exists (157); inspect and replace them periodically (157). (A table of resistance to chemicals of common glove materials is given on p.159).
Use appropriate (164-168) respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls (164-5), inspecting the respirator before use (169).
Avoid use of contact lenses in the laboratory unless necessary; if they are used, inform supervisor so special precautions can be taken (155).
Remove laboratory coats immediately on significant contamination (161).

(1) Planning: Seek information and advice about hazards (7), plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation (22, 23).

(m) Unattended operations: Leave lights on, place an appropriate sign on the door, and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water) to an unattended operation (27, 128).

(n) Use of hood: Use the hood for operations which might result in release of toxic chemical vapors or dust (198-9).
As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with a TLV of less than 50 ppm (13).
Confirm adequate hood performance before use; keep hood closed at all times except when adjustments within the hood are being made (200); keep materials stored in hoods to a minimum and do not allow them to block vents or air flow (200).
Leave the hood "on" when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "off" (200).
(o) Vigilance: Be alert to unsafe conditions and see that they are corrected when detected (22).

(p) Waste disposal: Assure that the plan for each laboratory operation includes plans and training for waste disposal (230).
Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures of the Chemical Hygiene Plan (22, 24).
Do not discharge to the sewer concentrated acids or bases (231); highly toxic, malodorous, or lachrymatory substances (2M); or any substances which might interfere with the biological activity of waste water treatment plants, create fire or explosion hazards, cause structural damage or obstruct flow (242).
(q) Working alone: Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous (28).

2. Working with Allergens and Embryotoxins

(a) Allergens (examples: diazomethane, isocyanates, bichromates): Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity (35).
(b) Embryotoxins (34-5) (examples: organomercurials lead compounds, formamide): If you are a woman of child bearing age, handle these substances only in a hood whose satisfactory performance has been confirmed using appropriate protective apparel (especially gloves) to prevent skin contact.
Review each use of these materials with the research supervisor and review continuing uses annually or whenever a procedural change is made.
Store these substances, properly in an adequately ventilated area in an unbreakable secondary container.
Notify supervisors of all incidents of exposure or spills; consult a qualified physician when appropriate.

3. Work with Chemicals of Moderate Chronic or High Acute Toxicity

EXAMPLES: diisopropylfluorophosphate (41), hydrofluoric acid (43), hydrogen cyanide (45).
Aim: To minimize exposure to these toxic substances by any route using all reasonable precautions (39).

Applicability: These precautions are appropriate stances with moderate chronic or high acute used significant quantities (39).

Location: Use and store these substances only in F restricted access with special warning signs (4229).

Always use a hood (previously evaluated to adequate performance with a face velocity of 60 linear feet per minute) (40) or other containment-device for procedures which may result in the ion of aerosols or vapor containing the substance (39); trap released vapors to prevent their discharge with the hood exhaust (40).

Personal protection: Always avoid skin contact by use of gloves and long sleeves (and other protective as appropriate) (39). Always wash hands and arms immediately after working with these materials (40).

Records: Maintain records of the amounts of these materials on hand, amounts used, and the names workers involved (40, 229).

Prevention of spills and accidents: Be prepared for accidents and spills (41). Assure that at least 2 people are present at all times if a compound in use is toxic or of unknown toxicity (39). Store breakable containers of these substances in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper (40).

If a major spill occurs outside the hood, evacuate the area; assure that cleanup personnel wear suitable protective apparel and equipment (41).

Waste: Thoroughly decontaminate or incinerate contaminated clothing or shoes (41). If possible chemically decontaminate by chemical conversion (40). Store contaminated waste in closed, suitably labeled, impervious containers (for liquids, in glass or plastic bottles half-filled with vermiculite) (40).

4. Work with Chemicals of High Chronic Toxicity

Examples: dimethylmercury and nickel carbonyl (48), benzo-a-pyrene (51), N-nitrosodiethylamine (54), other human carcinogens or substances with high carcinogenic potency in animals (38).

Further supplemental rules to be followed, in addition to all those mentioned above, for work with substances of known high chronic toxicity (in quantities above a few milligrams to a few grams, depending on the substance) (47). (Procedure A of "Prudent Practices" pp.47-50).

(a) Access: Conduct all transfers and work with these substances in a "controlled area": a restricted access hood, glove box, or portion of a lab, designated for use of highly toxic substances, for which all people with access are aware of the substances being used and necessary precautions (48).

(b) Approvals: Prepare a plan for use and disposal of these materials and obtain the approval of the laboratory supervisor (48).

(c) Non-contamination/Decontamination: Protect vacuum pumps against contamination by scrubbers HEPA filters and vent them into the hood (49). Decontaminate vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the controlled area (49, 50). Decontaminate the controlled area before normal work is resumed there (50).

(d) Exiting: On leaving a controlled area, remove any protective apparel (placing it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck (49).

(e) Housekeeping: Use a wet mop or a vacuum cleaner equipped with a HEPA filter instead of dry sweeping if the toxic substance was a dry powder (50).

(f) Medical surveillance: If using toxicologically significant quantities of such a substance on a regular bas:
(g) Records: Keep accurate records of the amounts of these substances stored (229) and used, the dates or use, and names of users (48).

(h) Signs and labels: Assure that the controlled area is conspicuously marked with warning and restricted access signs (49) and that all containers of these substances are appropriately labeled with identity and warning labels (48).

(i) Spills: Assure that contingency plans, equipment, and materials to minimize exposures of people at property in case of accident are available (233-4).

(j) Storage: Store containers of these chemicals only in a ventilated, limited access (48, 227, 229) area in appropriately labeled, unbreakable, chemically resistant, secondary containers (48, 229).

(k) Glove boxes: For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and pressure at least 0.5 inches of water (48). For a positive pressure glove box, thoroughly check for leaks before each use (49). In either case, trap the exit gases or filter them through a HEPA filter and then release them into the hood (49).

(l) Waste: Use chemical decontamination whenever possible; ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred from the controlled area in a secondary container under the supervision of authorized personnel (49, 50, 233).

5. Animal Work with Chemicals of High Chronic Toxicity

(a) Access: For large scale studies, special facilities with restricted access are preferable (56).

(b) Administration of the toxic substance: When possible, administer the substance by injection or gavage instead of in the diet. If administration is in the diet, use a caging system under negative pressure or under laminar air flow directed toward HEPA filters (56).

(c) Aerosol suppression: Devise procedures which minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces (e.g., use HEPA filtered vacuum equipment for cleaning, moisten contaminated bedding before removal from the cage, mix diets in closed containers in a hood) (55, 56).

(d) Personal protection: When working in the animal room, wear plastic or rubber gloves, fully buttoned laboratory coat or jumpsuit and, if needed because of incomplete suppression of aerosols, other apparel and equipment (shoe and head coverings, respirator) (56).

(e) Waste disposal: Dispose of contaminated animal tissues and excreta by incineration if the available incinerator can convert the contaminant to non-toxic products (238); otherwise, package the waste appropriately for burial in an EPA-approved site (239).

F. Safety Recommendations

The above recommendations from "Prudent Practices" do not include those which are directed primarily toward prevention of physical injury rather than toxic exposure. However, failure of precautions against injury will often have the secondary effect of causing toxic exposures. Therefore, we list below page references for recommendations concerning some of the major categories of safety hazards which also have implications for chemical hygiene:

1. Corrosive agents: (35-6)
2. Electrically powered laboratory apparatus: (179-92)
3. Fires, explosions: (26, 57-74, 162-4, 174-5, 219-20, 226-7)
4. Low temperature procedures: (26, 88)
5. Pressurized and vacuum operations (including use of compressed gas cylinders): (27, 75-101)
Special Procedures for Handling Hazardous Chemicals

Any chemical should be assumed to be hazardous unless all of the physical and chemical properties are clear known and appropriate references indicate the material is not hazardous. The following sections describe tl basic hazard classes and suggest procedures for handling hazardous chemicals safely. The CHO should have general awareness of where these materials are utilized frequently and pay particular attention to dispositic methods. The CHP should stress the importance of reviewing available information on each hazardous materi prior to use.

**Flammable/Combustible Chemicals**

Flammable chemicals are considered to be liquids with a flashpoint below 100 °F and solid materials that readi sustain combustion. Liquids with a flashpoint between 100 °F and 200 °F are generally classed as combustibl the same basic procedures should be applied when handling combustible liquids.

- Do not allow smoking or other sources of open flame in areas where flammable chemicals are used.
only trained individuals such as fire department personnel can do firefighting.

- Do not store flammable liquids in domestic-type refrigerators. An explosion may result. Use on explosion-proof refrigerators.

- Store glass containers of flammable liquids in approved storage cabinets. Do not store with oxidizing agents (e.g., nitric, perchloric, and sulfuric acids). Use safety cans whenever possible, but do not subject the to extreme changes in pressure or temperature. If there is any sign of a vapor or liquid leak, transfer the liquid another approved container

- Know the location of fire extinguishers, fire alarms, and emergency exits.

- After opening, transfer containers of flammable liquids in excess of 1 liter to safety cans or safe cabinets. One-liter glass bottles should be used when contamination from the safety-can can interfere with specific procedure. The spring action covers on safety cans have five important functions: to act as a pressure relief valve, to prevent leakage or spillage if the can is dropped or inverted, to minimize vapor escape, prevent a fire from entering a safety can, and to smother a fire inside a safety can.

- Normally, the spring action cover on safety cans prevents leakage of a liquid when the safety can inverted. Safety cans should not be stored in closed compartments that are subject to extreme changes pressure or in temperature. The pressure-release feature of a safety can may cause flammable vapors to le: into the closed compartment. The purpose of the flame arrester, located in the pouring spout, is to prevent escaping vapors to burn while dissipating heat so that vapors inside the container will not ignite or explode.

- Do not fill glass bottles completely full. Leave space for liquid expansion.

- Static electricity is generated when liquids, particularly flammable liquids, move in contact with other materials (e.g., pouring or pumping). If the static electric charge becomes sufficiently great, a spark can occur from one metal container to the other container and ignite the vapor/air mixture. The purpose of bonding is to prevent generation of static electricity by minimizing the electrical potential difference between the dispensing drum and the safety can; grounding is to minimize the electrical potential difference between the containers at the ground. Good wire to metal electrical contacts are necessary.

- Flammable liquids should not be heated with an open flame, hot plate, or uninsulated resistance heat. The preferred sources of heating are a heating mantle, steam bath, or hot water bath.

- When shaking flammable liquids in closed containers (separatory funnels) release the pressure frequently or the stopper may be forced out, spraying the chemical.

- Clean up all spills immediately.

- Do not expose flammable liquids to potential sources of ignition (e.g., electric motors, open flames, ovens). Use explosion-proof electrical outlets and light fixtures where required.

- In laboratory hoods, coat fans with nonsparking material where possible when handling volatile substances such as organic solvent extractions.

- Maintain inventory control of all flammable chemicals in the laboratory and storage areas.

- The maximum amount of flammable liquid that may be stored at any one time in a laboratory location normally 235 liters. Liquids may be stored in Underwriter Laboratories approved safety cabinets or in sealed containers of no more than 23-liter capacity each.
The Resource Conservation and Recovery Act (RCRA) defines a corrosive chemical as a liquid with a pH <2 >12.5. A more practical definition, from a personal protection standpoint, is a strong acid or base that burr irritates, or attacks tissue, generally through skin exposure. When ingested, these materials can attack the mouth, throat, esophagus, and stomach. Corrosive fumes are considered a respiratory hazard. The primary means of protection from corrosive chemicals is the use of gloves, goggles, face shields, aprons, laboratory coats, and other chemical-resistant clothing. Following are general rules for handling corrosive materials.

- Transport strong acids or bases in a protective carrier. Do not handle by the neck alone; support the weight of the bottle from the bottom when handling or pouring. Where possible, use plastic containers instead of glass.

- Do not store strong acids or bases with flammable liquids or oxidizing chemicals. Store perchloric acid by itself. Corrosive chemicals are best stored in sealed containers in special ventilated cabinets.

- Limit storage of corrosives in the laboratory to not more than a few days' use. Glass containers storing basic solutions should have plastic rather than glass stoppers, as basic material tends to bind or freeze glass.

- Handle strong acids or bases in laboratory hoods with glass partitions lowered to provide protection to hands and face. When opening bottles, place them in a sink with an absorbent cloth or towel covering the neck.

- Never add water to acids or alkalis; always add a concentrated or dilute acid or base to water, a small portion at a time. Use moist paper towels to clean off any acid or alkali drips remaining on the outside of the container. Pour with the container below eye level to avoid eye injury and with label up to avoid contaminating the label with drips.

- Neutralize spills of concentrated acid with sodium carbonate or bicarbonate; neutralize spills of concentrated alkali with boric or citric acid. Commercial spill kits are available.

- Thoroughly rinse with water all glassware used to hold corrosive chemicals.

**Explosive Chemicals**

**Ethers/Peroxide Formers**

Ethyl ether, isopropyl ether, 1,4-dioxane, and tetrahydrofuran are examples of low molecular weight ethers requiring special storage and disposal procedures. In addition to their dangerous fire hazard, organic peroxides can form in these compounds. When exposed to air when the peroxides are concentrated by evaporation of the ether, an explosion can occur. The following precautions are recommended for inclusion in the CHP regarding the handling of ethers.

- Clearly label all acid or alkali solutions.

- Ethers are preferably obtained in metal cans and stored in safety containers instead of glass bottles.

- All containers should be dated when opened and given expiration date.

- "Inhibited" grades (containing small amounts of water or alcohol) can be used longer (no more than months) than the pure "non-inhibited" grade, which should be disposed of within a few weeks following exposure to air. The latter often contains butylated hydroxytoluene.

- Store all ether cans in a cool place and away from direct heat and sunlight. If a refrigerator is used, must be explosion-proof.
• For disposal, to the container add approximately 100 ml of a 5% ferrous sulfate solution for each liter of ether. For smaller volumes, adjust the amount accordingly, that is, 1 ml of 5% ferrous sulfate solution for each 10 ml of ether. Mix (do not shake), and dispose of properly. Test strips for testing peroxide content are commercially available. Compounds other than ethers can form organic peroxides. The MSDS for all chemicals should be checked to determine if peroxide formation is possible. It is advisable never to leave a container around with very little ether left in it. Such containers should be promptly disposed of to minimize the risk of explosion.

**Picric Acid**

Picric acid is explosive when dry and should contain at least 10% water and be kept out of contact with metal as much as possible. Before being recapped, bottle necks and lids should always be wiped with a moist paper towel to prevent the formation of crystals around them. Picric acid must never be allowed to reach a dry state. **Never handle picric acid when dry!** Call the Office of Environmental Health and Safety x3-3353.

**Azide Solutions**

Sodium Azide is a preservative commonly used in many in-vitro diagnostic products. Continual discharge wastes into drains can bathe the drain pipeline with solutions of sodium azide. Over time, the azide can react with copper, lead, silver, brass, or solder in the plumbing system to form an accumulation of lead, silver, and copper azide. All of these compounds are extremely shock-sensitive when dry. Solutions containing sodium azide must never be discharged down drains. Drains suspected of having been contaminated with an azide should be treated with a strong caustic (such as NaOH or KOH) to prevent azide buildup.

**Toxic Chemicals and Chemicals of Unknown Toxicity**

The CHO should be aware of any of these materials that might be in use in the laboratory. Of special concern are the following:

**Cyanides**

Avoid contact of cyanide solutions with acids. Acids react with cyanides to produce hydrocyanic acid (pruss acid) vapor, which is potentially lethal. Cyanide solutions should be accumulated for off-site disposal.

**Mercury**

Mercury is extremely toxic in almost all forms (i.e., organic and inorganic compounds as well as the metal). Every laboratory should do a mercury assessment and include it as part of its CHP. Mercury should be stored in plastic, airtight containers, away from direct heat or sunlight, and at as close to ambient temperature as possible.

**Other**

Unknown chemicals, or those, for which complete physical and chemical hazards are not known, must be assumed to be hazardous. Appropriate PPE should be utilized.

**Compressed Gases**

Gas cylinders contain either compressed liquids or gases; a variety of hazards may be present, including pressure. Gas cylinders may represent the ultimate "insidious" hazard, as puncture, heat, faulty valves...
represent a significant hazard, even at the scale typically utilized in the laboratory.

Following are applicable safety rules that should be considered for inclusion in the CHP.

• The cylinder contents must be clearly identifiable.

• Handle cylinders carefully and do not roll, slide, or drop; transport large cylinders on a wheeled ca.
Do not lift a cylinder by its cap.

• Always securely fasten cylinders whether in storage, transit, or use.

• Never tamper with cylinder valves, force connections, or use homemade adapters. Use only approved equipment. Never repair or alter cylinders, valves, or safety relief devices.

• Compressed gas cylinders must be used only with a regulator compatible with its content. Close the cylinder valve when the compressed gas is not being used.

• When a compressed gas cylinder is "empty", turn off the cylinder valve and label the cylinder as empty.
Store separately from full cylinders. Current cylinder status tags should be attached to the tank at all times.

• Store compressed gas cylinders in well ventilated areas away from ignition sources, heat, flames, and flammable chemicals. Never artificially cool cylinders or place them where they can become part of an electric circuit.

• Never completely empty a compressed gas cylinder. A small amount of pressure prevents contamination on refill.

• Empty gas cylinders should not be refilled on laboratory premises. Never attempt to mix gases cylinders.

• If a gas cylinder leaks, close the valve and clearly identify the cylinder as unusable and hazardous.
Remove the cylinder outdoors or to a well-ventilated location away from possible sources of ignition if the gas is flammable. Contact the supplier. Most suppliers of compressed gases have emergency response capabilities.

• Keep the protective caps on the cylinders at all times except when the cylinders are in active use.

• Avoid using a wrench on valves equipped with handwheels. Never hammer a valve to open or to close it. Either of the above actions can cause the wheel valve assembly to leak.

• Check for gas leaks (e.g., use soapy water around connections).

• Do not store cylinders containing flammable gases with oxidizers, such as nitrous oxide. They must be separated by a minimum of 20 feet or a firewall at least 5 feet in height.

• Handle cylinders of hydrogen with care, because they have a wide flammable range and ignite easily.

• Do not use compressed air tanks to clean clothing or parts of the body.

• Install and store cylinders in accordance with local fire codes.

• Do not refill small propane fuel tanks when exhausted. Discard them safely (e.g., do not incinerate).
Procedures for Select Carcinogens, Reproductive Toxins, Highly Toxic Chemicals, and Chemicals of Unknown Toxicity

Definitions

All substances of unknown toxicity used in the laboratory must be considered highly toxic.

Carcinogens

Those substances regulated by OSHA as "select carcinogens"; listed as "known to be carcinogens" by the National Toxicology Program (NTP); and listed as Group 1 "carcinogenic to humans" by the International Agency for Research on Cancer (IARC). A substance is also considered to be carcinogenic if it is listed in IARC Group 2A, "probably carcinogenic to humans", or 2B, "possibly carcinogenic to humans"; or under the category, "reasonably anticipated to be a carcinogen", by NTP.

Reproductive Toxins

Substances that have an adverse effect on various aspects of reproduction, including fertility, gestation, lactation, and general reproductive performance. They include mutagens and teratogens.

Highly Toxic Materials

Those substances that have an LD$_{50}$ <50 mg/kg of body weight of the animal tested.

Other Considerations

Toxic materials defined by OSHA as toxic (LD$_{50}$ <~500 or >50 mg/kg of animal weight tested in rats).

Employee Qualifications for Working with Toxic Substances

Information and training are required under the Laboratory Standard. By definition, training is required for all the physical and health hazards listed by OSHA under 29 CFR 1910.1200, the Hazard Communication Standard. Any employee must be given training in working with any substance defined above (carcinogenic reproductive toxins, and highly toxic chemicals). Training must include safe handling procedures, the use of PPE, and the use of the proper equipment and work area. The employee qualifications for working with the substances should include a passing grade on a test designed to measure the employee's knowledge of laboratory safety with regard to these substances.

Designated Areas

Definition

A designated area may be defined as a hood, glove box, isolation cabinet, work area, or entire laboratory designed to isolate the worker from the substances listed in the previous section of this document during transfer operations, weighing, diluting, reacting, sieving, purifying, or distilling.

Standard Operating Procedures
For designated areas, standard operating procedures (SOPs) should be developed for the following maintenance, decontamination, emergency procedures, and waste disposal.

**Procedures for Working within Designated Areas**

All workers whose job requires the use of designated areas must be trained in their proper use, including the following:

- The designated area must be maintained; that is, there must be ventilation efficiency, proper equipment, proper PPE, and decontamination procedures.
- SOPs must be established for the use of all substances to be used in the designated area.
- An emergency plan must exist in the event of a designated area failure.
- There should be proper waste disposal.
- Special storage should exist for all substances used in the designated area. The following should be considered with regard to storage. Inventory control includes locked storage area, single individual responsibility for ordering and dispensing, MSDS issued with substance, minimum amount required, and proper labeling and label maintenance. The storage area should contain appropriate alarms, such as fire and vapor concentration system; no floor drain unless to an isolated sump; appropriate PPE, including respirators/SCBA or escape devices, goggles, face mask, and choice of gloves; emergency plan for evacuation personnel; and waste disposal plan.

