STANDARD OPERATING PROCEDURE for WORKING WITH HAZARDOUS and PARTICULARLY HAZARDOUS CHEMICALS In CENTER 1100 LABORATORIES

This is a General Use /Reference Technical Work Document (TWD)

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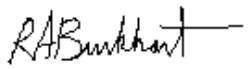

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1.0 PURPOSE AND SCOPE

This document makes use of information from many sources – including but not limited to the SNL ES&H Corporate Procedures. This document is not intended to provide all-inclusive requirements for chemical lab operations but should be used in concert with other Sandia Requirements documents such as ES&H Corporate Procedures. This is a General Use /Reference Procedure

The intention of this document is to ensure that routine chemical operations in Center 1100 are conducted in such a way as to minimize the risk to personnel, threat to the environment, and the generation of hazardous waste. This document is written to comply with the OSHA Laboratory Standard (29CFR1910-1450).

This document does not govern the use of the following:

- Explosives.
- Lasers.
- Radioactive materials
- Biohazardous materials.

It is the joint responsibility of managers and owners of chemical laboratories - considering the advice of the Industrial Hygienist assigned to Center 1100, and the Center 1100 ES&H Coordinator - to determine whether any specific chemical operation requires an activity-specific ES&H Technical Work Document (TWD).

2.0 OWNERSHIP

Center 1100 is responsible for this document. Send suggested changes or questions to the 1100 ES&H Coordinator.

3.0 RESPONSIBILITIES

- The safe handling of hazardous materials is an individual responsibility. Every Sandia employee, contractor, and visitor working with chemicals in Center 1100 must understand that chemical safety in the organization is an integral part of the job and not an optional function.
- During any operation, anyone may question the safety of any aspect of an activity and may at any time request the immediate cessation of the activity. Such requests should be made to the Department Manager, person conducting the operation at that time, or the 1100 ES&H Coordinator. The Department Manager or the 1100 ES&H Coordinator have the authority to make an initial evaluation and decision to stop or to continue the operation.
- If the operation is immediately dangerous to life or health, the individual questioning the safety of the operation is authorized to immediately terminate the operation in a manner that eliminates or reduces the hazard and does not introduce new hazards that are immediately dangerous to life or health.

NO JOB IS MORE IMPORTANT THAN YOUR HEALTH, YOUR SAFETY, AND THE PROTECTION OF OUR ENVIRONMENT.

3.1 Managers of Center 1100 laboratories shall ensure:

- the safe performance of experimental and support activities.
- all chemical operations within their departments and other departments that interface with chemical operations are critically examined for compliance with health and safety requirements.
- whether a particular operation needs a Controlled Activity ES&H TWD in addition to this SOP.

- that personnel follow requirements in the ES&H Corporate Procedures.
- that SNL personnel have read and affirmed their understanding of this SOP and SNL's Chemical Hygiene Plan (CHP), and have agreed to adhere to this SOP and SNL's CHP by signing the "Authorized Users' List" for the chemical lab(s) they will be working in.
- personnel who perform chemical laboratory operations in Center 1100 laboratories receive the appropriate health and safety-related training as specified in this SOP, and SNL's CHP.
- that new operations or hazards introduced into a laboratory are identified and evaluated.

Department Managers are encouraged to ask for assistance from the 1100 Customer Support Team Industrial Hygienist or the 1100 ES&H Coordinator in complying with the above requirements.

3.2 Laboratory personnel in Center 1100 laboratories shall:

- read the contents of and conduct laboratory operations according to this SOP and the SNL.
- read and understand the laboratory PHS and be familiar with hazards associated with the chemicals and other laboratory equipment with which they are working, as well as mitigations of these hazards.
- take all reasonable precautions to avoid endangering the environment and to prevent personal injury to themselves and to associates.
- know how to obtain a copy of the chemical inventory from the Chemical Inventory System (CIS) and individual material safety data sheet(s) (MSDS) for the chemicals they will work with.
- understand and follow approved safety and operational procedures and practices.
- take training as deemed appropriate by their Department Manager, as identified by the PHS.
- obtain special permits, if required and applicable, for operations.
- dispose of waste generated according to procedures in the ES&H Corporate Procedure, ESH100.2.ENV.22.
- inform management and appropriate ES&H personnel prior to using a hazardous chemical in an application for which a potential exposure exists that has not previously been evaluated.

4.0 TRAINING

4.1 Basic lab training

4.1.1 Personnel shall receive the following minimum training before working with hazardous chemicals:

- CHM100 Chemical Safety Training.
- CHM103 Site Specific Chemical Safety Training
- ENV112 Hazardous Waste and Environmental Management Training.