**APPENDIX C**

**INCOMPATIBILITY OF COMMON LABORATORY CHEMICALS**

When certain hazardous chemicals are stored or mixed together, violent reactions may occur because the chemicals are unsuitable for mixing, or are incompatible. Classes of incompatible chemicals should be segregated from each other during storage, according to hazard class. Use the following general guidelines for hazard class storage:

- Flammable/Combustible Liquids and Organic Acids
- Flammable Solids
- Mineral Acids Caustics
- Oxidizers
- Perchloric Acid
- Compressed Gases

Before mixing any chemicals, refer to this partial list, the chemicals' MSDS's or call the ORCBS to verify compatibility:

<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>INCOMPATIBLE CHEMICAL(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic acid</td>
<td>aldehyde, bases, carbonates, hydroxides, metals, oxidizers, peroxides, phosphates, xylene</td>
</tr>
<tr>
<td>Acetylene</td>
<td>halogens (chlorine, fluorine, etc.), mercury, potassium, oxidizers, silver acids, amines, oxidizers, plastics</td>
</tr>
<tr>
<td>Acetone</td>
<td>acids, chromium, ethylene, halogens, hydrogen, mercury, nitrogen, oxidizers, plastics, sodium chloride, sulfur</td>
</tr>
<tr>
<td>Alkali and alkaline earth metals</td>
<td>acids, aldehydes, amides, halogens, heavy metals, oxidizers, plastics, sulfur</td>
</tr>
<tr>
<td>Ammonia</td>
<td>acids, aldehydes, amides, halogens, heavy metals, oxidizers, plastics, sulfur</td>
</tr>
<tr>
<td>Ammonium nitrate</td>
<td>acids, alkalis, chloride salts, combustible materials, metals, organic</td>
</tr>
</tbody>
</table>
Aniline acids, aluminum, dibenzoyl peroxide, oxidizers, plastics
Azides acids, heavy metals, oxidizers
Bromine acetaldehyde, alcohol's, alkalis, amines, combustible materials, ethylene, fluorine, hydrogen, ketones (acetone, carbonyls, etc.), metals, sulfur
Calcium oxide acids, ethanol, fluorine, organic materials
Carbon (activated) alkali metals, calcium hypochlorite, halogens, oxidizers
Carbon tetrachloride benzoyl peroxide, ethylene, fluorine, metals, oxygen, plastics, silanes
Chlorates powdered metals, sulfur, finely divided organic or combustible materials
Chromic acid acetone, alcohol's, alkalis, ammonia, bases,
Chromium trioxide benzene, combustible materials, hydrocarbons, metals, organic materials, phosphorous, plastics
Chlorine alcohol's, ammonia, benzene, combustible materials, flammable compounds (hydrazine), hydrocarbons (acetylene, ethylene, etc.), hydrogen peroxide, iodine, metals, nitrogen, oxygen, sodium hydroxide
Chlorine dioxide hydrogen, mercury, organic materials, phosphorous, potassium hydroxide, sulfur
Copper calcium, hydrocarbons, oxidizers
Hydroperoxide reducing agents
Cyanides acids, alkaloids, aluminum, iodine, oxidizers, strong bases
Flammable liquids ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine alcohol's, aldehydes, ammonia, combustible materials, halocarbons, halogens, hydrocarbons, ketones, metals, organic acids
Hydrocarbons (Such as Butane, propane, benzene, turpentine, etc.)
Hydrofluoric acid metals, organic materials, plastics, silica (glass)

CHEMICAL INCOMPATIBLE CHEMICAL(S)

Hydrogen peroxide acetylaldehyde, acetic acid, acetone, alcohol's carboxylic acid, combustible materials, metals, nitric acid, organic compounds, phosphorous, sulfuric acid, sodium, aniline
Hydrogen sulfide acetylaldehyde, metals, oxidizers, sulfur
Hypochlorites acids, activated carbon
Iodine acetylaldehyde, acetylene, ammonia, metals, sodium
Mercury acetylene, aluminum, amines, ammonia, calcium, fulminic acid, lithium, oxidizer sodium nitrate acids, nitrates, metals, sulfur, sulfuric acid
Nitric acid acetic acid, acetonitrile, alcohol's, amines, (concentrated) ammonia, aniline, base
Nitric acid benzene, cumene, formic acid, ketones, metals, organic materials, plastics, sodium, toluene
Oxalic acid oxidizers, silver, sodium chlorite
Oxygen acetaldehyde, secondary alcohol's, alkalis and alkalines, ammonia, carbon monoxid combustible materials, ethers, flammable materials, hydrocarbons, metals, phosphorous, polymers
Perchloric acid acetic acid, alcohol's, aniline, combustible materials, dehydrating agents, eth benzene, hydriotic acid, hydrochloric acid, iodides, ketones, or-anic material, oxidizers, pyridine Peroxides, organic acids (organic or mineral) Phosphorus (white) oxygen (pure and in air), alkalis Potassium acetylene, acids, alcohol's, halogens, hydrazine, mercury, oxidizers, selenium, sulfur Potassium chlorate acids, ammonia, combustible materials, fluorine, hydrocarbons, metals, organ materials, sugars
Potassium perchlorate alcohol's, combustible materials, fluorine, hydrazine, metals, (also some chlorates)organic matter, reducing agents, sulfuric acid
Potassium permanganate benzaldehyde, ethylene glycol, glycerol, sulfuric acid
Silver acetylene, ammonia, oxidizers, ozonides, peroxymonofluoric acid
Sodium acids, hydrazine, metals, oxidizers, water
Sodium nitrate acetic anhydride, acids, metals, organic matter, peroxymonofluoric acid, reducing agents
Sodium peroxide acetic acid, benzene, hydrogen sulfide metals, oxidizers, peroxymonofluoric acid phosphorous, reducers, sugars, water
Sulfides acids
Sulfuric acid potassium chlorates, potassium perchlorate, potassium permanganate
### APPENDIX D

**COMMON LABORATORY FLAMMABLE AND COMBUSTIBLE CHEMICALS**

Flammable and combustible chemicals are the most commonly used hazardous chemicals. The hazard of a flammable or combustible chemical is based on its flash point, and, in the case of a flammable chemical, its boiling point as well. The National Fire Protection Association (NFPA) has identified flammability classes from the flash point and boiling point data of chemicals. The following table lists some common flammable and combustible chemicals, their flash points and boiling points, and associated NFPA flammability classes:

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Flash Point</th>
<th>Boiling Point</th>
<th>NFPA Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetaldehyde</td>
<td>-38/-39</td>
<td>69/21</td>
<td>IA</td>
</tr>
<tr>
<td>Dimethyl sulfide</td>
<td>-36/-38</td>
<td>99/37</td>
<td>IA</td>
</tr>
<tr>
<td>Ethyl ether</td>
<td>-49/-45</td>
<td>95/35</td>
<td>IA</td>
</tr>
<tr>
<td>Ethylene oxide</td>
<td>-20/-29</td>
<td>55/13</td>
<td>IA</td>
</tr>
<tr>
<td>Pentane</td>
<td>-57/-49</td>
<td>97/36</td>
<td>IA</td>
</tr>
<tr>
<td>Propane</td>
<td>-157/-105</td>
<td>-44/-42</td>
<td>IA</td>
</tr>
<tr>
<td>Benzene</td>
<td>12/-11</td>
<td>176/80</td>
<td>IB</td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>-22/-30</td>
<td>115/46</td>
<td>IB</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>-4/-20</td>
<td>179/81</td>
<td>IB</td>
</tr>
<tr>
<td>Ethyl alcohol</td>
<td>55/13</td>
<td>173/78</td>
<td>IB</td>
</tr>
<tr>
<td>n-Hexane</td>
<td>-7/-22</td>
<td>156/69</td>
<td>IB</td>
</tr>
<tr>
<td>Isopropyl alcohol</td>
<td>53/12</td>
<td>180/82</td>
<td>IB</td>
</tr>
<tr>
<td>Methyl alcohol</td>
<td>52/11</td>
<td>149/65</td>
<td>IB</td>
</tr>
<tr>
<td>Methyl ethyl ketone</td>
<td>16/-9</td>
<td>176/80</td>
<td>IB</td>
</tr>
<tr>
<td>Pyridine</td>
<td>68/20</td>
<td>239-241/116</td>
<td>IB</td>
</tr>
<tr>
<td>Tetrahydrofuran</td>
<td>6/-14</td>
<td>153/67</td>
<td>IB</td>
</tr>
<tr>
<td>Toluene</td>
<td>40/4</td>
<td>231/111</td>
<td>IB</td>
</tr>
<tr>
<td>Triethylamine</td>
<td>20/-7</td>
<td>193/89</td>
<td>IB</td>
</tr>
<tr>
<td>tert Butyl isocyanate</td>
<td>80/27</td>
<td>185-187/85-86</td>
<td>IC</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>82/28</td>
<td>270/132</td>
<td>IC</td>
</tr>
<tr>
<td>Epichlorohydrin</td>
<td>88/31</td>
<td>239-243/115-117</td>
<td>IC</td>
</tr>
<tr>
<td>2-Nitropropane</td>
<td>75/24</td>
<td>248/120</td>
<td>IC</td>
</tr>
<tr>
<td>Xylene</td>
<td>81-90/27-32</td>
<td>280-291/138-144</td>
<td>IC</td>
</tr>
<tr>
<td>Acetic Acid, glacial</td>
<td>103/39</td>
<td>244/48</td>
<td>II</td>
</tr>
<tr>
<td>Bromobenzene</td>
<td>118/48</td>
<td>307-316/153-158</td>
<td>II</td>
</tr>
</tbody>
</table>
APPENDIX E

FLAMMABLE AND COMBUSTIBLE LIQUID CONTAINMENT AND STORAGE REQUIREMENTS

Containment

Only approved containers and metal portable tanks authorized by NFPA (National Fire Protection Association) 30 shall be used to store flammable liquids.

<table>
<thead>
<tr>
<th>Container</th>
<th>Flammable Class</th>
<th>Combustible Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>IA</td>
<td>IC</td>
</tr>
<tr>
<td></td>
<td>1 pt*</td>
<td>1 gal</td>
</tr>
<tr>
<td>Metal or Approved Plastic</td>
<td>1 gal</td>
<td>5 gal</td>
</tr>
<tr>
<td>Safety Cans</td>
<td>2 gal</td>
<td>5 gal</td>
</tr>
<tr>
<td>Metal Drums</td>
<td>60 gal</td>
<td>60 gal</td>
</tr>
<tr>
<td>Approved Metal Portable Tanks</td>
<td>660 gal</td>
<td>660 gal</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>1 gal</td>
<td>5 gal</td>
</tr>
</tbody>
</table>

*Class IA and IB liquids may be stored up to one gallon in glass containers if liquid purity would be affected by storage in metal containers or if metal containers could undergo excessive corrosion by the contained liquid.

Storage

Only NFPA 45 approved amounts of flammable liquids shall be stored in laboratory units outside of flammable liquid storage rooms.

<table>
<thead>
<tr>
<th>Flammable Combustible Class</th>
<th>Maximum Quantity per 100 ft² of Laboratory Unit</th>
<th>Maximum Quantity per Laboratory Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>List as Class A Lab I</td>
<td>20 gallons</td>
<td>Unsprinklered 600 gallons</td>
</tr>
<tr>
<td>I, II and IIIA</td>
<td>40 gallons</td>
<td>Sprinklered 1200 gallons</td>
</tr>
<tr>
<td>List as Class B Lab</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>I, II and IIIA</td>
<td>List as Class C Lab</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td>20 gallons</td>
<td>400 gallons</td>
</tr>
<tr>
<td></td>
<td>4 gallons</td>
<td>150 gallons</td>
</tr>
<tr>
<td></td>
<td>8 gallons</td>
<td>200 gallons</td>
</tr>
</tbody>
</table>

The amounts above include quantities stored in approved storage cabinets and safety cans. Allowable quantities stored outside of approved storage cabinets and safety cans are 50% of the quantities listed above.

Laboratories listed as Class A shall be considered high hazard laboratories and shall not be used as instructional laboratories.

Laboratories listed as Class B shall be considered intermediate hazard laboratories. Laboratories listed as Class C shall be considered low hazard laboratories.

Should Class B or C laboratories be used for instructional purposes, quantities of flammable and combustible liquids shall be 50% of those listed in the above table.

APPENDIX F

COMMON LABORATORY CORROSIVES

**ORGANIC ACIDS**
- Formic Acid
- Acetic Acid (Glacial)
- Propionic Acid
- Butyric Acid
- Chloroacetic Acid
- Trichloroacetic Acid
- Acetyl Chloride
- Acetyl Bromide
- Chloroacetyl Chloride
- Oxalic Acid
- Propionyl Chloride
- Propionyl Bromide
- Acetic Anhydride
- Methyl Chloroformate
- Dimethyl Sulfate
- Chlorotrimethylsilane
- Dichlorodimethylsilane
- Phenol
- Benzoyl Chloride
- Benzoyl Bromide
- Benzyl Chloride
- Benzyl Bromide
- Salicylic Acid

**ORGANIC BASES**
- Ethylenediamine
Tetramethylethylenediamine
Hexamethylenediamine
Trimethylamine aq. Soln..
Triethylamine
Phenyldihydrazine
Piperazine
Hydroxylamine
Tetramethylammonium Hydroxide

ELEMENTS
Fluorine (gas)
Chlorine (gas)
Bromine (liquid)
Iodine (crystal)
Phosphorus

INORGANIC BASES
Ammonium Hydroxide
Calcium Hydroxide
Sodium Hydroxide
Potassium Hydroxide
Calcium Hydride
Sodium Hydride
Hydrazine
Ammonium Sulfide
Calcium Oxide

INORGANIC ACIDS
Hydrofluoric Acid
Hydrochloric Acid
Hydrobromic Acid
Hydriodic Acid
Sulfuric Acid
Chromerge™
No-Chromix™
Chlorosulfonic Acid
Sulfuryl Chloride
Bromine Pentafluoride
Thionyl Chloride
Tin Chloride
Tin Bromide
Titanium Tetrachloride
Perchloric Acid
Nitric Acid
Phosphoric Acid
Phosphorus Trichloride
Phosphorus Tribromide
Phosphorus Pentachloride
Phosphorus Pentoxide

ACID SALTS
Aluminum Trichloride
Antimony Trichloride
Ammonium Bifluoride
Calcium Fluoride
Ferric Chloride
Sodium Bisulfate
APPENDIX G

COMMON LABORATORY OXIDIZERS

Oxidizers react with other chemicals by giving off electrons and undergoing reduction. Uncontrolled reactions of oxidizers may result in a fire or an explosion, causing severe property damage or personal injury. Use oxidizers with extreme care and caution and follow all safe handling guidelines specified in the MSDS.

<table>
<thead>
<tr>
<th>Oxidizer</th>
<th>Oxidizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleach</td>
<td>Nitrites</td>
</tr>
<tr>
<td>Bromates</td>
<td>Nitrous oxide</td>
</tr>
<tr>
<td>Bromine</td>
<td>Ozanates</td>
</tr>
<tr>
<td>Butadiene</td>
<td>Oxides</td>
</tr>
<tr>
<td>Chlorates</td>
<td>Oxygen</td>
</tr>
<tr>
<td>Chloric Acid</td>
<td>Oxygen difluoride</td>
</tr>
<tr>
<td>Chlorine</td>
<td>Ozone</td>
</tr>
<tr>
<td>Chlorite</td>
<td>Peracetic Acid</td>
</tr>
<tr>
<td>Chromates</td>
<td>Perhaloate</td>
</tr>
<tr>
<td>Chromic Acid</td>
<td>Perborates</td>
</tr>
<tr>
<td>Dichromates</td>
<td>Percarbonates</td>
</tr>
<tr>
<td>Fluorine</td>
<td>Perchlorates</td>
</tr>
<tr>
<td>Haloate</td>
<td>Perchloric Acid</td>
</tr>
<tr>
<td>Halogens</td>
<td>Permanganates</td>
</tr>
<tr>
<td>Hydrogen Peroxide</td>
<td>Peroxides</td>
</tr>
<tr>
<td>Hypochlorites</td>
<td>Persulfate</td>
</tr>
<tr>
<td>Iodates</td>
<td>Sodium Borate Perhydrate</td>
</tr>
<tr>
<td>Mineral Acid</td>
<td>Sulfuric Acid</td>
</tr>
<tr>
<td>Nitrites</td>
<td>Nitrous oxide</td>
</tr>
<tr>
<td>Nitrous oxide</td>
<td>Oxides</td>
</tr>
<tr>
<td>Ozanates</td>
<td>Oxygen</td>
</tr>
<tr>
<td>Oxygen difluoride</td>
<td>Ozone</td>
</tr>
<tr>
<td>Ozone</td>
<td>Peracetic Acid</td>
</tr>
<tr>
<td>Perhaloate</td>
<td>Perborates</td>
</tr>
<tr>
<td>Percarbonates</td>
<td>Perchlorates</td>
</tr>
<tr>
<td>Perchloric Acid</td>
<td>Permanganates</td>
</tr>
<tr>
<td>Peroxides</td>
<td>Persulfate</td>
</tr>
<tr>
<td>Sodium Borate Perhydrate</td>
<td>Sulfuric Acid</td>
</tr>
</tbody>
</table>

References
# APPENDIX H

## Classes of Peroxidizable Chemicals

### A. Chemicals that form explosive levels of peroxides without concentration

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Peroxidizable Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butadiene</td>
<td>Divinylacetylene</td>
</tr>
<tr>
<td>Chloroprene</td>
<td>Isopropyl ether</td>
</tr>
<tr>
<td>Tetrafluoroethylene</td>
<td>Vinylidene chloride</td>
</tr>
</tbody>
</table>

### B. Chemicals that form explosive levels of peroxides on concentration

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Peroxidizable Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetal</td>
<td>Diacetylene</td>
</tr>
<tr>
<td>Acetaldehyde</td>
<td>Dicyclopentadiene</td>
</tr>
<tr>
<td>Benzyl alcohol</td>
<td>Diethyl ether</td>
</tr>
<tr>
<td>2-Butanol</td>
<td>Diethylene glycol dimethyl ether</td>
</tr>
<tr>
<td>Cumene</td>
<td>(diglyme)</td>
</tr>
<tr>
<td>Cyclohexanol</td>
<td>Dioxanes</td>
</tr>
<tr>
<td>2-Cyclohexen-1 -ol</td>
<td>Ethylene glycol dimethyl ether</td>
</tr>
<tr>
<td>Cyclohexene</td>
<td>(glyme)</td>
</tr>
<tr>
<td>Decahydronaphthalene</td>
<td>4-Heptanol</td>
</tr>
</tbody>
</table>

### C. Chemicals that may autopolymerize as a result of peroxide accumulation

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Peroxidizable Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic acid</td>
<td>Chlorotrifluoroethylene</td>
</tr>
<tr>
<td>Acrylonitrile</td>
<td>Methyl methacrylate</td>
</tr>
<tr>
<td>Butadiene</td>
<td>Styrene</td>
</tr>
<tr>
<td>Chloroprene</td>
<td>Tetrafluoroethylene</td>
</tr>
</tbody>
</table>

### D. Chemicals that may form peroxides but cannot clearly be placed in sections A-C

- Acrolein
- Allyl ether
- Allyl ethyl ether
- Allyl phenyl ether
- p-(n-Amyloxy)benzoyl chloride
- n-Amyl ether
- Benzyl n-butyl ether
- Benzyl ether
Benzyl methyl ether
Benzyl 1-naphthyl ether
1,2-Bis(2-chloroethoxy)ethane
Bis(2-ethoxyethyl) ether
Bis(2-(methoxyethoxy)ethyl) ether
Bis(2-chloroethyl) ether
Bis(2-ethoxyethyl) adipate
Bis(2-ethoxyethyl) phthalate
Bis(2-methoxyethyl) carbonate
Bis(2-methoxyethyl) ether
Bis(2-methoxyethyl)phthalate
Bis(2-chloroethyl) ether
Bis(4-chlorobutyl) ether
Bis(chloromethyl) ether
2-Bromomethyl ethyl ether
β-Bromophenetole
tert-Butyl methyl ether
n-Butyl phenyl ether
n-Butyl vinyl ether
Chloroacetaldehyde diethylacetel
2-Chlorobutadiene
1-(2-Chloroethoxy)-2-phenoxoethane
Chloroethylene
Chloromethyl methyl ether
β-Chlorophenetole
o-Chlorophenetole
p-Chlorophenetole
Cyclooctene
Cyclopropyl methyl ether
Diallyl ether
p-Di-n-butoxybenzene
1,2-Dibenzylxoyethane
p-Dibenzylxoybenzene
1,2-Dichloroethyl ethyl ether
2,4-Dichlorophenetole
Diethoxymethane
2,2-Diethoxypropane
Diethyl ethoxymethylenemalonate
Diethyl fumarate
Diethyl acetal
Diethylketene
m.o.p-Diethoxybenzene
1,2-Diethoxyethane
Di(1-propynyl) ether
Di (2-propynyl) ether
Di-n-propoxymethane
1,2-Epoxy-3-isopropoxypropane
1,2-Epoxy-3-phenoxyp propane
Ethoxyacetophenone
1-(2-Ethoxyethoxy)ethyl acetate
2-Ethoxyethyl acetate
(2-Ethoxyethyl)-o-benzoyl benzoate
1-Ethoxynaphthalene
o,p-Ethoxyphenyl isocyanate
1-Ethoxy-2-propyne
3-Ethoxypropionitrile
2-Ethylacrylaldehyde oxime
2-Ethylbutanol
Ethyl β-ethoxypropionate
2-Ethylhexanal
Ethyl vinyl ether
Furan p-Phenylphenetone
4,5-Hexadien-2-yn-1-ol
n-Hexyl ether
o,p-iodophenetole
Isoamyl benzyl ether
Isoamyl ether
Isobutyl vinyl ether
Isophorone
4-Methyl-2-pentanone
n-Methylphenetole
2-Methyltetrahydrofuran
3-Methoxy-1-butyl acetate
2-Methoxyethanol
3-Methoxyethyl acetate
2-Methoxyethyl vinyl ether
Methoxy-1,3,5,7-cycloocta tetraene
β-Methoxypropionitrile
m-Nitrophenetole
1-Octene
Oxybis(2-ethyl acetate)
Oxybis(2-ethyl benzoate)
β,β-Oxydipropionitrile
1-Pentene
Phenoxyacetyl chloride
α-Phenoxypropionyl chloride
Phenyl 0-propyl ether
n-Propylether
n-Propyl isopropyl ether
Sodium 8,11,14-eicosa tetraenoate
Sodium ethoxyacetylide
Tetrahydropyran
Triethylene glycol diacetate
Triethylene glycol dipropionate

D.Chemicals that may form peroxides but cannot clearly be placed in sections A-C

<table>
<thead>
<tr>
<th>Description</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>0- Bromophenetole</td>
<td></td>
</tr>
<tr>
<td>Dimethoxymethane</td>
<td></td>
</tr>
<tr>
<td>p- Bromophenetole</td>
<td></td>
</tr>
<tr>
<td>1,1-Dimethoxyethane</td>
<td></td>
</tr>
<tr>
<td>3-Bromopropyl phenyl ether</td>
<td></td>
</tr>
<tr>
<td>1,3-Butadiyne</td>
<td></td>
</tr>
<tr>
<td>3,3-Dimethoxypropene</td>
<td></td>
</tr>
<tr>
<td>Buten-3-yne</td>
<td></td>
</tr>
<tr>
<td>2,4-Dinitrophenetole</td>
<td></td>
</tr>
<tr>
<td>tert-Butyl ethyl ether</td>
<td></td>
</tr>
<tr>
<td>1,3-Dioxypane</td>
<td></td>
</tr>
<tr>
<td>p-Isopropoxypropionitrile</td>
<td></td>
</tr>
<tr>
<td>Isopropyl 2,4,5-trichloromphenoxycetate</td>
<td></td>
</tr>
<tr>
<td>Dimethylketene</td>
<td></td>
</tr>
<tr>
<td>Limonene</td>
<td></td>
</tr>
<tr>
<td>1,5-p-Methadiene</td>
<td></td>
</tr>
<tr>
<td>Methyl p-(n-amyloxy)benzoate</td>
<td></td>
</tr>
<tr>
<td>1,3,3-Trimethoxypropene</td>
<td></td>
</tr>
<tr>
<td>1,1,2,3-Tetrachlor-1 3-acetate butadiene</td>
<td></td>
</tr>
<tr>
<td>4-Vinyl cyclohexene</td>
<td></td>
</tr>
<tr>
<td>Vinylencarbonante</td>
<td></td>
</tr>
<tr>
<td>a When stored as a liquid monomer</td>
<td></td>
</tr>
<tr>
<td>b Although these chemicals form peroxides, no explosions involving these monomers</td>
<td></td>
</tr>
<tr>
<td>c When stored in liquid form, these chemicals form explosive levels of peroxides without concentration. They may also be stored as a gas in gas cylinders. When stored as a gas, these chemicals may autopolymerize as a result of peroxide accumulation.</td>
<td></td>
</tr>
<tr>
<td>d These chemicals easily form peroxides and should probably be considered under part B.</td>
<td></td>
</tr>
<tr>
<td>e OSHA-regulated carcinogen</td>
<td></td>
</tr>
<tr>
<td>f Extremely reactive and unstable compound.</td>
<td></td>
</tr>
</tbody>
</table>

Safe Storage Period for Peroxide Forming Chemicals

<table>
<thead>
<tr>
<th>Description</th>
<th>Period</th>
</tr>
</thead>
</table>
**Opened containers**

Chemicals in Part A   3 months
Chemicals in Parts B and D  12 months
Uninhibited chemicals in Part C  24 hours
Inhibited chemicals in Part C  12 months

a  Do not store under inert atmosphere, oxygen required for inhibitor to function.

Sources: Kelly, Richard J., Chemical Health & Safety, American Chemical Society, 1996, Sept, 28-36

Revised 12/97

---

**DETECTION AND INHIBITION OF PEROXIDES**

**BASIC PROTOCOLS**

**Ferrous Thiocyanate Detection Method**

Ferrous thiocyanate will detect hydroperoxides with the following test:

1. Mix a solution of 5 ml of 1% ferrous ammonium sulfate, 0.5 ml of 1N sulfuric acid and 0.5 ml of 0.1 N ammonium thiocyanate (if necessary decolorize with a trace of zinc dust)

2. Shake with an equal quantity of the solvent to be tested

3. If peroxides are present, a red color will develop

**Potassium Iodide Detection Method**

1. Add 1 ml of a freshly prepared 10% solution of potassium iodide to 10 ml of ethyl ether in a 25 ml glass-stoppered cylinder of colorless glass protected from light (both components are clear)

2. A resulting yellow color indicates the presence of 0.005% peroxides

**Inhibition of Peroxides**

1. Storage and handling under an inert atmosphere is a useful precaution

2. Addition of 0.001% hydroquinone, diphenylamine, polyhydroxyphenols, aminophenols or arylamines may stabilize ethers and inhibit formation of peroxides.

3. Dowex- 1 ® has been reported effective for inhibiting peroxide formation in ethyl ether.

4. 100 ppm of 1-naphthol effective for peroxide inhibition in isopropyl ether.

5. Hydroquinone effective for peroxide inhibition in tetrahydrofuran.
6. Stannous chloride or ferrous sulfate effective for peroxide inhibition in dioxane.

Peroxides Test Strips

These test strips are available from EM Scientific, cat. No.10011-i or from Lab Safety Supply, cat. No.1162. These strips quantify peroxides up to a concentration of 25 ppm. Aldrich Chemical has a peroxide test strip, cat. No. Z1O,168-0, that measures up to 1 ppm peroxide. The actual concentration at which peroxides become hazardous is not specifically stated in the literature. A number of publications use 100 ppm as a control value for managing the material safely.

Please note that these methods are BASIC protocols. Should a researcher perform one of these methods, all safety precautions should be thoroughly researched.

Sources:

APPENDIX I

SHOCK SENSITIVE AND EXPLOSIVE CHEMICALS

Shock sensitive refers to the susceptibility of a chemical to rapidly decompose or explode when struck, vibrated or otherwise agitated. Explosive chemicals are those chemicals which have a higher propensity to explode under a given set of circumstances (extreme heat, pressure, mixture with an incompatible chemical, etc.) than other chemicals. The label and MSDS will indicate if a chemical is shock sensitive or explosive. The chemicals listed below may be shock sensitive or explode under a given number of circumstances and are listed only as a guide some shock sensitive or explosive chemicals. Follow these guidelines:
• Write the date received and date opened on all containers of shock sensitive chemicals. Some chemicals become increasingly shock sensitive with age.
• Unless an inhibitor was added by the manufacturer, closed containers of shock sensitive materials should be discarded after one year.
• Wear appropriate personal protective equipment when handling shock sensitive chemicals.

- acetylene
- acetylies of heavy metal
- amatex
- amatol
- ammonal
- ammonium nitrate
- ammonium perchlorate
- ammonium picrate
- azides of heavy metals
- baratol
- calcium nitrate
- chlorate
- copper acetylide
- cyanuric triazide
- cyclotrimethylenetrinitramine
- dinitrophenol
- dinitrophenyl hydrazine
- dinitrotoluene
- ednatol
- erythritol tetranitrate
- fulminate of mercury
- fulminate of silver
- ethylene oxide
fulminating gold
fulminating mercury
fulminating platinum
fulminating silver g
elatinized nitrocellulose
guanyl
guanylnitrasmino
guanyltetrazene
hydrazine
nitrate carbohydrate
nitrate glucoside
nitrogen truodide
nitrogen trichloride
nitroglycerin
nitroglycide
nitroglycol
nitroguanidine
nitroparaffins
nitrourea
organic nitramines
ozonides
pentolite
perchlorates of heavy metals
peroxides
picramic acid
picramide
picratol
picric acid
picryl sulphanolic acid
silver acetylide
silver azide
tetranitromethane

Mixtures:

germanium
hexanitrodiphenyamine
hexanitrostilbene
hexogen
hydrazoic acid
lead azide
lead mononitroresorci nate
lead styphnate
mannitol hexanitrate
sodium picramate
tetranitrocarbazole
tetracene
tetrytol
trimethylethana nite
trimonite
trinitroanisole
trinitrobenzene
trinitrobenzoic acid
trinitroresol
trinitroresorcinol
tritonal
urea nitrate

References: Material Safety Data Sheets, various chemical companies
Overall Evaluations of Carcinogenicity to Humans

As evaluated in *IARC Monographs* Volumes 1-74 (a total of 837 agents, mixtures and exposures)

This list contains all hazards evaluated to date, according to the type of hazard posed and to the type of exposure. Where appropriate, chemical abstract numbers are given [in square brackets]. For details of the evaluation, the relevant Monograph should be consulted (volume number given in round brackets, followed by year of publication of latest evaluation). Use a free-text search to find a particular compound. The IARC website can be reached at [http://193.51.164.11/monoeval/crthall.html](http://193.51.164.11/monoeval/crthall.html)

Group 1: Carcinogenic to humans (75)

**Agents and groups of agents**

Aflatoxins, naturally occurring [1402-68-2] (Vol. 56; 1993)

4-Aminobiphenyl [92-67-1] (Vol. 1, Suppl. 7; 1987)

Arsenic [7440-38-2] and arsenic compounds (Vol. 23, Suppl. 7; 1987)
(NB: This evaluation applies to the group of compounds as a whole and not necessarily to all individual compounds within the group)

Asbestos [1332-21-4] (Vol. 14, Suppl. 7; 1987)

Azathioprine [446-86-6] (Vol. 26, Suppl. 7; 1987)

Benzene [71-43-2] (Vol. 29, Suppl. 7; 1987)

Benzidine [92-87-5] (Vol. 29, Suppl. 7; 1987)

Beryllium [7440-41-7] and beryllium compounds (Vol. 58; 1993)
(NB: Evaluated as a group)
$N,N$-Bis(2-chloroethyl)-2-naphthylamine (Chlornaphazine) [494-03-1] (Vol. 4, Suppl. 7; 1987)

Bis(chloromethyl)ether [542-88-1] and chloromethyl methyl ether [107-30-2] (technical-grade) (Vol. 4, Suppl. 7; 1987)

1,4-Butanediol dimethanesulfonate (Busulphan; Myleran) [55-98-1] (Vol. 4, Suppl. 7; 1987)

Cadmium [7440-43-9] and cadmium compounds (Vol. 58; 1993)
(NB: Evaluated as a group)

Chlorambucil [305-03-3] (Vol. 26, Suppl. 7; 1987)

1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea (Methyl-CCNU; Semustine) [13909-09-6] (Suppl. 7; 1987)

Chromium[VI] compounds (Vol. 49; 1990)
(NB: Evaluated as a group)

Ciclosporin [79217-60-0] (Vol. 50; 1990)

Cyclophosphamide [50-18-0] [6055-19-2] (Vol. 26, Suppl. 7; 1987)

Diethylstilboestrol [56-53-1] (Vol. 21, Suppl. 7; 1987)

Epstein-Barr virus (Vol. 70; 1997)

Erionite [66733-21-9] (Vol. 42, Suppl. 7; 1987)

Ethylene oxide [75-21-8] (Vol. 60; 1994)
(NB: Overall evaluation upgraded from 2A to 1 with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

*Helicobacter pylori* (infection with) (Vol. 61; 1994)

Hepatitis B virus (chronic infection with) (Vol. 59; 1994)

Hepatitis C virus (chronic infection with) (Vol. 59; 1994)

Human immunodeficiency virus type 1 (infection with) (Vol. 67; 1996)

Human papillomavirus type 16 (Vol. 64; 1995)

Human papillomavirus type 18 (Vol. 64; 1995)

Human T-cell lymphotropic virus type I (Vol. 67; 1996)

Melphalan [148-82-3] (Vol. 9, Suppl. 7; 1987)

8-Methoxypsoralen (Methoxsalen) [298-81-7] plus ultraviolet Aradiation (Vol. 24, Suppl. 7; 1987)
Mustard gas (Sulfur mustard) [505-60-2] (Vol. 9, Suppl. 7; 1987)

2-Naphthylamine [91-59-8] (Vol. 4, Suppl. 7; 1987)

Nickel compounds (Vol. 49; 1990)
(NB: Evaluated as a group)

Oestrogen therapy, postmenopausal (Vol. 72; 1999)

Oestrogens, nonsteroidal (Suppl. 7; 1987)
(NB: This evaluation applies to the group of compounds as a whole and not necessarily to all individual compounds within the group)

Oestrogens, steroidal (Suppl. 7; 1987)
(NB: This evaluation applies to the group of compounds as a whole and not necessarily to all individual compounds within the group)

*Opisthorchis viverrini* (infection with) (Vol. 61; 1994)

Oral contraceptives, combined (Vol. 72; 1999)
(NB: There is also conclusive evidence that these agents have a protective effect against cancers of the ovary and endometrium)

Oral contraceptives, sequential (Suppl. 7; 1987)

Radon [10043-92-2] and its decay products (Vol. 43; 1988)

*Schistosoma haematobium* (infection with) (Vol. 61; 1994)

Silica [14808-60-7], crystalline (inhaled in the form of quartz or cristobalite from occupational sources) (Vol. 68; 1997)

Solar radiation (Vol. 55; 1992)

Talc containing asbestiform fibres (Vol. 42, Suppl. 7; 1987)

Tamoxifen [10540-29-1] (Vol. 66; 1996)
(NB: There is also conclusive evidence that this agent (tamoxifen) reduces the risk of contralateral breast cancer)

2,3,7,8-Tetrachlorodibenzo-para-dioxin [1746-01-6] (Vol.69; 1997)
(NB: Overall evaluation upgraded from 2A to 1 with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Thiotepa [52-24-4] (Vol. 50; 1990)

Treosulfan [299-75-2] (Vol. 26, Suppl. 7; 1987)

Vinyl chloride [75-01-4] (Vol. 19, Suppl. 7; 1987)
Alcoholic beverages (Vol. 44; 1988)

Analgesic mixtures containing phenacetin (Suppl. 7; 1987)

Betel quid with tobacco (Vol. 37, Suppl. 7; 1987)

Coal-tar pitches [65996-93-2] (Vol. 35, Suppl. 7; 1987)

Coal-tars [8007-45-2] (Vol. 35, Suppl. 7; 1987)

Mineral oils, untreated and mildly treated (Vol. 33, Suppl. 7; 1987)

Salted fish (Chinese-style) (Vol. 56; 1993)

Shale-oils [68308-34-9] (Vol. 35, Suppl. 7; 1987)

Soots (Vol. 35, Suppl. 7; 1987)

Tobacco products, smokeless (Vol. 37, Suppl. 7; 1987)

Tobacco smoke (Vol. 38, Suppl. 7; 1987)

Wood dust (Vol. 62; 1995)

**Exposure circumstances**

Aluminium production (Vol. 34, Suppl. 7; 1987)

Auramine, manufacture of (Suppl. 7; 1987)

Boot and shoe manufacture and repair (Vol. 25, Suppl. 7; 1987)

Coal gasification (Vol. 34, Suppl. 7; 1987)

Coke production (Vol. 34, Suppl. 7; 1987)

Furniture and cabinet making (Vol. 25, Suppl. 7; 1987)

Haematite mining (underground) with exposure to radon (Vol. 1, Suppl. 7; 1987)

Iron and steel founding (Vol. 34, Suppl. 7; 1987)

Isopropanol manufacture (strong-acid process) (Suppl. 7; 1987)

Magenta, manufacture of (Vol. 57; 1993)

Painter (occupational exposure as a) (Vol. 47; 1989)

Rubber industry (Vol. 28, Suppl. 7; 1987)

Strong-inorganic-acid mists containing sulfuric acid (occupational exposure to) (Vol. 54; 1992)
Group 2A: Probably carcinogenic to humans (59)

Agents and groups of agents

Acrylamide [79-06-1] (Vol. 60; 1994)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Adriamycin [23214-92-8] (Vol. 10, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Androgenic (anabolic) steroids (Suppl. 7; 1987)

Azacitidine [320-67-2] (Vol. 50; 1990)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Benz[a]anthracene [56-55-3] (Vol. 32, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Benzidine-based dyes (Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Benz[a]pyrene [50-32-8] (Vol. 32, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Bischloroethyl nitrosourea (BCNU) [154-93-8] (Vol. 26, Suppl. 7; 1987)

1,3-Butadiene [106-99-0] (Vol. 71; 1999)

Captafol [2425-06-1] (Vol. 53; 1991)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Chloramphenicol [56-75-7] (Vol. 50; 1990)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

α-Chlorinated toluenes (benzal chloride [98-87-3], benzotrichloride [98-07-7], benzyl chloride [100 44-7]) and benzoyl chloride [98-88-4] (combined exposures) (Vol. 29, Suppl. 7, Vol. 71; 1999)

1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU) [13010-47-4] (Vol. 26, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)
(NB: Evaluated as a group)

Chlorozotocin [54749-90-5] (Vol. 50; 1990)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Cisplatin [15663-27-1] (Vol. 26, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Clonorchis sinensis (infection with) (Vol. 61; 1994)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Dibenz[a,h]anthracene [53-70-3] (Vol. 32, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

1,2-Dimethylhydrazine [540-73-8] (Vol. 4, Suppl. 7, Vol. 71; 1999)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Dimethyl sulfate [77-78-1] (Vol. 4, Suppl. 7, Vol. 71; 1999)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

N-Ethyl-N-nitrosourea [759-73-9] (Vol. 17, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Formaldehyde [50-00-0] (Vol. 62; 1995)

Human papillomavirus type 31 (Vol. 64; 1995)
IQ (2-Amino-3-methylimidazo[4,5-f]quinoline) [76180-96-6] (Vol. 56; 1993)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Kaposi's sarcoma herpesvirus/human herpesvirus 8 (Vol. 70; 1997)

5-Methoxypsoralen [484-20-8] (Vol. 40, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

4,4’-Methylene bis(2-chloroaniline) (MOCA) [101-14-4] (Vol. 57; 1993)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

N-Methyl-N’-nitro-N-nitrosoguanidine (MNNG) [70-25-7] (Vol. 4, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

N-Methyl-N-nitrosourea [684-93-5] (Vol. 17, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Nitrogen mustard [51-75-2] (Vol. 9, Suppl. 7; 1987)

N-Nitrosodiethylamine [55-18-5] (Vol. 17, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

N-Nitrosodimethylamine [62-75-9] (Vol. 17, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Phenacetin [62-44-2] (Vol. 24, Suppl. 7; 1987)

Procarbazine hydrochloride [366-70-1] (Vol. 26, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Styrene-7,8-oxide [96-09-3] (Vol. 60; 1994)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)


Trichloroethylene [79-01-6] (Vol. 63; 1995)
1,2,3-Trichloropropane [96-18-4] (Vol. 63; 1995)

Tris(2,3-dibromopropyl) phosphate [126-72-7] (Vol. 20, Suppl. 7, Vol. 71; 1999)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Ultraviolet radiation A (Vol. 55; 1992)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Ultraviolet radiation B (Vol. 55; 1992)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Ultraviolet radiation C (Vol. 55; 1992)
(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

(NB: Overall evaluation upgraded from 2B to 2A with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Vinyl fluoride [75-02-5] (Vol. 63; 1995)

**Mixtures**

Creosotes [8001-58-9] (Vol. 35, Suppl. 7; 1987)

Diesel engine exhaust (Vol. 46; 1989)

Hot mate (Vol. 51; 1991)

Non-arsenical insecticides (occupational exposures in spraying and application of) (Vol. 53; 1991)

Polychlorinated biphenyls [1336-36-3] (Vol. 18, Suppl. 7; 1987)

**Exposure circumstances**

Art glass, glass containers and pressed ware (manufacture of) (Vol. 58; 1993)

Hairdresser or barber (occupational exposure as a) (Vol. 57; 1993)

Petroleum refining (occupational exposures in) (Vol. 45; 1989)

Sunlamps and sunbeds (use of) (Vol. 55; 1992)

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**Group 2B: Possibly carcinogenic to humans (228)**

**Agents and groups of agents**


Acetaldehyde [75-07-0] (Vol. 36, Suppl. 7, Vol. 71; 1999)

Acrylonitrile [107-13-1] (Vol. 71; 1999)

AF-2 [2-(2-Furyl)-3-(5-nitro-2-furyl)acrylamide] [3688-53-7] (Vol. 31, Suppl. 7; 1987)

Aflatoxin M1 [6795-23-9] (Vol. 56; 1993)

para-Aminoazobenzene [60-09-3] (Vol. 8, Suppl. 7; 1987)

ortho-Aminoazotoluene [97-56-3] (Vol. 8, Suppl. 7; 1987)

2-Amino-5-(5-nitro-2-furyl)-1,3,4-thiadiazole [712-68-5] (Vol. 7, Suppl. 7; 1987)

Amitrole [61-82-5] (Vol. 41, Suppl. 7; 1987)

ortho-Anisidine [90-04-0] (Vol. 73; 1999)


Aramite® [140-57-8] (Vol. 5, Suppl. 7; 1987)

Auramine [492-80-8] (technical-grade) (Vol. 1, Suppl. 7; 1987)

Azaserine [115-02-6] (Vol. 10, Suppl. 7; 1987)