Note: CHM103 can be provided by the Manager of the specific chemical lab(s) (or their delegate). (This shall be provided at the time of the initial assignment, whenever a new physical hazard or health hazard is introduced into their work area and Members of the Workforce who have not previously been trained on the new hazard and prior to assignments involving new exposure situations).

4.2 Additional Training

In addition, other chemical operations training may be required as specified in the PHS documentation or required by the Manager or Lab Owner of the specific lab to supplement site-specific training. This additional training could include the following (this is not intended to be an all-inclusive list):

- BEA100 Beryllium Awareness Training.
- MED105HF Work involving Hydrofluoric Acid.
- MED105C Working with Cyanide or Cyanide containing chemicals.
- NANO100 Nanosafety Course
- PRS115 Cryogen Safety

5.0 CONTACTS AND DEFINITIONS

1100 ES&H Coordinator
(Bob Burkhart (1100) 844-6497 pager 283-1402)
1100 CST IH – Customer Support Team Industrial Hygienist assigned to Center 1100
(Brad Lackey 284-8082 pager 283-1389)
1100 CST EP – Customer Support Team Environmental Protection Liaison
(Linda Daillebout 844-2868 pager 951-6096)
1100 CST SE - Customer Support Team Safety Engineer assigned to Center 1100
(Steve Hale (4122) 845-8342 pager 283-1473)
PHS – Primary Hazard Screening
http://info.sandia.gov/esh/phs/
CIS – Chemical Information System
http://cis/
MSDS - Material Safety Data Sheet(s)
(located through the http://cis web site)
CHP – Chemical Hygiene Plan. ESH100.2.IH.4, Evaluate and Control Chemical Hazards

Useful Definitions:

Technical work documents (TWDs) – A formally approved document used to identify activity-level work hazards and their associated work control measures. TWDs are developed as part of implementation of the Integrated Safety Management System (ISMS). TWDs provide an administrative control to communicate to Members of the Workforce the activity-level work hazards and associated work controls during normal activities or foreseeable emergencies. The following are examples of TWDs used at SNL to control hazardous work:

- ES&H Standard Operating Procedures (ES&H SOPs).
- Health and Safety Plans (HASPs).
- Operating Procedures (OPs).
- Permits, such as Safe Work Permits (SWPs) and radiological work permits (RWPs).
- Pressure Safety Data Packages for pressure and vacuum systems.
- Plans, such as emergency response plans and facility- or building-specific evacuation/emergency plans.

See ESH100.2.GEN.3, Develop and Use Technical Work Documents, for more information on TWDs.

Particularly Hazardous Substance – Includes substances that are "select carcinogens," reproductive toxins", and substances that have a high degree of "acute toxicity".

Select Carcinogen – Any substance which meets one of the following criteria:

- Regulated by OSHA as a carcinogen.
- Listed under the category, "known to be carcinogens," in the Annual Report on carcinogens published by the National Toxicology Program (NTP)(latest edition).
- Listed under Group 1 ("carcinogenic to humans") by the International Agency for research on Cancer Monographs (IARC)(latest editions); or
- 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:
  - 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).
  - 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.

Reproductive toxins – Chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

Acute toxicity – Those substances defined in 29 CFR 1910.1450 as highly toxic or toxic which may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration.

6.0 HAZARD IDENTIFICATION

6.1 Prior to the start of any work, the manager of a laboratory shall assure that:

- Hazards are identified and analyzed and a PHS document has been completed and approved.
- Hazards are controlled to minimize adverse consequences and/or the likelihood of adverse consequences.
- Hazards identifications, analyses, and emergency plans are current, and all administrative and engineering controls are in place and operational.
- Members of the Workforce are knowledgeable of the hazards and hazard controls applicable to the activity in which they are involved.
- Identified risks are acceptable.

6.2 The hazards covered by this SOP

The hazards covered by this SOP include those likely to be encountered when personnel engage in the laboratory use of hazardous chemicals. **THIS INCLUDES PARTICULARLY HAZARDOUS SUBSTANCES.** Site-specific physical and health hazards shall be identified prior to commencing work with hazardous chemicals.

6.2.1 Physical Hazards

The following are terms used in MSDSs to describe the types of physical hazards:

- Combustible.
- Flammable.
- Compressed Gas.
- Explosive (not covered by this OP).
- Peroxide.
- Oxidizer.
- Pyrophoric.
- Unstable.
- Water Reactive.