(NB: Overall evaluation upgraded from 3 to 2B with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Benzo[b]fluoranthene [205-99-2] (Vol. 32, Suppl. 7; 1987)

Benzo[j]fluoranthene [205-82-3] (Vol. 32, Suppl. 7; 1987)

Benzo[k]fluoranthene [207-08-9] (Vol. 32, Suppl. 7; 1987)


Benzyl violet 4B [1694-09-3] (Vol. 16, Suppl. 7; 1987)

Bleomycins [11056-06-7] (Vol. 26, Suppl. 7; 1987)
(NB: Overall evaluation upgraded from 3 to 2B with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Bracken fern (Vol. 40, Suppl. 7; 1987)


Butylated hydroxyanisole (BHA) [25013-16-5] (Vol. 40, Suppl. 7; 1987)

Carbon black [1333-86-4] (Vol. 65; 1996)


Ceramic fibres (Vol. 43; 1988)

Chlordane [57-74-9] (Vol. 53; 1991)

Chlordecone (Kepone) [143-50-0] (Vol. 20, Suppl. 7; 1987)

Chlorendic acid [115-28-6] (Vol. 48; 1990)

para-Chloroaniline [106-47-8] (Vol. 57; 1993)

Chloroform [67-66-3] (Vol. 73; 1999)


Chlorophenoxy herbicides (Vol. 41, Suppl. 7; 1987)

4-Chloro-ortho-phenylenediamine [95-83-0] (Vol. 27, Suppl. 7; 1987)

Chloroprene [126-99-8] (Vol. 71; 1999)

Chlorothalonil [1897-45-6] (Vol. 73; 1999)

CI Acid Red 114 [6459-94-5] (Vol. 57; 1993)

CI Basic Red 9 [569-61-9] (Vol. 57; 1993)

CI Direct Blue 15 [2429-74-5] (Vol. 57; 1993)

Citrus Red No. 2 [6358-53-8] (Vol. 8, Suppl. 7; 1987)

Cobalt [7440-48-4] and cobalt compounds (Vol. 52; 1991) (NB: Evaluated as a group)

para-Cresidine [120-71-8] (Vol. 27, Suppl. 7; 1987)

Cycasin [14901-08-7] (Vol. 10, Suppl. 7; 1987)

Dacarbazine [4342-03-4] (Vol. 26, Suppl. 7; 1987)

Dantron (Chrysazin; 1,8-Dihydroxyanthraquinone) [117-10-2] (Vol. 50; 1990)
DDT \([p,p'-DDT, 50-29-3]\) (Vol. 53; 1991)

\(N,N'-\text{Diacetylbenzidine} [613-35-4]\) (Vol. 16, Suppl. 7; 1987)

2,4-Diaminoanisole \([615-05-4]\) (Vol. 27, Suppl. 7; 1987)

4,4'-Diaminodiphenyl ether \([101-80-4]\) (Vol. 29, Suppl. 7; 1987)

2,4-Diaminotoluene \([95-80-7]\) (Vol. 16, Suppl. 7; 1987)

Dibenzo[\(a,h\)]acridine \([226-36-8]\) (Vol. 32, Suppl. 7; 1987)

Dibenzo[\(a,j\)]acridine \([224-42-0]\) (Vol. 32, Suppl. 7; 1987)

\(7H\)-Dibenzo[\(c,g\)]carbazole \([194-59-2]\) (Vol. 32, Suppl. 7; 1987)

Dibenzo[\(a,e\)]pyrene \([192-65-4]\) (Vol. 32, Suppl. 7; 1987)

Dibenzo[\(a,h\)]pyrene \([189-64-0]\) (Vol. 32, Suppl. 7; 1987)

Dibenzo[\(a,i\)]pyrene \([189-55-9]\) (Vol. 32, Suppl. 7; 1987)

Dibenzo[\(a,l\)]pyrene \([191-30-0]\) (Vol. 32, Suppl. 7; 1987)

1,2-Dibromo-3-chloropropane \([96-12-8]\) (Vol. 20, Suppl. 7, Vol. 71; 1999)

\textit{para}-Dichlorobenzene \([106-46-7]\) (Vol. 73; 1999)

3,3'-Dichlorobenzidine \([91-94-1]\) (Vol. 29, Suppl. 7; 1987)

3,3'-Dichloro-4,4'-diaminodiphenyl ether \([28434-86-8]\) (Vol. 16, Suppl. 7; 1987)

1,2-Dichloroethane \([107-06-2]\) (Vol. 20, Suppl. 7, Vol. 71; 1999)

Dichloromethane (methylene chloride) \([75-09-2]\) (Vol. 71; 1999)

1,3-Dichloropropene \([542-75-6]\) (technical-grade) (Vol. 41, Suppl. 7, Vol. 71; 1999)

Dichlorvos \([62-73-7]\) (Vol. 53; 1991)

Di(2-ethylhexyl) phthalate \([117-81-7]\) (Vol. 29, Suppl. 7; 1987)

1,2-Diethylhydrazine \([1615-80-1]\) (Vol. 4, Suppl. 7, Vol. 71; 1999)

Diglycidyl resorcinol ether \([101-90-6]\) (Vol. 36, Suppl. 7, Vol. 71; 1999)

Dihydrorosafole \([94-58-6]\) (Vol. 10, Suppl. 7; 1987)

Diisopropyl sulfate \([2973-10-6]\) (Vol. 54, Vol. 71; 1999)
3,3'-Dimethoxybenzidine (ortho-Dianisidine) [119-90-4](Vol. 4, Suppl. 7; 1987)

para-Dimethylaminoazobenzene [60-11-7] (Vol. 8, Suppl.7; 1987)

trans-2-[(Dimethylamino)methylimino]-5-[2-(5-nitro-2-furyl)-vinyl]-1,3,4-oxadiazole [25962-77-0] (Vol. 7, Suppl. 7; 1987)

2,6-Dimethylaniline (2,6-Xylidine) [87-62-7] (Vol. 57; 1993)

3,3'-Dimethylbenzidine (ortho-Tolidine) [119-93-7] (Vol.1, Suppl. 7; 1987)

1,1-Dimethylhydrazine [57-14-7] (Vol. 4, Suppl. 7, Vol. 71; 1999)

3,7-Dinitrofluoranthene [105735-71-5] (Vol. 65; 1996)


1,6-Dinitropyrene [42397-64-8] (Vol. 46; 1989)

1,8-Dinitropyrene [42397-65-9] (Vol. 46; 1989)

2,4-Dinitrotoluene [121-14-2] (Vol. 65; 1996)

2,6-Dinitrotoluene [606-20-2] (Vol. 65; 1996)

1,4-Dioxane [123-91-1] (Vol. 11, Suppl. 7, Vol. 71; 1999)

Disperse Blue 1 [2475-45-8] (Vol. 48; 1990)

(NB: Overall evaluation upgraded from 3 to 2B with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)


Ethylene thiourea [96-45-7] (Vol. 7, Suppl. 7; 1987)

Ethyl methanesulfonate [62-50-0] (Vol. 7, Suppl. 7; 1987)

Foreign bodies, implanted in tissues (Vol. 74; 1999)
Polymeric, prepared as thin smooth films (with the exception of poly(glycolic acid))
Metallic, prepared as thin smooth films
Metallic cobalt, metallic nickel and an alloy powder containing 66-67% nickel, 13-16% chromium and 7% iron

2-(2-Formylhydrazino)-4-(5-nitro-2-furyl)thiazole [3570-75-0] (Vol. 7, Suppl. 7; 1987)

Furan [110-00-9] (Vol. 63; 1995)

Glasswool (Vol. 43; 1988)
Glu-P-1 (2-Amino-6-methyldipyrido[1,2-a:3',2'-d]imidazole)[67730-11-4] (Vol. 40, Suppl. 7; 1987)
Glu-P-2 (2-Aminodipyrido[1,2-a:3',2'-d]imidazole)[67730-10-3] (Vol. 40, Suppl. 7; 1987)
Griseofulvin [126-07-8] (Vol. 10, Suppl. 7; 1987)
HC Blue No. 1 [2784-94-3] (Vol. 57; 1993)
Heptachlor [76-44-8] (Vol. 53; 1991)
Hexachlorobenzene [118-74-1] (Vol. 20, Suppl. 7; 1987)
Hexachloroethane [67-72-1] (Vol. 73; 1999)
Hexachlorocyclohexanes (Vol. 20, Suppl. 7; 1987)
Human immunodeficiency virus type 2 (infection with) (Vol. 67; 1996)
Human papillomaviruses: some types other than 16, 18, 31 and 33 (Vol. 64; 1995)
Indeno[1,2,3-cd]pyrene [193-39-5] (Vol. 32, Suppl. 7; 1987)
Lasiocarpine [303-34-4] (Vol. 10, Suppl. 7; 1987)
Lead [7439-92-1] and lead compounds, inorganic (Vol. 23, Suppl. 7; 1987)
(NB: Evaluated as a group)
Magenta [632-99-5] (containing CI Basic Red 9) (Vol. 57; 1993)
MeA-α-C (2-Amino-3-methyl-9H-pyrido[2,3-b]indole)[68006-83-7] (Vol. 40, Suppl. 7; 1987)
Medroxyprogesterone acetate [71-58-9] (Vol. 21, Suppl. 7; 1987)
MelQ (2-Amino-3,4-dimethylimidazo[4,5-f]quinoline) [77094-11-2](Vol. 56; 1993)
MelQx (2-Amino-3,8-dimethylimidazo[4,5-f]quinoxaline) [77500-04-0](Vol. 56; 1993)
Merphalan [531-76-0] (Vol. 9, Suppl. 7; 1987)
2-Methylaziridine (Propyleneimine) [75-55-8] (Vol. 9, Suppl. 7, Vol. 71; 1999)
Methylazoxymethanol acetate [592-62-1] (Vol. 10, Suppl. 7; 1987)

5-Methylchrysene [3697-24-3] (Vol. 32, Suppl. 7; 1987)

4,4'-Methylene bis(2-methylaniline) [838-88-0] (Vol. 4, Suppl. 7; 1987)

4,4'-Methylenedianiline [101-77-9] (Vol. 39, Suppl. 7; 1987)

Methylmercury compounds (Vol. 58; 1993)
(NB: Evaluated as a group)

2-Methyl-1-nitroanthraquinone [129-15-7] (uncertain purity) (Vol. 27, Suppl. 7; 1987)

N-Methyl-N-nitrosourethane [615-53-2] (Vol. 4, Suppl. 7; 1987)

Methylthiouracil [56-04-2] (Vol. 7, Suppl. 7; 1987)

Metronidazole [443-48-1] (Vol. 13, Suppl. 7; 1987)

Mirex [2385-85-5] (Vol. 20, Suppl. 7; 1987)

Mitomycin C [50-07-7] (Vol. 10, Suppl. 7; 1987)

Monocrotaline [315-22-0] (Vol. 10, Suppl. 7; 1987)

5-(Morpholinomethyl)-3-[(5-nitrofurfurylidene)amino]-2-oxazolidinone [3795-88-8] (Vol. 7, Suppl. 7; 1987)

Nafenopin [3771-19-5] (Vol. 24, Suppl. 7; 1987)

Nickel, metallic [7440-02-0] and alloys (Vol. 49; 1990)

Niridazole [61-57-4] (Vol. 13, Suppl. 7; 1987)

Nitrilotriacetic acid [139-13-9] and its salts (Vol. 73; 1999)
(NB: Evaluated as a group)

5-Nitroacenaphthene [602-87-9] (Vol. 16, Suppl. 7; 1987)

2-Nitroanisole [91-23-6] (Vol. 65; 1996)

Nitrobenzene [98-95-3] (Vol. 65; 1996)

6-Nitrochrysene [7496-02-8] (Vol. 46; 1989)

Nitrofen [1836-75-5] (technical-grade) (Vol. 30, Suppl. 7; 1987)


1-[(5-Nitrofurfurylidene)amino]-2-imidazolidinone [555-84-0] (Vol. 7, Suppl. 7; 1987)
N-[4-(5-Nitro-2-furyl)-2-thiazolyl]acetamide [531-82-8] (Vol. 7, Suppl. 7; 1987)

Nitrogen mustard N-oxide [126-85-2] (Vol. 9, Suppl. 7; 1987)


1-Nitropyrene [5522-43-0] (Vol. 46; 1989)


N-Nitrosodi-n-butylamine [924-16-3] (Vol. 17, Suppl. 7; 1987)

N-Nitrosodiethanolamine [1116-54-7] (Vol. 17, Suppl. 7; 1987)

N-Nitrosodi-n-propylamine [621-64-7] (Vol. 17, Suppl. 7; 1987)

3-(N-Nitrosomethylamino)propionitrile [60153-49-3] (Vol. 37, Suppl. 7; 1987)

4-(N-Nitrosomethylamino)-1-(3-pyridyl)-1-butanone (NNK) [64091-91-4] (Vol. 37, Suppl. 7; 1987)

N-Nitrosomethylvinylamine [4549-40-0] (Vol. 17, Suppl. 7; 1987)

N-Nitrosomorpholine [59-89-2] (Vol. 17, Suppl. 7; 1987)

N'-Nitrosonornicotine [16543-55-8] (Vol. 37, Suppl. 7; 1987)

N-Nitrosopiperidine [100-75-4] (Vol. 17, Suppl. 7; 1987)

N-Nitrosopyrrolidine [930-55-2] (Vol. 17, Suppl. 7; 1987)

N-Nitrososarcosine [13256-22-9] (Vol. 17, Suppl. 7; 1987)


Oestrogen-progestogen therapy, postmenopausal (Vol. 72; 1999)

Oil Orange SS [2646-17-5] (Vol. 8, Suppl. 7; 1987)

Oxazepam [604-75-1] (Vol. 66; 1996)

Palygorskite (attapulgite) [12174-11-7] (long fibres, > 5 micrometers) (Vol. 68; 1997)

Panfuran S [794-93-4] (containing dihydroxymethylfuratrizine) (Vol. 24, Suppl. 7; 1987)

Phenazopyridine hydrochloride [136-40-3] (Vol. 24, Suppl. 7; 1987)

Phenobarbital [50-06-6] (Vol. 13, Suppl. 7; 1987)
Phenoxybenzamine hydrochloride [63-92-3] (Vol. 24, Suppl. 7; 1987)


Phenytoin [57-41-0] (Vol. 66; 1996)

PhIP (2-Amino-1-methyl-6-phenylimidazo[4,5-b]pyridine)[105650-23-5] (Vol. 56; 1993)


Ponceau MX [3761-53-3] (Vol. 8, Suppl. 7; 1987)

Ponceau 3R [3564-09-8] (Vol. 8, Suppl. 7; 1987)

Potassium bromate [7758-01-2] (Vol. 73; 1999)

Progestins (Suppl. 7; 1987)

Progestogen-only contraceptives (Vol. 72; 1999)

1,3-Propane sultone [1120-71-4] (Vol. 4, Suppl. 7, Vol. 71; 1999)

β-Propiolactone [57-57-8] (Vol. 4, Suppl. 7, Vol. 71; 1999)

Propylene oxide [75-56-9] (Vol. 60; 1994)

Propylthiouracil [51-52-5] (Vol. 7, Suppl. 7; 1987)

Rockwool (Vol. 43; 1988)

Safrole [94-59-7] (Vol. 10, Suppl. 7; 1987)

Schistosoma japonicum (infection with) (Vol. 61; 1994)


Sterigmatocystin [10048-13-2] (Vol. 10, Suppl. 7; 1987)

Streptozotocin [18883-66-4] (Vol. 17, Suppl. 7; 1987)

Styrene [100-42-5] (Vol. 60; 1994)

(NB: Overall evaluation upgraded from 3 to 2B with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Sulfallate [95-06-7] (Vol. 30, Suppl. 7; 1987)

Tetrafluoroethylene [116-14-3] (Vol. 19, Suppl. 7, Vol. 71; 1999)
Tetranitromethane [509-14-8] (Vol. 65; 1996)

Thioacetamide [62-55-5] (Vol. 7, Suppl. 7; 1987)

4,4'-Thiodianiline [139-65-1] (Vol. 27, Suppl. 7; 1987)

Thiourea [62-56-6] (Vol. 7, Suppl. 7; 1987)


*ortho*-Toluidine [95-53-4] (Vol. 27, Suppl. 7; 1987)

Toxins derived from *Fusarium moniliforme* (Vol. 56; 1993)

Trichlormethine (Trimustine hydrochloride) [817-09-4] (Vol. 50; 1990)

Trp-P-1 (3-Amino-1,4-dimethyl-5$H$-pyrido[4,3-$b$]indole)[62450-06-0] (Vol. 31, Suppl. 7; 1987)

Trp-P-2 (3-Amino-1-methyl-5$H$-pyrido[4,3-$b$]indole)[62450-07-1] (Vol. 31, Suppl. 7; 1987)

Trypan blue [72-57-1] (Vol. 8, Suppl. 7; 1987)

Uracil mustard [66-75-1] (Vol. 9, Suppl. 7; 1987)

Urethane [51-79-6] (Vol. 7, Suppl. 7; 1987)


4-Vinylcyclohexene [100-40-3] (Vol. 60; 1994)

4-Vinylcyclohexene diepoxide [106-87-6] (Vol. 60; 1994)

**Mixtures**

Bitumens [8052-42-4], extracts of steam-refined and air-refined (Vol. 35, Suppl. 7; 1987)

Carrageenan [9000-07-1], degraded (Vol. 31, Suppl. 7; 1987)

Chlorinated paraffins of average carbon chain length C12 and average degree of chlorination approximately 60% (Vol. 48; 1990)

Coffee (urinary bladder) (Vol. 51; 1991)
(NB: There is some evidence of an inverse relationship between coffee drinking and cancer of the large bowel; coffee drinking could not be classified as to its carcinogenicity to other organs)

Diesel fuel, marine (Vol. 45; 1989)
(NB: Overall evaluation upgraded from 3 to 2B with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Engine exhaust, gasoline (Vol. 46; 1989)
Gasoline (Vol. 45; 1989)
(NB: Overall evaluation upgraded from 3 to 2B with supporting evidence from other data relevant to the evaluation of carcinogenicity and its mechanisms)

Pickled vegetables (traditional in Asia) (Vol. 56; 1993)

Polybrominated biphenyls [Firemaster BP-6, 59536-65-1] (Vol. 41, Suppl. 7; 1987)

Toxaphene (Polychlorinated camphenes) [8001-35-2] (Vol. 20, Suppl. 7; 1987)

Welding fumes (Vol. 49; 1990)

**Exposure circumstances**
Carpentry and joinery (Vol. 25, Suppl. 7; 1987)

Dry cleaning (occupational exposures in) (Vol. 63; 1995)

Printing processes (occupational exposures in) (Vol. 65; 1996)

Textile manufacturing industry (work in) (Vol. 48; 1990)

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**Group 3: Unclassifiable as to carcinogenicity to humans (474)**

**Agents and groups of agents**
Acridine orange [494-38-2] (Vol. 16, Suppl. 7; 1987)

Acriflavinium chloride [8018-07-3] (Vol. 13, Suppl. 7; 1987)

Acrolein [107-02-8] (Vol. 63; 1995)


Acrylic fibres (Vol. 19, Suppl. 7; 1987)

Acrylonitrile-butadiene-styrene copolymers (Vol. 19, Suppl. 7; 1987)

Actinomycin D [50-76-0] (Vol. 10, Suppl. 7; 1987)

Agaritine [2757-90-6] (Vol. 31, Suppl. 7; 1987)

Aldicarb [116-06-3] (Vol. 53; 1991)

Aldrin [309-00-2] (Vol. 5, Suppl. 7; 1987)


Allyl isothiocyanate [57-06-7] (Vol. 73; 1999)

Amaranth [915-67-3] (Vol. 8, Suppl. 7; 1987)

5-Aminoacenaphthene [4657-93-6] (Vol. 16, Suppl. 7; 1987)

2-Aminoanthraquinone [117-79-3] (Vol. 27, Suppl. 7; 1987)

para-Aminobenzoic acid [150-13-0] (Vol. 16, Suppl. 7; 1987)

1-Amino-2-methylanthraquinone [82-28-0] (Vol. 27, Suppl. 7; 1987)

2-Amino-4-nitrophenol [99-57-0] (Vol. 57; 1993)

2-Amino-5-nitrophenol [121-88-0] (Vol. 57; 1993)

4-Amino-2-nitrophenol [119-34-6] (Vol. 16, Suppl. 7; 1987)

2-Amino-5-nitrothiazole [121-66-4] (Vol. 31, Suppl. 7; 1987)

11-Aminoundecanoic acid [2432-99-7] (Vol. 39, Suppl. 7; 1987)

Ampicillin [69-53-4] (Vol. 50; 1990)

Anaesthetics, volatile (Vol. 11, Suppl. 7; 1987)

Angelcin [523-50-2] plus ultraviolet A radiation (Vol. 40, Suppl. 7; 1987)

Aniline [62-53-3] (Vol. 27, Suppl. 7; 1987)

para-Anisidine [104-94-9] (Vol. 27, Suppl. 7; 1987)

Anthanthrene [191-26-4] (Vol. 32, Suppl. 7; 1987)

Anthracene [120-12-7] (Vol. 32, Suppl. 7; 1987)

Anthranilic acid [118-92-3] (Vol. 16, Suppl. 7; 1987)

Antimony trisulfide [1345-04-6] (Vol. 47; 1989)

Apholate [52-46-0] (Vol. 9, Suppl. 7; 1987)

para-Aramid fibrils [24938-64-5] (Vol. 68; 1997)

Atrazine [1912-24-9] (Vol. 73; 1999)
(NB: Overall evaluation downgraded from 2B to 3 with supporting evidence from other data relevant to carcinogenicity and its mechanisms)

Aurothioglucose [12192-57-3] (Vol. 13, Suppl. 7; 1987)

2-(1-Aziridinyl)ethanol [1072-52-2] (Vol. 9, Suppl. 7; 1987)
Azobenzene [103-33-3] (Vol. 8, Suppl. 7; 1987)
Benz[a]acridine [225-11-6] (Vol. 32, Suppl. 7; 1987)
Benz[c]acridine [225-51-4] (Vol. 32, Suppl. 7; 1987)
Benzo[ghi]fluoranthene [203-12-3] (Vol. 32, Suppl. 7; 1987)
Benzo[a]fluorene [238-84-6] (Vol. 32, Suppl. 7; 1987)
Benzo[b]fluorene [243-17-4] (Vol. 32, Suppl. 7; 1987)
Benzo[c]fluorene [205-12-9] (Vol. 32, Suppl. 7; 1987)
Benzo[ghi]perylene [191-24-2] (Vol. 32, Suppl. 7; 1987)
Benzo[c]phenanthrene [195-19-7] (Vol. 32, Suppl. 7; 1987)
Benzo[e]pyrene [192-97-2] (Vol. 32, Suppl. 7; 1987)

para-Benzquinone dioxime [105-11-3] (Vol. 29, Suppl. 7, Vol. 71; 1999)
Benzoyl peroxide [94-36-0] (Vol. 36, Suppl. 7, Vol. 71; 1999)
Bis(1-aziridinyl)morpholinophosphine sulfide [2168-68-5] (Vol. 9, Suppl. 7; 1987)
Bis(2-chloroethyl)ether [111-44-4] (Vol. 9, Suppl. 7, Vol. 71; 1999)
1,2-Bis(chloromethoxy)ethane [13483-18-6] (Vol. 15; Suppl. 7, Vol. 71; 1999)
1,4-Bis(chloromethoxymethyl)benzene [56894-91-8] (Vol. 15, Suppl. 7, Vol. 71; 1999)
Bis(2-chloro-1-methylethyl)ether [108-60-1] (Vol. 41, Suppl. 7, Vol. 71; 1999)
Bis(2,3-epoxycyclopentyl)ether [2386-90-5] (Vol. 47, Vol. 71; 1999)
Bisulfites (Vol. 54; 1992)
Blue VRS [129-17-9] (Vol. 16, Suppl. 7; 1987)
Brilliant Blue FCF, disodium salt [3844-45-9] (Vol. 16, Suppl.7; 1987)
Butylated hydroxytoluene (BHT) [128-37-0] (Vol. 40, Suppl. 7; 1987)
Butyl benzyl phthalate [85-68-7] (Vol. 73; 1999)
γ-Butyrolactone [96-48-0] (Vol. 11, Suppl. 7, Vol. 71; 1999)
Caffeine [58-08-2] (Vol. 51; 1991)
Cantharidin [56-25-7] (Vol. 10, Suppl. 7; 1987)
Captan [133-06-2] (Vol. 30, Suppl. 7; 1987)
Carbaryl [63-25-2] (Vol. 12, Suppl. 7; 1987)
3-Carbethoxypsoralen [20073-24-9] (Vol. 40, Suppl. 7; 1987)
Carmoisine [3567-69-9] (Vol. 8, Suppl. 7; 1987)
Carrageenan [9000-07-1], native (Vol. 31, Suppl. 7; 1987)
Chloral [75-87-6] (Vol. 63; 1995)
Chloral hydrate [302-17-0] (Vol. 63; 1995)
Chlordimeform [6164-98-3] (Vol. 30, Suppl. 7; 1987)
Chlorinated drinking-water (Vol. 52; 1991)
Chlorobenzilate [510-15-6] (Vol. 30, Suppl. 7; 1987)
Chlorodifluoromethane [75-45-6] (Vol. 41, Suppl. 7, Vol. 71; 1999)
Chloroethane [75-00-3] (Vol. 52, Vol. 71; 1999)
4-Chloro-meta-phenylenediamine [5131-60-2] (Vol. 27, Suppl. 7; 1987)
Chlorpropham [101-21-3] (Vol. 12, Suppl. 7; 1987)
Chloroquine [54-05-7] (Vol. 13, Suppl. 7; 1987)
Cholesterol [57-88-5] (Vol. 31, Suppl. 7; 1987)
Chromium[III] compounds (Vol. 49; 1990)
Chromium [7440-47-3], metallic (Vol. 49; 1990)
Chrysene [218-01-9] (Vol. 32, Suppl. 7; 1987)
Chrysoidine [532-82-1] (Vol. 8, Suppl. 7; 1987)
Cl Acid Orange 3 [6373-74-6] (Vol. 57; 1993)
Cimetidine [51481-61-9] (Vol. 50; 1990)
Cinnamyl anthranilate [87-29-6] (Vol. 31, Suppl. 7; 1987)
Cl Pigment Red 3 [2425-85-6] (Vol. 57; 1993)
Citrinin [518-75-2] (Vol. 40, Suppl. 7; 1987)
Clofibrate [637-07-0] (Vol. 66; 1996)
Clomiphene citrate [50-41-9] (Vol. 21, Suppl. 7; 1987)
Coal dust (Vol. 68; 1997)
Copper 8-hydroxyquinoline [10380-28-6] (Vol. 15, Suppl. 7; 1987)
Coronene [191-07-1] (Vol. 32, Suppl. 7; 1987)
Coumarin [91-64-5] (Vol. 10, Suppl. 7; 1987)
meta-Cresidine [102-50-1] (Vol. 27, Suppl. 7; 1987)
Crotonaldehyde [4170-30-3] (Vol. 63; 1995)
Cyclamates [sodium cyclamate, 139-05-9] (Vol. 73; 1999)
Cyclochlorotline [12663-46-6] (Vol. 10, Suppl. 7; 1987)
Cyclopenta[cd]pyrene [27208-37-3] (Vol. 32, Suppl. 7; 1987)
D & C Red No. 9 [5160-02-1] (Vol. 57; 1993)
Dapsone [80-08-0] (Vol. 24, Suppl. 7; 1987)
Deltamethrin [52918-63-5] (Vol. 53; 1991)
Diacetylaminoazotoluene [83-63-6] (Vol. 8, Suppl. 7; 1987)
Diallate [2303-16-4] (Vol. 30, Suppl. 7; 1987)
1,2-Diamino-4-nitrobenzene [99-56-9] (Vol. 16, Suppl. 7; 1987)
1,4-Diamino-2-nitrobenzene [5307-14-2] (Vol. 57; 1993)
2,5-Diaminotoluene [95-70-5] (Vol. 16, Suppl. 7; 1987)
Diazepam [439-14-5] (Vol. 66; 1996)
Diazomethane [334-88-3] (Vol. 7, Suppl. 7; 1987)
Dibenzo[a,j]anthracene [224-41-9] (Vol. 32, Suppl. 7; 1987)
Dibenzo-para-dioxin (Vol. 69; 1997)
Dibenzo[a,e]fluoranthene [5385-75-1] (Vol. 32, Suppl. 7; 1987)
Dibenzo[h,rst]pentaphene [192-47-2] (Vol. 3, Suppl. 7; 1987)
Dichloroacetic acid [79-43-6] (Vol. 63; 1995)
Dichloroacetonitrile [3018-12-0] (Vol. 52, Vol. 71; 1999)
*meta*-Dichlorobenzene [541-73-1] (Vol. 73; 1999)
*ortho*-Dichlorobenzene [95-50-1] (Vol. 73; 1999)
*trans*-1,4-Dichlorobutene [110-57-6] (Vol. 15, Suppl. 7, Vol. 71; 1999)
2,6-Dichloro-para-phenylenediamine [609-20-1] (Vol. 39, Suppl. 7; 1987)
1,2-Dichloropropane [78-87-5] (Vol. 41, Suppl. 7, Vol. 71; 1999)
Dieldrin [60-57-1] (Vol. 5, Suppl. 7; 1987)
Di(2-ethylhexyl) adipate [103-23-1] (Vol. 29, Suppl. 7; 1987)
Dihydroxymethylfuratrizine [794-93-4] (Vol. 24, Suppl. 7; 1987)
Dimethoxane [828-00-2] (Vol. 15, Suppl. 7; 1987)
3,3’-Dimethoxybenzidine-4,4’-diisocyanate [91-93-0] (Vol. 39, Suppl. 7; 1987)
para-Dimethylaminoazobenzenediazo sodium sulfonate [140-56-7] (Vol. 8, Suppl. 7; 1987)
4,4’-Dimethylangelicin [22975-76-4] plus ultraviolet A radiation (Suppl. 7; 1987)
4,5’-Dimethylangelicin [4063-41-6] plus ultraviolet A radiation (Suppl. 7; 1987)
N,N-Dimethylaniline [121-69-7] (Vol. 57; 1993)
Dimethylformamide [540-73-8] (Vol. 47; Vol. 71; 1999)
1,4-Dimethylphenanthrene [22349-59-3] (Vol. 32, Suppl. 7; 1987)
1,3-Dinitropyrene [75321-20-9] (Vol. 46; 1989)
3,5-Dinitrotoluene [618-85-9] (Vol. 65; 1996)
Dinitrosopentamethylenetetramine [101-25-7] (Vol. 11, Suppl. 7; 1987)
2,4’-Diphenyldiamine [492-17-1] (Vol. 16, Suppl. 7; 1987)
Disperse Yellow 3 [2832-40-8] (Vol. 48; 1990)
Disulfiram [97-77-8] (Vol. 12, Suppl. 7; 1987)
Dithranol [1143-38-0] (Vol. 13; Suppl. 7; 1987)
Doxefazepam [40762-15-0] (Vol. 66; 1996)
Droloxifene [82413-20-5] (Vol. 66; 1996)
Dulcin [150-69-6] (Vol. 12, Suppl. 7; 1987)
Endrin [72-20-8] (Vol. 5, Suppl. 7; 1987)
Eosin [15086-94-9] (Vol. 15, Suppl. 7; 1987)

Estazolam [29975-16-4] (Vol. 66; 1996)

Ethionamide [536-33-4] (Vol. 13, Suppl. 7; 1987)

Ethylene [74-85-1] (Vol. 60; 1994)

Ethylene sulfide [420-12-2] (Vol. 11, Suppl. 7; 1987)

2-Ethylhexyl acrylate [103-11-7] (Vol. 60; 1994)

Ethyl selenac [5456-28-0] (Vol. 12, Suppl. 7; 1987)

Ethyl tellurac [20941-65-5] (Vol. 12, Suppl. 7; 1987)

Eugenol [97-53-0] (Vol. 36, Suppl. 7; 1987)

Evans blue [314-13-6] (Vol. 8, Suppl. 7; 1987)

Fast Green FCF [2353-45-9] (Vol. 16, Suppl. 7; 1987)


Ferbam [14484-64-1] (Vol. 12, Suppl. 7; 1987)

Ferric oxide [1309-37-1] (Vol. 1, Suppl. 7; 1987)

Fluometuron [2164-17-2] (Vol. 30, Suppl. 7; 1987)

Fluoranthene [206-44-0] (Vol. 32, Suppl. 7; 1987)

Fluorene [86-73-7] (Vol. 32, Suppl. 7; 1987)

Fluorescent lighting (Vol. 55; 1992)

Fluorides (inorganic, used in drinking-water) (Vol. 27, Suppl. 7; 1987)

5-Fluorouracil [51-21-8] (Vol. 26, Suppl. 7; 1987)

Foreign bodies, implanted in tissues (Vol. 74; 1999)

Metallic chromium or titanium, cobalt-based, chromium-based and titanium-based alloys, stainless steel and depleted uranium

Furazolidone [67-45-8] (Vol. 31, Suppl. 7; 1987)

Furfural [98-01-1] (Vol. 63; 1995)
Gemfibrozil [25812-30-0] (Vol. 66; 1996)
Glass filaments (Vol. 43; 1988)
Glycidyl oleate [5431-33-4] (Vol. 11, Suppl. 7; 1987)
Glycidyl stearate [7460-84-6] (Vol. 11, Suppl. 7; 1987)
Guinea Green B [4680-78-8] (Vol. 16, Suppl. 7; 1987)
Gyromitrin [16568-02-8] (Vol. 31, Suppl. 7; 1987)
Haematite [1317-60-8] (Vol. 1, Suppl. 7; 1987)
HC Blue No. 2 [33229-34-4] (Vol. 57; 1993)
HC Red No. 3 [2871-01-4] (Vol. 57; 1993)
HC Yellow No. 4 [59820-43-8] (Vol. 57; 1993)
Hepatitis D virus (Vol. 59; 1994)
Hexachlorobutadiene [87-68-3] (Vol. 73; 1999)
Hexachlorophene [70-30-4] (Vol. 20, Suppl. 7; 1987)
Human T-cell lymphotropic virus type II (Vol. 67; 1996)
Hycanthone mesylate [23255-93-8] (Vol. 13, Suppl. 7; 1987)
Hydralazine [86-54-4] (Vol. 24, Suppl. 7; 1987)
Hydrochloric acid [7647-01-0] (Vol. 54; 1992)
Hydrochlorothiazide [58-93-5] (Vol. 50; 1990)
4-Hydroxyazobenzene [1689-82-3] (Vol. 8, Suppl. 7; 1987)
8-Hydroxyquinoline [148-24-3] (Vol. 13, Suppl. 7; 1987)
Hydroxysenkirkine [26782-43-4] (Vol. 10, Suppl. 7; 1987)
Hypochlorite salts (Vol. 52; 1991)
Iron sorbitol-citric acid complex [1338-16-5] (Vol. 2, Suppl. 7; 1987)
Isatidine [15503-86-3] (Vol. 10, Suppl. 7; 1987)
Isonicotinic acid hydrazide (isoniazid) [54-85-3] (Vol. 4, Suppl. 7; 1987)
Isophosphamide [3778-73-2] (Vol. 26, Suppl. 7; 1987)
Isopropanol [67-63-0] (Vol. 15, Suppl. 7, Vol. 71; 1999)
Isopropyl oils (Vol. 15, Suppl. 7, Vol. 71; 1999)
Isosafrole [120-58-1] (Vol. 10, Suppl. 7; 1987)
Jacobine [6870-67-3] (Vol. 10, Suppl. 7; 1987)
Kaempferol [520-18-3] (Vol. 31, Suppl. 7; 1987)
Lead, organo [75-74-1], [78-00-2] (Vol. 23, Suppl. 7; 1987)
Light Green SF [5141-20-8] (Vol. 16, Suppl. 7; 1987)
Luteoskyrin [21884-44-6] (Vol. 10, Suppl. 7; 1987)
Malathion [121-75-5] (Vol. 30, Suppl. 7; 1987)
Maleic hydrazide [123-33-1] (Vol. 4, Suppl. 7; 1987)
Maneb [12427-38-2] (Vol. 12, Suppl. 7; 1987)
Mannomustine dihydrochloride [551-74-6] (Vol. 9, Suppl. 7; 1987)
Medphalan [13045-94-8] (Vol. 9, Suppl. 7; 1987)
Melamine [108-78-1] (Vol. 73; 1999)
6-Mercaptopurine [50-44-2] (Vol. 26, Suppl. 7; 1987)
Mercury [7439-97-6] and inorganic mercury compounds (Vol. 58; 1993)
Metabisulfites (Vol. 54; 1992)
Methotrexate [59-05-2] (Vol. 26, Suppl. 7; 1987)

5-Methylangelicin [73459-03-7] plus ultraviolet A radiation (Suppl. 7; 1987)


Methyl tert-butyl ether [1634-04-4] (Vol. 73; 1999)

Methyl carbamate [598-55-0] (Vol. 12, Suppl. 7; 1987)

Methyl chloride [74-87-3] (Vol. 41, Suppl. 7, Vol. 71; 1999)

1-Methylchrysene [3351-28-8] (Vol. 32, Suppl. 7; 1987)

2-Methylchrysene [3351-32-4] (Vol. 32, Suppl. 7; 1987)

3-Methylchrysene [3351-31-3] (Vol. 32, Suppl. 7; 1987)

4-Methylchrysene [3351-30-2] (Vol. 32, Suppl. 7; 1987)

6-Methylchrysene [1705-85-7] (Vol. 32, Suppl. 7; 1987)

N-Methyl-N,N,N',4-dinitrosoaniline [99-80-9] (Vol. 1, Suppl. 7; 1987)

4,4'-Methylene bis(N,N-dimethyl)benzenamine [101-61-1] (Vol. 27, Suppl. 7; 1987)


2-Methylfluoranthene [33543-31-6] (Vol. 32, Suppl. 7; 1987)

3-Methylfluoranthene [1706-01-0] (Vol. 32, Suppl. 7; 1987)

Methylglyoxal [78-98-8] (Vol. 51; 1991)


Methyl methacrylate [80-62-6] (Vol. 60; 1994)

N-Methylolacrylamide [90456-67-0] (Vol. 60; 1994)

Methyl parathion [298-00-0] (Vol. 30, Suppl. 7; 1987)

1-Methylphenanthrene [832-69-9] (Vol. 32, Suppl. 7; 1987)

7-Methylpyrido[3,4-c]psoralen [85878-63-3] (Vol. 40, Suppl. 7; 1987)

Methyl red [493-52-7] (Vol. 8, Suppl. 7; 1987)

Methyl selenac [144-34-3] (Vol. 12, Suppl. 7; 1987)
Modacrylic fibres (Vol. 19, Suppl. 7; 1987)


Musk ambrette [83-66-9] (Vol. 65; 1996)


1,5-Naphthalenediamine [2243-62-1] (Vol. 27, Suppl. 7; 1987)

1,5-Naphthalene diisocyanate [3173-72-6] (Vol. 19, Suppl. 7, Vol. 71; 1999)

1-Naphthylamine [134-32-7] (Vol. 4, Suppl. 7; 1987)

1-Naphthylthiourea (ANTU) [86-88-4] (Vol. 30, Suppl. 7; 1987)

Nithiazide [139-94-6] (Vol. 31, Suppl. 7; 1987)

5-Nitro-ortho-anisidine [99-59-2] (Vol. 27, Suppl. 7; 1987)

9-Nitroanthracene [602-60-8] (Vol. 33, Suppl. 7; 1987)


4-Nitrobiphenyl [92-93-3] (Vol. 4, Suppl. 7; 1987)

3-Nitrofluoranthene [892-21-7] (Vol. 33, Suppl. 7; 1987)

Nitrofural (Nitrofurazone) [59-87-0] (Vol. 50; 1990)

Nitrofurantoin [67-20-9] (Vol. 50; 1990)

1-Nitronaphthalene [86-57-7] (Vol. 46; 1989)


3-Nitroperylene [20589-63-3] (Vol. 46; 1989)

2-Nitropyrene [789-07-1] (Vol. 46; 1989)

N'-Nitrosoanabasine [37620-20-5] (Vol. 37, Suppl. 7; 1987)

N'-Nitrosoanatabine [71267-22-6] (Vol. 37, Suppl. 7; 1987)

N-Nitrosodiphenylamine [86-30-6] (Vol. 27, Suppl. 7; 1987)
N-Nitrosoguacine [55557-01-2] (Vol. 37, Suppl. 7; 1987)
N-Nitrosoguacoline [55557-02-3] (Vol. 37, Suppl. 7; 1987)
N-Nitrosohydroxyproline [30310-80-6] (Vol. 17, Suppl. 7; 1987)
3-(N-Nitrosomethylamino)propionaldehyde [85502-23-4] (Vol. 37, Suppl. 7; 1987)
4-(N-Nitrosomethylamino)-4-(3-pyridyl)-1-butanal (NNA) [64091-90-3] (Vol. 37, Suppl. 7; 1987)
N-Nitrosoproline [7519-36-0] (Vol. 17, Suppl. 7; 1987)
Nitrotoluenes [88-72-2; 99-08-1; 99-99-0] (Vol. 65; 1996)
5-Nitro-ortho-toluidine [99-55-8] (Vol. 48; 1990)
Nitrovin [804-36-4] (Vol. 31, Suppl. 7; 1987)
Nylon 6 [25038-54-4] (Vol. 19, Suppl. 7; 1987)
Oestradiol mustard [22966-79-6] (Vol. 9, Suppl. 7; 1987)
Oesthorchis felineus (infection with) (Vol. 61; 1994)
Orange I [523-44-4] (Vol. 8, Suppl. 7; 1987)
Orange G [1936-15-8] (Vol. 8, Suppl. 7; 1987)
Oxyphenbutazone [129-20-4] (Vol. 13, Suppl. 7; 1987)
Palygorskite (attapulgite) [12174-11-7] (short fibres, < 5 micrometers) (Vol. 68; 1997)
Paracetamol (Acetaminophen) [103-90-2] (Vol. 73; 1999)
Parasorbic acid [10048-32-5] (Vol. 10, Suppl. 7; 1987)
Parathion [56-38-2] (Vol. 30, Suppl. 7; 1987)
Patulin [149-29-1] (Vol. 40, Suppl. 7; 1987)
Penicillic acid [90-65-3] (Vol. 10, Suppl. 7; 1987)
Permethrin [52645-53-1] (Vol. 53; 1991)
Perylene [198-55-0] (Vol. 32, Suppl. 7; 1987)
Phenantherene [85-01-8] (Vol. 32, Suppl. 7; 1987)
Phenelzine sulfate [156-51-4] (Vol. 24, Suppl. 7; 1987)
Phenicarbazide [103-03-7] (Vol. 12, Suppl. 7; 1987)
Phenylbutazone [50-33-9] (Vol. 13, Suppl. 7; 1987)
meta-Phenylenediamine [108-45-2] (Vol. 16, Suppl. 7; 1987)
para-Phenylenediamine [106-50-3] (Vol. 16, Suppl. 7; 1987)
N-Phenyl-2-naphthylamine [135-88-6] (Vol. 16, Suppl. 7; 1987)
ortho-Phenylphenol [90-43-7] (Vol. 73; 1999)
Picrotop [1918-02-1] (Vol. 53; 1991)
Piperonyl butoxide [51-03-6] (Vol. 30, Suppl. 7; 1987)
Polyacrylic acid [9003-01-4] (Vol. 19, Suppl. 7; 1987)