6.2.3 Health Hazards

The following is a target organ categorization of effects which may occur, including examples of signs and symptoms of exposure to chemicals which have been found to cause such effects. Examples are presented to illustrate the range and diversity of effects and hazards found in the workplace, but are not intended to be all-inclusive:

a. Hepatotoxins Signs and Symptoms Chemicals	Chemicals which produce liver damage Jaundice, liver enlargement Carbon tetrachloride, nitrosamines
b. Nephrotoxins Signs and Symptoms Chemicals	Chemicals which produce kidney damage Edema, proteinuria Haolgenated hydrocarbons, uranium
C Neurotoxins Signs and symptoms Chemicals	Chemicals which produce their primary toxic effects on the nervous system Narcosis, behavioral changes, decrease in motor functions Mercury, carbon disulfide
d. Agents which act on the blood or hematopoietic system Signs and Symptoms Chemicals	Decrease hemoglobin function, deprive the body tissues of oxygen Cyanosis, loss of consciousness Carbon monoxide, cyanides
e. Agents which damage the lung Signs and Symptoms Chemicals	Chemicals which irritate or damage the pulmonary tissue Cough, tightness in chest, shortness of breath Silica, asbestos
f. Reproductive toxins	Chemicals which affect the reproductive capabilities, including chromosomal damage (mutations) and effects on fetuses

Signs and Symptoms Chemicals	(teratogenesis) Birth defects, sterility Lead, DBCP (1,2 Dibromo 3-Chloropropane)
g. Cutaneous hazards Signs and Symptoms Chemicals	Chemicals which affect the dermal layer of the body Defatting of the skin, rashes, irritation Ketones, chlorinated compounds
h. Eye hazards Signs and Symptoms Chemicals	Chemicals which affect the eye or visual capacity Conjunctivitis, corneal damage Organic solvents, acids

In addition, any chemical which meets the following definitions is considered a **health hazard**:

i. Ototoxic chemicals	ACGIH identified chemical substances that have the potential to produce hearing loss or other adverse effects on organs or nerves involved in hearing or balance. ACGIH ototoxic chemicals include: Toluene; Manganese; N-butanol; Lead. May require hearing conservation provisions of potentially exposed Members of the Workforce (See ES&H Manual Section 6E).
j. Beryllium	Exposure monitoring for beryllium and OSHA-regulated substances must be initiated if there is reason to believe exposure levels for that substance routinely exceeds the action level (or the OSHA PEL or ACGIH TLV in the absence of an action level). See ES&H Manual Section 6Z.
k. Irritant	A chemical, which is not corrosive, but which causes a reversible inflammatory effect on living tissue by chemical action at the site of contact.
l. Corrosive	A chemical that causes visible destruction of, or irreversible alterations in living tissue by chemical action at the site of contact.
m. Toxic	Specific LD50 or LC50 levels are associated with this term. See definition in the ES&H Manual glossary.
n. Highly Toxic	Specific LD50 or LC50 levels are associated with this term. See definition in the ES&H Manual glossary.
o. Sensitizer	A chemical that causes substantial proportion of exposed people or animals to develop an allergic reaction in the normal tissue after repeated exposure to the chemical.
p. Carcinogen	See definition in the ES&H Manual glossary.

7.0 SIGNS AND LABELS

7.1 Signs

Every chemical work area shall have a Sandia Workplace Hazard Awareness System (SWHAS) sign:

- on every entrance identifying specific hazards therein (see ESH100.2.IS.9, Apply Signs and Tags).
  - listing the names of individuals responsible for the laboratory.
  - containing current information.
- SNL personnel shall identify and post signs to designate areas where work with Particularly Hazardous Substances will be conducted (see "Particularly Hazardous Substances" section below).

Location signs should be posted for exits, safety showers, eyewash stations as well as other safety equipment. Warning signs should be posted at areas or equipment where special or unusual hazards exist.

7.2 Labels

- No chemicals shall be accepted from JIT or other suppliers if they are incorrectly labeled or "out-of date".
- Personnel shall not remove or deface labels on incoming containers of hazardous chemicals.
- Ensure that chemical containers have labels that adequately identify the contents of the container so associated hazards may be readily determined.
- Lab notebook references to the identity of samples is acceptable providing the notebook is readily available to the lab workers.
- Labels may be removed from containers after the container is empty and has been cleaned if required.
- Assure chemical has CIS barcode label. If not, register in CIS. See ESH100.2.IH.20, Maintain an Accurate Chemical and Biological Material Inventory.

8.0 CHEMICALS – PROCUREMENT, STORAGE, AND USE

8.1 PROCURING CHEMICALS

8.1.1 Before procuring any chemical, laboratory workers should:

- become familiar with the hazards associated with that material by consulting any of the following:
  a) Previous experiences with the chemical.
  b) MSDS.
  c) Other current references for hazardous materials.
  d) 1100 ES&H Coordinator or 1100 Customer Support Team Industrial Hygienist.
- attempt to use a less hazardous chemical as an alternative, if experimentally possible.
- ensure that appropriate storage and operational facilities and equipment are available.
- ensure the there is disposal path for the chemical (Contact Customer Support Environmental Protection Liaison).