Polychlorinated dibenzo-para-dioxins (other than 2,3,7,8-tetrachlorodibenzo-para-dioxin)(Vol. 69; 1997)

Polychlorinated dibenzofurans (Vol. 69; 1997)
Polychloroprene [9010-98-4] (Vol. 19, Suppl. 7; 1987)
Polyethylene [9002-88-4] (Vol. 19, Suppl. 7; 1987)
Polymethylene polyphenyl isocyanate [9016-87-9] (Vol. 19, Suppl.7; 1987)
Polymethyl methacrylate [9011-14-7] (Vol. 19, Suppl. 7; 1987)
Polypropylene [9003-07-0] (Vol. 19, Suppl. 7; 1987)
Polystyrene [9003-53-6] (Vol. 19, Suppl. 7; 1987)
Polytetrafluoroethylene [9002-84-0] (Vol. 19, Suppl. 7; 1987)
Polyurethane foams [9009-54-5] (Vol. 19, Suppl. 7; 1987)
Polyvinyl acetate [9003-20-7] (Vol. 19, Suppl. 7; 1987)
Polyvinyl alcohol [9002-89-5] (Vol. 19, Suppl. 7; 1987)

Ponceau SX [4548-53-2] (Vol. 8, Suppl. 7; 1987)

Potassium bis(2-hydroxyethyl)dithiocarbamate [23746-34-1] (Vol.12, Suppl. 7; 1987)

Prazepam [2955-38-6] (Vol. 66; 1996)

Prednimustine [29069-24-7] (Vol. 50; 1990)

Prednisone [53-03-2] (Vol. 26, Suppl. 7; 1987)

Proflavine salts (Vol. 24, Suppl. 7; 1987)

Pronetalol hydrochloride [51-02-5] (Vol. 13, Suppl. 7; 1987)

Propham [122-42-9] (Vol. 12, Suppl. 7; 1987)

\( n \)-Propyl carbamate [627-12-3] (Vol. 12, Suppl. 7; 1987)

Propylene [115-07-1] (Vol. 60; 1994)

Ptaquiloside [87625-62-5] (Vol. 40, Suppl. 7; 1987)

Pyrene [129-00-0] (Vol. 32, Suppl. 7; 1987)

Pyrido[3,4-c]psoralen [85878-62-2] (Vol. 40, Suppl. 7;1987)

Pyrimethamine [58-14-0] (Vol. 13, Suppl. 7; 1987)


Quintozene (Pentachloronitrobenzene) [82-68-8] (Vol. 5, Suppl. 7; 1987)

Reserpine [50-55-5] (Vol. 24, Suppl. 7; 1987)


Retrorsine [480-54-6] (Vol. 10, Suppl. 7; 1987)

Rhodamine B [81-88-9] (Vol. 16, Suppl. 7; 1987)


Riddelliine [23246-96-0] (Vol. 10, Suppl. 7; 1987)

Rifampicin [13292-46-1] (Vol. 24, Suppl. 7; 1987)
Ripazepam [26308-28-1] (Vol. 66; 1996)

Rugulosin [23537-16-8] (Vol. 40, Suppl. 7; 1987)

Saccharated iron oxide [8047-67-4] (Vol. 2, Suppl. 7; 1987)

Saccharin [81-07-2] and its salts (Vol. 73; 1999)
(NB: Overall evaluation downgraded from 2B to 3 with supporting evidence from other data relevant to carcinogenicity and its mechanisms)

Scarlet Red [85-83-6] (Vol. 8, Suppl. 7; 1987)

Schistosoma mansoni (infection with) (Vol. 61; 1994)

Selenium [7782-49-2] and selenium compounds (Vol. 9, Suppl. 7; 1987)

Semicarbazide hydrochloride [563-41-7] (Vol. 12, Suppl. 7; 1987)

Seneciphylline [480-81-9] (Vol. 10, Suppl. 7; 1987)

Senkirkine [2318-18-5] (Vol. 31, Suppl. 7; 1987)

Sepiolite [15501-74-3] (Vol. 68; 1997)

Shikimic acid [138-59-0] (Vol. 40, Suppl. 7; 1987)

Silica [7631-86-9], amorphous (Vol. 68; 1997)

Simazine [122-34-9] (Vol. 73; 1999)

Sodium chlorite [7758-19-2] (Vol. 52; 1991)

Sodium diethyldithiocarbamate [148-18-5] (Vol. 12, Suppl. 7; 1987)

Spironolactone [52-01-7] (Vol. 24, Suppl. 7; 1987)

Styrene-acrylonitrile copolymers [9003-54-7] (Vol. 19, Suppl. 7; 1987)

Styrene-butadiene copolymers [9003-55-8] (Vol. 19, Suppl. 7; 1987)

Succinic anhydride [108-30-5] (Vol. 15, Suppl. 7; 1987)

Sudan I [842-07-9] (Vol. 8, Suppl. 7; 1987)

Sudan II [3118-97-6] (Vol. 8, Suppl. 7; 1987)

Sudan III [85-86-9] (Vol. 8, Suppl. 7; 1987)

Sudan Brown RR [6416-57-5] (Vol. 8, Suppl. 7; 1987)
Sulfafurazole (Sulfisoxazole) [127-69-5] (Vol. 24, Suppl. 7; 1987)

Sulfamethoxazole [723-46-6] (Vol. 24, Suppl. 7; 1987)

Sulfites (Vol. 54; 1992)

Sulfur dioxide [7446-09-5] (Vol. 54; 1992)

Sunset Yellow FCF [2783-94-0] (Vol. 8, Suppl. 7; 1987)

Surgical implants (Vol. 74; 1999)
Orthopaedic implants and devices, of complex composition
Cardiac pacemakers
Dental materials
Ceramic materials
Surgical implants, female breast reconstruction, silicone (Vol. 74; 1999)

Symphytine [22571-95-5] (Vol. 31, Suppl. 7; 1987)

Talc [14807-96-6], not containing asbestiform fibres (Vol. 42, Suppl. 7; 1987)

Tannic acid [1401-55-4] and tannins (Vol. 10, Suppl. 7; 1987)


2,2',5,5'-Tetrachlorobenzidine [15721-02-5] (Vol. 27, Suppl. 7; 1987)

1,1,1,2-Tetrachloroethane [630-20-6] (Vol. 41, Suppl. 7, Vol. 71; 1999)

1,1,2,2-Tetrachloroethane [79-34-5] (Vol. 20, Suppl. 7, Vol. 71; 1999)

Tetrachlorvinphos [22248-79-9] (Vol. 30, Suppl. 7; 1987)

Tetrakis(hydroxymethyl)phosphonium salts (Vol. 48, Vol. 71; 1999)

Theobromine [83-67-0] (Vol. 51; 1991)

Theophylline [58-55-9] (Vol. 51; 1991)

Thiouracil [141-90-2] (Vol. 7, Suppl. 7; 1987)

Thiram [137-26-8] (Vol. 53; 1991)


Toremifene [89778-26-7] (Vol. 66; 1996)
Toxins derived from *Fusarium sporotrichioides* (Vol. 56; 1993)

Trichlorfon [52-68-6] (Vol. 30, Suppl. 7; 1987)

Trichloroacetic acid [76-03-9] (Vol. 63; 1995)


1,1,1-Trichloroethane [71-55-6] (Vol. 20, Suppl. 7, Vol. 71; 1999)

1,1,2-Trichloroethane [79-00-5] (Vol. 52, Vol. 71; 1999)


Trifluralin [1582-09-8] (Vol. 53; 1991)

4,4',6-Trimethylangelicin [90370-29-9] plus ultraviolet A radiation (Suppl. 7; 1987)

2,4,5-Trimethylaniline [137-17-7] (Vol. 27, Suppl. 7; 1987)

2,4,6-Trimethylaniline [88-05-1] (Vol. 27, Suppl. 7; 1987)

4,5',8-Trimethylpsoralen [3902-71-4] (Vol. 40, Suppl. 7; 1987)

2,4,6-Trinitrotoluene [118-96-7] (Vol. 65; 1996)

Triphenylene [217-59-4] (Vol. 32, Suppl. 7; 1987)

Tris(aziridinyl)-*para*-benzoquinone (Triaziquone) [68-76-8] (Vol. 9, Suppl. 7; 1987)

Tris(1-aziridinyl)phosphine oxide [545-55-1] (Vol. 9, Suppl. 7; 1987)

2,4,6-Tris(1-aziridinyl)-s-triazine [51-18-3] (Vol. 9, Suppl. 7; 1987)


1,2,3-Tris(chloromethoxy)propane [38571-73-2] (Vol. 15, Suppl. 7, Vol. 71; 1999)

Tris(2-methyl-1-aziridinyl)phosphine oxide [57-39-6] (Vol. 9, Suppl. 7; 1987)

Vat Yellow 4 [128-66-5] (Vol. 48; 1990)

Vinblastine sulfate [143-67-9] (Vol. 26, Suppl. 7; 1987)

Vincristine sulfate [2068-78-2] (Vol. 26, Suppl. 7; 1987)

Vinyl chloride-vinyl acetate copolymers [9003-22-9] (Vol. 19, Suppl. 7; 1987)

Vinylidene chloride-vinyl chloride copolymers [9011-06-7] (Vol.19, Suppl. 7; 1987)


N-Vinyl-2-pyrrolidone [88-12-0] (Vol. 19, Suppl. 7, Vol. 71; 1999)


Wollastonite [13983-17-0] (Vol. 68; 1997)


2,4-Xylidine [95-68-1] (Vol. 16, Suppl. 7; 1987)

2,5-Xylidine [95-78-3] (Vol. 16, Suppl. 7; 1987)

Yellow AB [85-84-7] (Vol. 8, Suppl. 7; 1987)

Yellow OB [131-79-3] (Vol. 8, Suppl. 7; 1987)

Zectran [315-18-4] (Vol. 12, Suppl. 7; 1987)

Zeolites [1318-02-1] other than erionite (clinoptilolite, phillipsite, mordenite, non-fibrous Japanese zeolite, synthetic zeolites) (Vol.68; 1997)

Zineb [12122-67-7] (Vol. 12, Suppl. 7; 1987)

Ziram [137-30-4] (Vol. 53; 1991)

**Mixtures**

Betel quid, without tobacco (Vol. 37, Suppl. 7; 1987)

Bitumens [8052-42-4], steam-refined, cracking-residue and air-refined (Vol. 35, Suppl. 7; 1987)

Crude oil [8002-05-9] (Vol. 45; 1989)

Diesel fuels, distillate (light) (Vol. 45; 1989)

Fuel oils, distillate (light) (Vol. 45; 1989)

Jet fuel (Vol. 45; 1989)

Mate (Vol. 51; 1991)

Mineral oils, highly-refined (Vol. 33, Suppl. 7; 1987)

Petroleum solvents (Vol. 47; 1989)

Printing inks (Vol. 65; 1996)
Terpene polychlorinates (Strobane®) [8001-50-1] (Vol. 5, Suppl. 7; 1987)

Exposure circumstances
Flat-glass and specialty glass (manufacture of) (Vol. 58; 1993)

Hair colouring products (personal use of) (Vol. 57; 1993)

Leather goods manufacture (Vol. 25, Suppl. 7; 1987)

Leather tanning and processing (Vol. 25, Suppl. 7; 1987)

Lumber and sawmill industries (including logging) (Vol. 25, Suppl. 7; 1987)

Paint manufacture (occupational exposure in) (Vol. 47; 1989)

Pulp and paper manufacture (Vol. 25, Suppl. 7; 1987)

Group 4: Probably not carcinogenic to humans (1)

APPENDIX J CONTINUED

NTP

Names and Synonyms of Carcinogens

Known To Be Human Carcinogens: This list includes agents, substances, mixtures, and medical treatments that are known to be carcinogenic in humans. To view individual profiles, the entire Summary Report on Carcinogens, 8th Edition or to order the printed copy visit the EHIS Home Page.

The NTP website can be reached at http://ntp-server.niehs.nih.gov .

<table>
<thead>
<tr>
<th>CASRN</th>
<th>NAME OR SYNONYM</th>
<th>KNOW</th>
<th>FIRST LISTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1402-68-2</td>
<td>Aflatoxins</td>
<td>K</td>
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<tr>
<td>92-67-14</td>
<td>4-Aminobiphenyl (4-Aminodiphenyl)</td>
<td>K</td>
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<tr>
<td>91-59-82</td>
<td>2-Aminonaphthalene (See 2-Naphthylamine)</td>
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<tr>
<td>CAS Number</td>
<td>Chemical Name</td>
<td>carcinogen (K)</td>
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<td>1332-21-4</td>
<td>Asbestos</td>
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<td>446-86-6</td>
<td>Azathioprine</td>
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<td>71-43-2</td>
<td>Benzene</td>
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<td>92-87-5</td>
<td>Benzidine</td>
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<td>542-88-1</td>
<td>Bis(chloromethyl) Ether</td>
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<td>55-98-1</td>
<td>Busulfan (See 1,4-Butanediol Dimethylsulfonate)</td>
<td>K</td>
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</tr>
<tr>
<td>55-98-1</td>
<td>1,4-Butanediol Dimethylsulfonate (Myleran®; Busulfan)</td>
<td>K</td>
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<tr>
<td>305-03-3</td>
<td>Chlorambucil</td>
<td>K</td>
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<tr>
<td>13909-09-6</td>
<td>(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea (MeCCNU)</td>
<td>K</td>
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<tr>
<td>107-30-2</td>
<td>Chloromethyl Methyl Ether</td>
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<td>8007-45-2</td>
<td>Coal Tar (under Soots, Tars, and Mineral Oils)</td>
<td>K</td>
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<tr>
<td>8001-58-9</td>
<td>Creosote (Coal) (under Soots, Tars, and Mineral Oils)</td>
<td>K</td>
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<td>8021-39-4</td>
<td>Creosote (Wood) (under Soots, Tars, and Mineral Oils)</td>
<td>K</td>
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<tr>
<td>50-18-0</td>
<td>Cyclophosphamide</td>
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<td>59865-13-3</td>
<td>Cyclosporin A (Cyclosporine A; Ciclosporin)</td>
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<td>56-53-1</td>
<td>Diethylstilbestrol</td>
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<td>66733-21-9</td>
<td>Erionite</td>
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<td>7758-97-6</td>
<td>Lead Chromate (under Chromium and Certain Chromium Compounds)</td>
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<td>13909-09-6</td>
<td>MeCCNU [See 1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea]</td>
<td>K</td>
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<tr>
<td>148-82-3</td>
<td>Melphalan</td>
<td>K</td>
<td>1</td>
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<tr>
<td>298-81-7</td>
<td>Methoxsalen (under Methoxsalen with Ultraviolet A Therapy (PUVA)) (methoxsalen not carcinogenic alone)</td>
<td>K</td>
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<td>505-60-2</td>
<td>Mustard Gas</td>
<td>K</td>
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<td>55-98-1</td>
<td>Myleran® (See 1,4-Butanediol Dimethylsulfonate)</td>
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<td>91-59-8</td>
<td>2-Naphthylamine (β-Naphthylamine; 2-Aminonaphthalene)</td>
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<td>7280-37-7</td>
<td>Piperazine Estrone Sulfate (under Conjugated Estrogens)</td>
<td>K</td>
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<tr>
<td>10043-92-2</td>
<td>Radon</td>
<td>K</td>
<td>7</td>
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<tr>
<td>16680-47-0</td>
<td>Sodium Equilin Sulfate (under Conjugated Estrogens)</td>
<td>K</td>
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<tr>
<td>438-67-5</td>
<td>Sodium Estrone Sulfate (under Conjugated Estrogens)</td>
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<tr>
<td>7789-06-2</td>
<td>Strontium Chromate (under Chromium and Certain Chromium Compounds)</td>
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<td>7795-27-8</td>
<td>Tars</td>
<td>K</td>
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<tr>
<td>52-24-4</td>
<td>Thiopeta [in 7th ARC as Tris(1-aziridinyl)phosphine Sulfide]</td>
<td>K</td>
<td>2c 8d</td>
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<tr>
<td>1314-20-1</td>
<td>Thorium Dioxide</td>
<td>K</td>
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<tr>
<td>52-24-4</td>
<td>Tris(1-aziridinyl)phosphine Sulfide (Thiopeta)</td>
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<td>2c 8d</td>
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<td>75-01-4</td>
<td>Vinyl Chloride</td>
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<tr>
<td>13530-65-9</td>
<td>Zinc Chromate (under Chromium and Certain Chromium)</td>
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</tbody>
</table>
**Names and Synonyms of Carcinogens**

**Reasonably Anticipated To Be Human Carcinogens:** This list includes agents, substances, and mixtures that are Reasonably Anticipated to Be Human Carcinogens. To view individual profiles, the entire Summary Report on Carcinogens, 8th Edition or to order the printed copy visit the EHI Home Page.

<table>
<thead>
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<th>CASRN</th>
<th>NAME OR SYNONYM</th>
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<td>75-07-0</td>
<td>Acetaldehyde</td>
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<td>53-96-3</td>
<td>2-Acetaminofluorene</td>
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<td>Acrylamide</td>
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<td>Acrylonitrile</td>
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<td>25316-40-9</td>
<td>Adriamycin® (Doxorubicin hydrochloride)</td>
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<td>117-79-3</td>
<td>2-Aminoanthraquinone</td>
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<td>97-56-3</td>
<td>o-Aminoazotoluene</td>
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<td>82-28-0</td>
<td>1-Amino-2-methylanthraquinone</td>
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<td>61-82-5</td>
<td>Amitrole</td>
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<td>134-29-2</td>
<td>p-Anisidine Hydrochloride</td>
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<td>Aroclor (under Polychlorinated Biphenyls)</td>
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<td>Aroclor® 1254 (under Polychlorinated Biphenyls)</td>
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<td>Aroclor® 1260 (under Polychlorinated Biphenyls)</td>
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<td>154-93-8</td>
<td>BCNU [See Bis(chloroethyl) Nitrosourea]</td>
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<td>56-55-3</td>
<td>Benz[a]anthracene (under Polycyclic Aromatic Hydrocarbons, 15 Listings)</td>
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<td>205-99-2</td>
<td>Benzo[b]fluoranthene (under Polycyclic Aromatic Hydrocarbons, 15 Listings)</td>
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<td>207-08-9</td>
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<td>Benzo[a]pyrene (under Polycyclic Aromatic Hydrocarbons, 15 Listings)</td>
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<td>Benzotrichloride</td>
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<td>Beryllium Aluminum Alloy (under Beryllium and Certain Beryllium Compounds)</td>
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<td>13327-32-7</td>
<td>Beryllium Hydroxide (under Beryllium and Certain Beryllium Compounds)</td>
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<td>1304-56-9</td>
<td>Beryllium Oxide (under Beryllium and Certain Beryllium Compounds)</td>
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<td>13598-15-7</td>
<td>Beryllium Phosphate (under Beryllium and Certain Beryllium Compounds)</td>
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<td>7787-56-6</td>
<td>Beryllium Sulfate Tetrahydrate (under Beryllium and Certain Beryllium Compounds)</td>
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<td>Beryllium Zinc Silicate (under Beryllium and Certain Beryllium Compounds)</td>
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<td>1302-52-9</td>
<td>Beryl Ore (under Beryllium and Certain Beryllium Compounds)</td>
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<td>154-93-8</td>
<td>Bis(chloroethyl) Nitrosourea (BCNU)</td>
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<td>Bis(2-ethylhexyl) Phthalate [See Di(2-ethylhexyl) phthalate]</td>
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<td>75-27-4</td>
<td>Bromodichloromethane</td>
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<td>106-99-4</td>
<td>L3-Butadiene</td>
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<td>25013-16-5</td>
<td>Butylated Hydroxyanisole (BHA)</td>
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<td>7440-43-9</td>
<td>Cadmium (under Cadmium and Certain Cadmium Compounds)</td>
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<td>10108-64-2</td>
<td>Cadmium Chloride (under Cadmium and Certain Cadmium Compounds)</td>
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<td>Cadmium Oxide (under Cadmium and Certain Cadmium Compounds)</td>
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<td>Cadmium Sulfate (under Cadmium and Certain Cadmium Compounds)</td>
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<td>1306-23-6</td>
<td>Cadmium Sulfide (under Cadmium and Certain Cadmium Compounds)</td>
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<td>56-23-5</td>
<td>Carbon Tetrachloride</td>
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<td>13010-47-4</td>
<td>CCNU [See 1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea]</td>
<td>R</td>
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<td>143-50-4</td>
<td>Chlordecone (see Kepone®)</td>
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<td>115-28-6</td>
<td>Chlorentic Acid</td>
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<td>108147-26-2</td>
<td>Chlorinated Paraffins (C12, 60% Chlorine)</td>
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<td>1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)</td>
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<td>67-66-3</td>
<td>Chloroform</td>
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<td>563-47-3</td>
<td>3-Chloro-2-methylpropene</td>
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<td>95-83-4</td>
<td>Chloro-o-phenylenediamine</td>
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<td>95-69-2</td>
<td>p-Chloro-o-toluidine</td>
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<td>3165-93-3</td>
<td>p-Chloro-o-toluidine Hydrochloride</td>
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<td>54749-90-5</td>
<td>Chlorozotocin</td>
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<td>C.I. Basic Red 9 Monohydrochloride</td>
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<td>15663-27-1</td>
<td>Cisplatin</td>
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<td>120-71-8</td>
<td>p-Cresidine</td>
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<td>14464-46-1</td>
<td>Cristobalite [under Silica, Crystalline (Respirable Size)]</td>
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<td>135-20-6</td>
<td>Cupferron</td>
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<td>117-10-2</td>
<td>Danthron (1,8-Dihydroxyanthraquinone)</td>
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<td>50-29-3</td>
<td>DDT (Dichlorodiphenyltrichloroethane)</td>
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<td>13654-09-6</td>
<td>Decabromobiphenyl (Under Polybrominated Biphenyls)</td>
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<td>117-81-7</td>
<td>DEHP [See Di(2-ethylhexyl) Phthalate]</td>
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<td>55-18-5</td>
<td>DEN (See N-Nitrosodiethylamine)</td>
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<td>39156-41-7</td>
<td>2,4-Diaminoanisole Sulfate</td>
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<td>101-80-4</td>
<td>Diaminodiphenyl Ether (See 4,4-Oxydianiline)</td>
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<td>95-80-8</td>
<td>2,4-Diaminotoluene</td>
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<td>Dibenzo[a,h]acridine (under Polycyclic Aromatic Hydrocarbons, 15 Listings)</td>
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<td>Dibenzo[a,j]acridine (under Polycyclic Aromatic Hydrocarbons, 15 Listings)</td>
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<td>Dibenzo[a,h]anthracene (under Polycyclic Aromatic Hydrocarbons, 15 Listings)</td>
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<td>7H-Dibenzo[c,g]carbazole (under Polycyclic Aromatic Hydrocarbons)</td>
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<td>Dibenzo[a,e]pyrene (under Polycyclic Aromatic Hydrocarbons, 15 Listings)</td>
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<td>96-12-8</td>
<td>1,2-Dibromo-3-chloropropene</td>
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<td>106-93-4</td>
<td>1,2-Dibromoethane (Ethylene dibromide; EDB)</td>
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<td>106-46-7</td>
<td>1,4-Dichlorobenzene (p-Dichlorobenzene)</td>
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<td>91-94-13</td>
<td>3,3-Dichlorobenzidine</td>
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<td>3,3-Dichlorobenzidine Dihydrochloride</td>
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<td>Dichlorodiphenyltrichloroethane (See DDT)</td>
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<td>1,2-Dichloroethane (Ethylene Dichloride)</td>
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<td>Dichloromethane (Methylene Chloride)</td>
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<td>542-75-6</td>
<td>1,3-Dichloropropene (Technical Grade)</td>
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<td>1464-53-5</td>
<td>Diepoxybutane</td>
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<td>1,4-N,N-Diethyldithiocarbamic acid 2-chloroallyl ester (See Sulfallate)</td>
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<td>117-81-7</td>
<td>Di(2-ethylhexyl) Phthalate [DEHP; Bis(2-ethylhexyl phthalate)]</td>
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<td>55-18-5</td>
<td>Diethyl Nitrosamine (See N-Nitrosodiethylamine)</td>
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<td>64-67-5</td>
<td>Diethyl Sulfate</td>
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<td>Diglycidyl Resorcinol Ether</td>
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<td>117-10-2</td>
<td>1,8-Dihydroxyanthraquinone [See Danthron]</td>
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<td>119-90-4</td>
<td>3,3-Dimethoxybenzidine</td>
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<td>60-11-7</td>
<td>4-Dimethylaminoazobenzene</td>
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<td>Dimethylcarbamoyl Chloride</td>
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<td>1,1-Dimethylhydrazine (UDMH)</td>
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<td>62-75-9</td>
<td>Dimethyl Nitrosamine (See N-Nitrosodimethylamine)</td>
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<td>Dimethyl Sulfate</td>
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<td>Dimethylvinyl Chloride</td>
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<td>42397-64-8</td>
<td>1,6-Dinitropyrene</td>
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<td>123-91-1</td>
<td>1,4-Dioxane</td>
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<td>DMN (See N-Nitrosodimethylamine)</td>
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<td>CAS Number</td>
<td>Chemical Name</td>
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<td>759-73-9</td>
<td>N-ethyl-N-nitrosourea (N-Nitroso-N-ethylurea)</td>
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<tr>
<td>106-89-8</td>
<td>Epichlorohydrin</td>
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<td>50-28-2</td>
<td>Estradiol-17b (under Estrogens [Not Conjugated])</td>
<td>R</td>
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<td>53-16-7</td>
<td>Estrone (under Estrogens [Not Conjugated])</td>
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<td>57-63-6</td>
<td>Ethynylestradiol (under Estrogens [Not Conjugated])</td>
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<td>140-88-5</td>
<td>Ethyl Acrylate</td>
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<td>51-79-6</td>
<td>Ethyl Carbamate (See Urethane)</td>
<td>R</td>
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<tr>
<td>106-93-1</td>
<td>Ethylene Dibromide [See 1,2-Dibromoethane (EDB)]</td>
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<td>107-06-2</td>
<td>Ethylene Dichloride (See 1,2-Dichloroethane)</td>
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<td>75-21-8</td>
<td>Ethylene Oxide</td>
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<td>Ethylene Thiourea</td>
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<td>Ethyl Methanesulfonate</td>
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<td>759-73-9</td>
<td>N-Ethyl-N-nitrosourea (See N-Nitroso-N-ethylurea)</td>
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<td>67774-32-7</td>
<td>FireMaster BP-6 (under Polybrominated Biphenyls)</td>
<td>R</td>
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<td>67774-32-7</td>
<td>FireMaster FF-1 (Hexabromobiphenyl; under Polybrominated Biphenyls)</td>
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<td>50-00-0</td>
<td>Formaldehyde (gas)</td>
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<td>110-00-9</td>
<td>Furane</td>
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<td>Glasswool</td>
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<td>Glycidol</td>
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<td>Hexabromobiphenyl (FireMaster FF-1, Under Polybrominated Biphenyls)</td>
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<td>118-74-1</td>
<td>Hexachlorobenzene</td>
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<td>319-84-6</td>
<td>Hexachlorocyclohexane (under Lindane and Other Hexachlorocyclohexane Isomers)</td>
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<td>319-85-7</td>
<td>Hexachlorocyclohexane (under Lindane and Other Hexachlorocyclohexane Isomers)</td>
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<td>Hexachloroethane</td>
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<td>680-31-9</td>
<td>Hexamethylphosphoramide</td>
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<td>302-01-2</td>
<td>Hydrazine</td>
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<td>10034-93-2</td>
<td>Hydrazine Sulfate</td>
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<td>122-66-7</td>
<td>Hydrazobenzene</td>
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<td>193-39-5</td>
<td>Indeno[1,2,3-cd]pyrene (under Polycyclic Aromatic Hydrocarbons, 15 Listings)</td>
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<td>9004-66-4</td>
<td>Iron Dextran Complex</td>
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<td>37317-41-2</td>
<td>Kanechlor® 500 (under Polychlorinated Biphenyls)</td>
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<td>143-50-4</td>
<td>Kepone® (Chlordecone)</td>
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<td>301-04-2</td>
<td>Lead Acetate</td>
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<td>7446-27-7</td>
<td>Lead Phosphate</td>
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<td>Lindane (under Lindane and Other Hexachlorocyclohexane Isomers)</td>
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<td>101-14-4</td>
<td>MBOCA [See 4,4-Methylenebis(2-chloraniline)]</td>
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<td>72-33-3</td>
<td>Mestranol (under Estrogens [Not Conjugated])</td>
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<td>2-Methylaziridine (Propylenimine)</td>
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<td>2-Methylchrysene (under Polycyclic Aromatic Hydrocarbons, 15 Listings)</td>
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<td>4,4-Methylenebis(2-chloraniline) (MBOCA)</td>
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<td>4,4-Methylenedianiline</td>
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<td>13552-44-8</td>
<td>4,4-Methylenedianiline Dihydrochloride</td>
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<td>Methyl Methanesulfonate</td>
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<td>N-Methyl-N-nitro-N-nitrosoguanidine</td>
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<td>N-Methyl-N-nitrosourea (See N-Nitroso-N-methylurea)</td>
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<td>443-48-1</td>
<td>Metronidazole</td>
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<td>Michler’s Ketone [4,4-(Dimethylamino)benzophenone]</td>
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<td>2385-85-5</td>
<td>Mirex</td>
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<td>7440-02-4</td>
<td>Nickel (under Nickel and Certain Nickel Compounds)</td>
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<td>Nickel Acetate(under Nickel and Certain Nickel Compounds)</td>
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<td>Nickel Carbonate(under Nickel and Certain Nickel Compounds)</td>
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<td>Nickel Carbonyl(under Nickel and Certain Nickel Compounds)</td>
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<td>Nickel Hydroxide(under Nickel and Certain Nickel Compounds)</td>
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<td>1313-99-1</td>
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<td>Nitrolotriacetic Acid</td>
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<td>91-23-6</td>
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<td>55-86-7</td>
<td>Nitrogen Mustard Hydrochloride</td>
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<td>97-46-9</td>
<td>1-Nitropropane</td>
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<td>N-Nitroso-n-butyl-N-(4-hydroxybutyl)amine (under N-Nitrosodi-n-butylamine)</td>
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<td>N-Nitrosonomnicotine</td>
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<td>Norethisterone</td>
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<td>Oxymetholone</td>
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<td>PAHs (See Polycyclic Aromatic Hydrocarbons)</td>
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<td>PBBs (See Polybrominated Biphenyls)</td>
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<td>1336-36-3</td>
<td>PCBs (under Polychlorinated Biphenyls)</td>
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<td>Perchloroethylene (See Tetrachloroethylene)</td>
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<td>62-44-2</td>
<td>Phenacetin (See also Analgesic Mixtures Containing Phenacetin, p. 12)</td>
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<td>Phenazopyridine Hydrochloride</td>
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<td>Polycyclic Aromatic Hydrocarbons (PAHs)</td>
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<td>1,3-Propane Sultone</td>
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<td>57-57-8</td>
<td>b-Propiolactone</td>
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<td>75-56-9</td>
<td>Propylene Oxide</td>
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<td>75-55-8</td>
<td>Propylenimine (See 2-Methylaziridine)</td>
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<td>51-52-5</td>
<td>Propylthiouracil</td>
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<td>14808-60-7</td>
<td>Quartz [under Silica, Crystalline (Respirable Size)]</td>
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<td>Reserpine</td>
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<td>Saccharin</td>
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<td>94-59-7</td>
<td>Safrole</td>
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<td>Selenium Sulfide</td>
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<td>Silica, Crystalline (Respirable Size)</td>
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<td>Streptozotocin</td>
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<td>Sulfallate</td>
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<td>1746-01-6</td>
<td>2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)</td>
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<td>Tetrachloroethylene (Perchloroethylene)</td>
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<td>509-14-8</td>
<td>Tetranitromethane</td>
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<td>62-55-5</td>
<td>Thioacetamide</td>
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<td>Thiourea</td>
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<td>Toluene Diisocyanate</td>
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<td>o-Toluidine</td>
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<td>636-21-5</td>
<td>p-Toluidine Hydrochloride</td>
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<td>Toxaphene</td>
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<td>88-06-2</td>
<td>2,4,6-Trichlorophenol</td>
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<td>96-18-4</td>
<td>1,2,3-Trichloropropene</td>
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<tr>
<td>15468-32-3</td>
<td>Tridymite [under Silica, Crystalline (Respirable Size)]</td>
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<tr>
<td>126-72-7</td>
<td>Tris(2,3-dibromopropyl) Phosphate</td>
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<td>57-14-7</td>
<td>UDMH (See 1,1-Dimethylhydrazine)</td>
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<tr>
<td>51-79-6</td>
<td>Urethane (Urethan; Ethyl carbamate)</td>
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<tr>
<td>106-87-64</td>
<td>Vinyl-1-cyclohexene Diepoxide</td>
<td>R</td>
<td>7</td>
</tr>
</tbody>
</table>

*Known (K) = Known to be a Human Carcinogen*  
*RAHC (R) = Reasonably Anticipated to be a Human Carcinogen*  
*Numbers designate the number of the Report on Carcinogens when first listed.*
DELISTED SUBSTANCES

In this Table are several substances formerly listed in the NTP Report on Carcinogens. These chemicals are not present in the *Eighth Report on Carcinogens* because either no documented continued exposure of residents of the United States to these chemicals/substances exists (since they are no longer produced or used), or because there has been a revision in the rulings/findings as to the carcinogenic potential of these entries (due to new tests, etc.). The last Report on Carcinogens in which these chemicals/substances appeared, and to which therefore reference can be made for all information available, is also given in this Table.

<table>
<thead>
<tr>
<th>Substance Name</th>
<th>CASRN</th>
<th>Last Listing</th>
<th>Reason for Delisting</th>
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<tr>
<td>Aramite®</td>
<td>140-57-8</td>
<td>4th ARC (1985)</td>
<td>No U.S. residents exposed</td>
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<tr>
<td>N,N-Bis(2-chloroethyl)-2-naphthylamine (Chlornaphazin e)</td>
<td>494-03-1</td>
<td>4th ARC (1985)</td>
<td>No U.S. residents exposed</td>
</tr>
<tr>
<td>Chloramphenicol</td>
<td>56-75-7</td>
<td>1st ARC (1980)</td>
<td>Human data considered inadequate</td>
</tr>
<tr>
<td>Cycasin</td>
<td>14901-08-7</td>
<td>4th ARC (1985)</td>
<td>No U.S. residents exposed</td>
</tr>
<tr>
<td>Methyl Iodide</td>
<td>78-88-4</td>
<td>4th ARC (1985)</td>
<td>Re-evaluated by IARC; now considered &quot;equivocal&quot;</td>
</tr>
<tr>
<td><em>p-</em></td>
<td>156-10-5</td>
<td>5th</td>
<td>Insufficient</td>
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</tbody>
</table>

a ARC= Annual Report on Carcinogens

APPENDIX K

INDUSTRIAL TOXICOLOGY - OVERVIEW

Chemical Toxicology

Toxicology is the study of the nature and action of chemical poisons.

Toxicity is the ability of a chemical molecule or compound to produce injury once it reaches a susceptible site in or on the body.

Toxicity hazard is the probability that injury will occur considering the manner in which the substance is used.
Dose-Response Relationship

The potential toxicity (harmful action) inherent in a substance is exhibited only when that substance comes in contact with biological system. A chemical normally thought of as "harmless" may evoke a toxic response if added to a biological system sufficient amount. The toxic potency of a chemical is thus defined by the response that is produced in a biological system.

Routes of Entry into the Body

There are four main routes by which hazardous chemicals enter the body:

- **Inhalation**: Absorption through the respiratory tract. Most important in terms of severity.
- **Skin absorption or absorption through the mucous membranes**.
- **Ingestion**: Absorption through the digestive tract. Can occur through eating or smoking with contaminated hands or in contaminated work areas.
- **Injection**: Introduction of toxin into bloodstream; can occur by accidental needle stick or puncture of skin with a sharp object.

Exposure Limits as Related to Routes of Entry

Most exposure standards are based on the inhalation route of exposure. They are normally expressed in terms of parts per milli (ppm) or milligrams per cubic meter (mg/m) concentration in air.

The Occupational Safety and Health Administration (OSHA) has established Permissible Exposure Limits (PELs) and the American Conference of Governmental Industrial Hygienists (ACGIH) has established Threshold Limit Values (TLV's) for employee exposure limits. In many instances, the PEL and TLV are represented as the same number. In the instances where one is lower than the other, it is a prudent safety practice to maintain exposures at the lowest level achievable.

If a significant route of exposure for a substance is through skin contact, the TLV or PEL will have a "skin" notation. Examples: pesticides, carbon tetrachloride, cyanides, ethylenediamine and thallium.

Appendix K of this document lists PELs and TLV’s for many hazardous chemicals. For a more complete list, see the ACGIH publication Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices.” The latest editions lists both TLV's and PELs.

Types of Effects

**Acute poisoning** is characterized by rapid absorption of the substance when the exposure is sudden and severe. Normally, a single large exposure is involved. Examples are carbon monoxide or cyanide poisoning.

**Chronic poisoning** is characterized by prolonged or repeated exposures of a duration measured in days, months or years. Symptoms may not be immediately apparent. Examples are lead or mercury poisoning, or pesticide exposure.

**Local** refers to the site of action of an agent where the action takes place at the point or area of contact. The site may be skin, mucous membranes, the respiratory tract, gastrointestinal system, eyes, etc. Absorption does not necessarily occur. Examples are strong acids or alkalis.

**Systemic** refers to a site of action other than the point of contact and presupposes absorption has taken place. For example, an inhaled material may act on the liver. For example, inhaled benzene affects the bone marrow.

**Cumulative poisons** are characterized by materials that tend to build up in the body as a result of numerous chronic exposures. Their effects are not seen until a critical body burden is reached. Examples are heavy metals.

**Synergistic or potentiating** effects occur when two or more hazardous materials present at the same time have a resulting action greater than the effect predicted based on the individual substances. For example, workers exposed to benzene may show a din toxic effect in hematopoietic tissue and therefore be more susceptible to oxygen-displacing agents such as carbon monoxide.

Other Factors Affecting Toxicity

Rate of entry and route of exposure how fast the toxic dose is delivered and by what means.

Age - can effect the capacity to repair damaged tissue.
Previous exposure - can lead to tolerance, increased sensitivity, or make no difference.

State of health, medications, physical condition, and life style can affect the toxic response. Pre-existing disease can result increased sensitivity.

Environmental factors - temperature and pressure, for example, can affect exposure.

Host factors - genetic predisposition and the sex of the exposed individual.

Physical Class Affects on Toxicity

When considering the toxicity of gases and vapors, the solubility of the substance is a key factor. Highly soluble materials like ammonia irritate the upper respiratory tract. On the other hand, relatively insoluble materials like nitrogen dioxide penetrate deeper into the lung. Fat soluble materials, like pesticides, tend to have longer residence times in the body.

An aerosol is composed of solid or liquid particles of microscopic size dispersed in a gaseous medium. The toxic potential of an aerosol is only partially described by its concentration in milligrams per cubic meter (mg/m3). For a proper assessment of the toxic hazard, the size of the aerosol's particles is important. Particles above 1 micrometer tend to deposit in the upper respiratory tract. Particles less than 1 micrometer in diameter enter the lung. Very small particles (< 0.2 µm) are generally not deposited.

Physiological Classifications of Toxic Materials

Irritants are materials that cause inflammation of mucous membranes with which they come in contact. Inflammation of tissue results from concentration far below those needed to cause corrosion. Examples include:

- ammonia
- hydrogen chloride
- halogens
- alkaline dusts and mists
- hydrogen fluoride
- ozone
- phosgene
- nitrogen dioxide
- arsenic trichloride

Irritants can also cause changes in the mechanics of respiration and lung function. Examples include:

- sulfur dioxide
- formaldehyde
- sulfuric acid
- iodine

Long term exposure to irritants can result in increased mucous secretions and chronic bronchitis.

A primary irritant exerts no systemic toxic action because the products formed on the tissue of the respiratory tract are non-toxic because the irritant action is far in excess of any systemic toxic action. Example: hydrogen chloride.

A secondary irritant's effect on mucous membranes is over-shadowed by a systemic effect resulting from absorption. Examples include:

- hydrogen sulfide
- aromatic hydrocarbons

Exposure to a secondary irritant can result in pulmonary edema, hemorrhage, and tissue necrosis.

Corrosives are chemicals which may cause visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact. Examples include:

- sulfuric acid
- potassium hydroxide
- chromic acid
- sodium hydroxide

Asphyxiants have the ability to deprive tissue of oxygen.
Simple asphyxiants are inert gases that displace oxygen. Examples include:
  - nitrogen
  - nitrous oxide
  - carbon dioxide
  - hydrogen

Chemical asphyxiants render the body incapable of utilizing an adequate oxygen supply. They are toxic at very low concentration (few ppm). Examples include:
  - carbon monoxide
  - cyanides
  - hydrogen sulfide

Primary anesthetics have a depressant effect upon the central nervous system particularly the brain. Examples include:
  - halogenated hydrocarbons
  - alcohols

Hepatotoxic agents cause damage to the liver. Examples include:
  - carbon tetrachloride
  - nitrosamines
  - tetrachloroethane

Nephrotoxic agents cause damage to the kidneys. Examples include:

Neurotoxic agents damage the nervous system. The nervous system is especially sensitive to organometallic compounds and certain sulfide compounds. Examples include:
  - trialkyl tin compounds
  - organic phosphorus insecticides
  - tetraethyl lead
  - thallium

Hematopoletic (blood) system agents either directly affect blood cells or bone marrow. Examples include:
  - nitrites
  - aniline
  - toluidine
  - benzene

Pulmonary tissue (lungs) agents can be toxic, through other means than by immediate irritant action. Fibrotic changes can caused by free crystalline silica and asbestos. Other dusts can cause a restrictive disease called pneumoconiosis. Examples include:
  - coal dust
  - cotton dust
  - wood dust

A teratogen (embryo toxic or fetotoxic agent) is an agent which interferes with normal embryonic development without damage the mother or lethal effect on the fetus. Effects are not hereditary. Examples include:
  - lead
  - dibromo dichloropropane

A mutagen is a chemical agent which may be able to react with nucleophilic structures such as DNA. Mutations can occur on the gene level (gene mutations) when, for example, one nucleotide base-pair is change to another. Mutations can also occur on the chromosomal level (chromosomal mutations) when the number of chromosomal units or their morphological structure is altered. Examples of mutagens include most radioisotopes, barium permanganate and methyl isocyanate.

A sensitizer causes a substantial proportion of exposed people to develop an allergic reaction in normal tissue after repeat exposure to the chemical. The reaction may be as mild as a rash (contact dermatitis) or as serious as anaphylactic shock. Examples include:
• poison ivy
• chlorinated hydrocarbons
• amines

TARGET ORGAN EFFECTS

• nickel compounds
• chromium compounds
• formaldehyde
• toluene dusocyanate

The following is a target organ categorization of effects which may occur from exposure to hazardous chemicals, including examples of signs and symptoms and chemicals which have been found to cause such effects.

• **Hepatotoxins (liver)**
  Signs and symptoms: jaundice, liver enlargement
  Example chemicals: carbon tetrachloride, nitrosamines, chloroform, toluene, perchloroethylene, cresol, dimethylsulfate

• **Nephrotoxins (kidney)**
  Signs and symptoms: edema, proteinuria
  Example chemicals: halogenated hydrocarbons, uranium, chloroform, mercury, dimethyl sulfate

• **Neurotoxins (nervous system)**
  Signs and symptoms: narcosis, behavioral changes, decreased muscle coordination
  Example chemicals: mercury, carbon disulfide, benzene, carbon tetrachloride, lead, mercury, nitrobenzene

• **Hematopoietic (blood) system**
  Signs and symptoms: cyanosis, loss of consciousness.
  Example chemicals: carbon monoxide, cyanides, nitrobenzene, aniline, arsenic, benzene, toluene

• **Pulmonary (lung) system**
  Signs and symptoms: cough, tightness in chest, shortness of breath.
  Example chemicals: sulfide chromium, nickel, alcohol.
  silica asbestos, nitrogen dioxide, ozone, hydrogen

• **Reproductive system (mutations and teratogenesis)**
  Signs and symptoms: birth defects, sterility.
  Example chemicals: lead, dibromo dichloropropane.

• **Skin (dermal layer)**
  Signs and symptoms: defatting of skin, rashes, irritation.
  Example chemicals: ketones, chlorinated compounds, alcohols, nickel, phenol, trichloroethylene.

• **Eye or vision**
  Signs and symptoms: conjunctivitis, corneal damage.
  Example chemicals: organic solvents, acids, cresol, quinone, hydroquinone, benzyl chloride, butyl alcohol, bases.
Respirators are not typically utilized in Research Laboratories. Engineering controls including fume hoods and good work practices should be used to eliminate the need for respiratory protection.
Please contact the Environmental Health and Safety staff in Risk Management for information pertaining to your specific area at x3-3353.
APPENDIX M

Laboratory Exhaust Hood Annual Surveillance Data and Certificate

Fume hoods are surveyed annually by Environmental Health and Safety (EH&S) staff in Risk Management (RM). The survey consists of measuring the face velocity of the hood and using a smoke stick to visually check its containment effectiveness. If the hood passes both the face velocity and smoke containment tests, the hood certification label is updated. If the hood does not pass the survey and the problem is so severe that the fume hood is unsafe for use, then it is labeled with a "DO NOT USE" sign. If adjustments are necessary, it is not updated and the problem is sent to Facilities Management with a repair request.

Facilities Management or a designated contractor repairs the hood, resurveys, places the hood certification label on the hood and notifies EH&S staff. If it is a problem that relates to users (e.g. a
Investigator’s responsibility to get the problem corrected and contact the EH&S staff to resurvey the fume hood. It is the responsibility of anyone working in the laboratory to notify EH&S staff if a fume hood does not have a current certification date (not more than one year old).

The average face velocity criteria used for most hoods at Brown is 100 feet per minute. The hood face is divided into nine equal areas and face velocity is measured in the center of these equal areas. Each measurement must be within 20 percent of the accepted average face velocity criteria. The nine readings are averaged and the face velocity at the approximately 18” opened sash height is indicated on the survey label. The line that indicates the maximum safe operating sash height can be found on the certification sticker.

Once the face velocity measurements are completed, the containment tests are conducted on the hood with smoke sticks. The hood face is traversed with a smoke stick to observe the air flow patterns. No back flows which result in release of smoke from the hood are permitted. If problems exist, the hood is not updated and goes on the list of uncertified hoods with a description of what EH&S staff believes is causing the containment problem. All problems will be reported by EH&S staff to Facilities Management.

The physical condition is noted on the hood worksheet if there is a problem. If parts of the fume hood are missing, such as the air foil or side panels, this will be noted. Removal of air foils usually results in a hood with unacceptable containment.

Biological safety cabinets are surveyed by a contract made through the laboratory department. The EH&S staff recommends that biological safety cabinets be certified on an annual basis and whenever moved. It is the responsibility of the Chemical Hygiene Officer to see that they be done as required.

If there is any question about a fume hood’s operation, the EH&S staff should be called immediately at x3-1737 or x3-3353. When a new fume hood is installed, it is the responsibility of the Chemical Hygiene Officer to see that no hazardous substances are used in the hood until it is surveyed and labeled by EH&S staff or an approved contractor. If changes of any kind are made to the fume hood system, EH&S staff should be notified so a hood survey can be conducted.
APPENDIX N

Air Monitoring Results

Within 15 days of receiving air-monitoring results, Environmental Health and Safety (EH&S) staff in Risk Management (RM) shall notify the employee either individually or in writing.

All air monitoring results will be kept on file by the Departmental Chemical Hygiene Officer and also at in Risk Management. They are available for review upon request.
APPENDIX O

Recordkeeping Forms, Annual Audit Forms

NOTE: Insert forms as they are developed.
ACGIH -- The American Conference of Governmental Industrial Hygienists is a voluntary membership organization of professional industrial hygiene personnel in governmental or educational institutions. The ACGIH develops and publishes recommended occupational exposure limits each year called Threshold Limit Values (TLV's) for hundreds of chemicals, physical agents, and includes Biological Exposure Indices (BEI).

**Action Level** -- A concentration designated in 29 CFR part 1910 for a specific substance, calculated as an eight hour time-weight average, which initiates certain required activities such as exposure monitoring and medical surveillance.

**Acute** -- Severe, often dangerous exposure conditions in which relatively rapid changes occur. **Acute Exposure** -- An intense exposure over a relatively short period of time.

ANSI -- The American National Standards Institute is a voluntary membership organization (run with private funding) that develops national consensus standards for a wide variety of devices and procedures.

**Asphyxiant** -- A chemical (gas or vapor) that can cause death or unconsciousness by suffocation. Simple asphyxiants such as nitrogen, either use up or displace oxygen in the air. They become especially dangerous in confined or enclosed spaces. Chemical asphyxiants, such as carbon monoxide and hydrogen sulfide, interfere with the body's ability to absorb or transport oxygen to tissues.

**Autoclave** -- A device to expose items to steam at a high pressure in order to decontaminate the materials or render them sterile.

**Biohazard** -- Infectious agents that present a risk or potential risk to the health of humans or other animals, either directly through infection or indirectly through damage to the environment.

**Boiling Point** -- The temperature at which the vapor pressure of a liquid equals atmospheric pressure or at which the liquid changes to a vapor. The boiling point is usually expressed in degrees Fahrenheit. If a flammable material has a low boiling point, it indicates a special fire hazard.

**"C"** or **Ceiling** -- A description usually seen in connection with a published exposure limit. It refers to the concentration that should not be exceeded, even for an instant. It may be written as TLV-C or Threshold Limit Value ceiling (See also THRESHOLD LIMIT VALUE).

**Carcinogen** -- A substance that may cause cancer in animals or humans.

**C.A.S. Number** -- Identifies a particular chemical by the Chemical Abstracts Service, a service of the American Chemical Society that indexes and compiles abstracts of worldwide chemical literature called "Chemical Abstracts."

**Chemical Hygiene Officer** -- An employee who is designated by the employee and who is qualified by training and experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure.

**Chemical Hygiene Plan** -- A written program developed and implemented by the department which sets forth procedures, personal protective equipment and work practices that are capable of protecting students, instructors and other persons from the health hazards presented by the hazardous chemicals used in that particular workplace.

**Chronic exposure** -- A prolonged exposure occurring over a period of days, weeks, or years.

**Combustible** -- According to the DOT and NFPA, COMBUSTIBLE liquids are those having a flash point at or above 100°F.
under certain circumstances, and must be handled with caution. Substances such as wood, paper, etc., are termed "Ordinary Combustibles."

**Compressed Gas** -- A gas or mixture of gases that, in a container, will have an absolute pressure exceeding 40 psi at 70°F or 21.1°C. A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130°F or 54.4°C, regardless of the pressure at 70°F. A liquid having a vapor pressure exceeding 40 psi at 100°F or 37.8°C.

**Concentration** -- The relative amount of a material in combination with another material. For example, 5 parts (of acetone) per million (parts of air).

**Corrosive** -- A substance that, according to the DOT, causes visible destruction or permanent changes in human skin tissue at the site of contact or is highly corrosive to steel.

**Cutaneous/Dermal** -- Pertaining to or affecting the skin.

**Cytotoxin** -- A substance toxic to cells in culture, or to cells in an organism.

**Decomposition** -- The breakdown of a chemical or substance into different parts or simpler compounds. Decomposition can occur due to heat, chemical reaction, decay, etc.

**Designated Area** -- An area which may be used for work with "select carcinogens," reproductive toxins or substances which have a high degree of acute toxicity. This area may be the entire laboratory or an area under a device such as a laboratory hood.

**Dermatitis** -- An inflammation of the skin.

**Dilution Ventilation** -- See GENERAL VENTILATION.

**DOT** -- The United States Department of Transportation is the Federal agency that regulates the labeling and transportation of hazardous materials.

**Dyspnea** -- Shortness of breath, difficult or labored breathing.

**EPA** -- The Environmental Protection Agency is the governmental agency responsible for administration of laws to control and reduce pollution of air, water, and land systems

**EPA Number** -- The number assigned to chemicals regulated by the Environmental Protection Agency (EPA).

**Epidemiology** -- The study of disease in human populations. **Erythema** -- A reddening of the skin.

**Evaporation Rate** -- The rate at which a material is converted to vapor (evaporates) at a given temperature and pressure when compared to the evaporation rate of a given substance. Health and fire hazard evaluations of materials involve consideration of evaporation rates as one aspect of the evaluation.

**Explosive** -- A chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure or high temperature.

**Flammable Gas** -- A gas that, at an ambient temperature and pressure, forms a flammable mixture with air at a concentration of 1 percent by volume or less; or, a gas that, at an ambient temperature and pressure forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.

**Flammable Liquid** -- According to the DOT and NFPA a flammable liquid is one that has a flash point below 100°F. (See **FLASH POINT**).

**Flammable Solid** -- A solid, other than a blasting agent or explosive, that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently it creates a serious hazard.

**Flash Point** -- The lowest temperature at which a liquid gives off enough vapor to form an ignitable mixture and burn when a source of ignition (sparks, open flames, etc.) is present. Two tests are used to determine the flash point: open cup and closed cup. The test method is indicated on the MSDS after the flash point

**Fume** -- A solid particle that has condensed from the vapor state

**Gas** -- Chemical substances that exist in the gaseous state at room temperature.
mechanically induced fresh air movements to mix with and dilute contaminants in the workroom air. This is not the recommended type of ventilation to control contaminants that are highly toxic, when there may be corrosion problems from the contaminant, when the worker is close to where the contaminant is being generated, and where fire or explosion hazards are generated close to sources of ignition (See LOCAL EXHAUST VENTILATION).

**Grams per Kilogram (g/Kg)** -- This indicates the dose of a substance given to test animals in toxicity studies. For example, a dose may be 2 grams (of substance) per kilogram of body weight (of the experimental animal).

**Hazardous Chemicals** -- Any chemical for which there is significant evidence, that acute or chronic health effects may occur to exposed personnel. The term "health hazard" includes chemicals that are carcinogens, toxins, irritants, corrosives, sensitizers or other agents that can damage the lungs, skin, eyes or mucous membranes.

**Ignitability** -- A solid, liquid or compressed gas waste that has a flash point of less than 140°F. Ignitability material may be regulated by the EPA as a hazardous waste, as well.

**Incompatible** -- The term applied to two substances to indicate that one material cannot be mixed with the other without the possibility of a dangerous reaction.

**Ingestion** -- Taking a substance into the body through the mouth as food, drink, medicine, or unknowingly as on contaminated hands or cigarettes, etc.

**Inhalation** -- The breathing in of an airborne substance that may be in the form of gas, fumes, mists, vapors, dusts, or aerosols.

**Inhibitor** -- A substance that is added to another to prevent or slow down an unwanted reaction or change.

**Irritant** -- A substance that produces an irritation effect when it contacts skin, eyes, nose, or respiratory system.

**Laboratory** -- A facility where relatively small quantities of hazardous materials are used on a non-production basis.

**Laboratory Scale** -- Work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person.

**Laboratory-type Hood** -- A device constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of airborne contaminants into the laboratory.

**Laboratory Use of Hazardous Materials** -- The handling or use of chemicals in which the following conditions are met: (1) Chemical manipulations are carried out on a laboratory scale, (2) Multiple chemical procedures or chemicals are used, (3) The procedures involved are not part of a production process, (4) Protective laboratory practices and equipment are available and in common use to minimize the potential for personnel exposure to hazardous chemicals.

**Laminar Flow** -- Air flow in which the entire mass of air within a designated space moves with uniform velocity in a single direction along parallel flow lines with a minimum of mixing.

**Lethal Concentration50** -- The concentration of an air contaminant (LC50) that will kill 50 percent of the test animals in a group during a single exposure.

**Lethal Dos50** -- The dose of a substance or chemical that will (LD50) kill 50 percent of the test animals in a group within the first 30 days following exposure.

**Local Exhaust Ventilation** (Also known as exhaust ventilation.) -- A ventilation system that captures and removes air contaminants at the point they are being produced before they escape into the workroom air. The system consists of hoods, ductwork, a fan and possibly an air cleaning device. Advantages of local exhaust ventilation over general ventilation include: removing the contaminant rather than diluting it; less airflow making it a more economical system over the long run; and conservation or reclamation of valuable materials. However, the system must be properly designed with the correctly shaped and placed hoods, correctly sized fans and correctly connected ductwork.

**Lower Explosive Limit (LEL)** (Also known as Lower Flammable Limit-LFL) -- The lowest concentration of a substance that will produce a fire or flash when an ignition source (flame, spark, etc.) is present. It is expressed in percent of vapor or gas in the air by volume. Below the LEL or LFL, the air/contaminant mixture is theoretically too "lean" to burn (See also UEL).

**Melting Point** -- The temperature at which a solid changes to a liquid. A melting range any be given for mixtures.
MSHA -- The Mine Safety and Health Administration; a Federal agency that regulates the mining industry in the safety and health area.

Mutagen -- Anything that can cause a change (or mutation) in the genetic material of a living cell.

Narcosis -- Stupor or unconsciousness caused by exposure to a chemical.

NFPA -- The National Fire Protection Association is a voluntary membership organization whose aims are to promote and improve fire protection and prevention. NFPA has published 16 volumes of codes known as the National Fire Codes. Within these codes is Standard No.704, "Identification of the Fire Hazards of Materials." This is a system that rates the hazard of a material during a fire. These hazards are divided into health, flammability, and reactivity hazards and appear in a well-known diamond system using from zero through four to indicate severity of the hazard. Zero indicates no special hazard and four indicates severe hazard.

NIOSH -- The National Institute for Occupational Safety and Health is a Federal agency that among its various responsibilities trains occupational health and safety professionals, conducts research on health and safety concerns, and tests and certifies respirators for workplace use.

Occupational Safety and Health Administration (OSHA) -- A Federal agency under the Department of Labor that publishes and enforces safety and health regulations for most businesses and industries in the United States.

Odor Threshold -- The minimum concentration of a substance at which a majority of test subjects can detect and identify the substance's characteristic odor.

Oxidation -- The process of combining oxygen with some other substance or a chemical change in which an atom loses electrons.

Oxidizer -- Is a substance that gives up oxygen easily to stimulate combustion of organic material.

Oxygen Deficiency -- An atmosphere having less than the normal percentage of oxygen found in normal air. Normal air contains 21% oxygen at sea level.

Permissible Exposure Limit (PEL) -- An exposure limit that is published and enforced by OSHA as a legal standard. PEL may be either a time-weighted-average (TWA) exposure limit (8 hour), a 15-minute short term exposure limit (STEL), or a ceiling (C). The PELs are found in Tables Z-1, Z-2, or Z-3 of OSHA regulations 1910.1000. (See also TLV).

Personal Protective Equipment -- Any devices or clothing worn by the worker to protect against hazards in the environment. Examples are respirators, gloves, and chemical splash goggles.

Physical Hazard -- A chemical that has scientifically valid evidence proving it to be a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive.

Polymerization -- A chemical reaction in which two or more small molecules combine to form larger molecules that contain repeating structural units of the original molecules. A hazardous polymerization is the above reaction with an uncontrolled release of energy.

RAD -- The unit of absorbed dose equal to 100 ergs per gram or 0.01 joules per kilogram of absorbing material.

Reactivity -- A substance's susceptibility to undergoing a chemical reaction or change that may result in dangerous side effects, such as explosion, burning, and corrosive or toxic emissions. The conditions that cause the reaction, such as heat, other chemicals, and dropping, will usually be specified as "Conditions to Avoid" when a chemical's reactivity is discussed on a MSDS.

Reproductive Toxins -- Chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses.

Respirator -- A device which is designed to protect the wearer from inhaling harmful contaminants.

Respiratory Hazard -- A particular concentration of an airborne contaminant that, when it enters the body by way of the respiratory system or by being breathed into the lungs, results in some bodily function impairment.

Select carcinogen -- A chemical listed by the National Toxicology Program (NTP) as 'known to be carcinogenic' or by the International Agency for Research on Cancer (IARC) as a Group 1 carcinogen. Also included are chemicals or processes listed in either Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by NTP and that cause statistical significant tumor incidence in experimental animals in accordance with any of the following criteria:
10 mg/m³
• 2. After repeated skin application of less than 300 mg/kg of body weight per week
• 3. After oral dosages of less than 50 mg/kg of body weight per day

Sensitizer -- A substance that may cause no reaction in a person during initial exposures, but afterwards, further exposures will cause an allergic response to the substance.

Short Term Exposure Limit -- Represented as STEL or TLV-STEL, this is the maximum concentration to which workers can be exposed for a short period of time (15 minutes) for only four times throughout the day with at least one hour between exposures. Also, the daily TLV-TWA must not be exceeded.

"Skin" -- This designation sometimes appears alongside a TLV or PEL. It refers to the possibility of absorption of the particular chemical through the skin and eyes. Thus, protection of large surface areas of skin should be considered to prevent skin absorption so that the TLV is not invalidated.

Systemic -- Spread throughout the body; affecting many or all body systems or organs; not localized in one spot or area.

Teratogen -- An agent or substance that may cause physical defects in the developing embryo or fetus when a pregnant female is exposed to that substance.

Threshold Limit Value -- Airborne concentrations of substances devised by the ACGIH that represents conditions under which it is believed that nearly all workers may be exposed for a conventional 8-hour workday and a 40-hour work week, without adverse effect. TLV's are advisory exposure guidelines, not legal standards, that are based on evidence from industrial experience, animal studies, or human studies when they exist. There are three different types of TLV's: Time Weighted Average (TLV-TWA), Short Term Exposure Limit (TLV-STEL) and Ceiling (TLV-C). (See also PEL).

Time Weighted Average -- The average time, over a given work period (e.g. 8-hour workday) of a person's exposure to a chemical or an agent. The average is determined by sampling for the contaminant throughout the time period. Represented as TLV-TWA.

Toxicity -- The potential of a substance to exert a harmful effect on humans or animals and a description of the effect and the conditions or concentration under which the effect takes place.

Trade Name -- The commercial name or trademark by which a chemical is known. One chemical may have a variety of trade names depending on the manufacturers or distributors involved.

Unstable (Reactive) -- A chemical that, in its pure state or as commercially produced, will react vigorously in some hazardous way under shock conditions (i.e., dropping), certain temperatures, or pressures.

Upper Explosive Limit -- Also known as Upper Flammable Limit, is the highest concentration (expressed in percent of vapor or gas in the air by volume) of a substance that will burn or explode when an ignition source is present. Theoretically, above this limit the mixture is said to be too "rich" to support combustion. The difference between the LEL and the UEL constitutes the flammable range or explosive range of a substance. That is, if the LEL is 1ppm and the UEL is 5ppm, then the explosive range of the chemical is 1ppm to 5ppm. (See also LEL).

Vapor -- The gaseous state of substances which are normally in the liquid or solid state (at normal room temperature and pressure) Vapors evaporate into the air from liquids such as solvents. Solvents with low boiling points will evaporate.

Vapor Pressure -- The pressure that a solid or liquid exerts when it is in equilibrium with its vapor at a given temperature.

Water-reactive -- A chemical that reacts with water to release a gas that is either flammable or presents a health hazard.