8.1.2 When procuring chemicals:

- personnel should avoid ordering excess quantities. This is preferable to the possible result of disposal of excess quantities of chemicals at a later date.
- chemical quantities on hand should be limited to the quantities necessary for immediate needs.
- personnel should consider checking:
  a. CIS http://cis to see if the chemical could be obtained from other onsite chemical users.
  b. the Chemical Exchange program.

8.1.3 No chemicals shall be accepted from suppliers if they are incorrectly labeled or “out-of date”.

8.1.4 CIS Inventory

- Chemicals or gases procured thru Sandia’s JIT are:
  a) bar-coded and inventoried by the JIT contractor.
  b) delivered by the respective contractor personnel to the specified locations.
- Chemicals or gases procured from other sources shall be barcoded and inventoried into CIS by the requestor.
- Reminder, remove barcode from containers prior to disposal and ensure the chemical is removed from the CIS inventory.
- Leave barcode on gas cylinders that are returned to JIT Vender: however, delete the barcode from CIS inventory.

8.2 CHEMICAL STORAGE

8.2.1 All chemicals should be stored:

- To minimize risk to personnel and the environment.
- Outside of a fume hood. Fume hoods are not chemical storage areas.
- To avoid common storage of incompatible materials.
- Incompatible materials shall be stored separately, with the level of separation based on the severity of the incompatibility (e.g., acids and bases may be placed in separate secondary chemical containers on separate shelves). See Appendix (6) for a listing of storage incompatibilities.
- Away from exposure to direct sunlight.
- In closed containers that are in good condition.
- If flammable and requiring refrigeration, in an explosion-proof refrigerator.

8.2.2 **Stored chemicals should be examined at least annually** for expiration and signs of deterioration or degradation of container integrity. Some chemicals are subject to degradation with time (see Appendix (7)) and storage of these materials shall be regularly reviewed.

8.2.3 See Supplemental Information and Requirements for information on procurement, storage and use of:

- TAX-FREE ALCOHOL (non-denatured ethanol) (Section 9.1).
- PEROXIDEABLE CHEMICALS (Section 9.2).

8.2.4 Flammable Chemicals

- Flammable chemicals shall be stored in a flammable storage cabinet.
- Flammable gases should not be stored in non-vented cabinets.
- Do not place flammable storage cabinets near an egress route.
- Flammable storage cabinets are normally not vented, and vent bungs should be in place (where accumulating vapors pose problems, an industrial hygienist should be consulted to assist in defining suitable ventilation practices).
- Flammable solids shall be stored in a flammable storage cabinet that has been labeled "Flammable Solids".

8.2.5 Sensitive Chemicals

- "Sensitive Chemicals" are defined as chemicals which are most likely to be used for the clandestine manufacture of illicit drugs. These chemicals may be controlled drugs or precursors that could be illegally used for the manufacture of such drugs. See Appendix (1) for a partial list of sensitive chemicals.
- Sensitive chemicals shall be stored in a separate, locked storage cabinet.
- Labels should indicate the specific hazards of the contents and that the contents are "controlled."

8.3 WORKING WITH HAZARDOUS CHEMICALS

8.3.1 Personnel working with chemicals in Center 1100 labs should:

- Be familiar with the physical and health hazards and the signs and symptoms of exposure associated with the chemicals they use.
- Review associated MSDS documents.
- Review other reference material as needed to determine safe operational procedures.
- Contact the 1100 ES&H Coordinator or 1100 Customer Support Team Industrial Hygienist for additional information as needed.

8.3.2 Personnel shall follow these general procedures for their personal safety:

- Personnel shall understand and implement procedures for proper handling, storage, and disposal of hazardous chemicals and equipment they use.
- Personnel shall avoid underestimation of risk.
- Exposure shall be minimized, even for substances of no known significant hazard.
- Shoes that expose toes, or any portion of the foot, shall not be worn in chemical work areas.
- Lab coats and/or splash aprons are recommended when using common chemicals.
- Lab coats and/or splash aprons are **required** when using Particularly Hazardous Substances. This PPE shall remain in the laboratory.
- No one shall intentionally taste or smell chemicals.
- Mouth suction for pipetting shall not be used.
- Exposure to any chemical shall be minimized, since few laboratory chemicals are without hazards.
- Personnel should assume that
    a) any mixture will be as toxic as its most toxic component.
    b) all substances of unknown toxicity are presumed to be toxic.
- Skin contact with chemicals should be avoided.
- **Personnel should avoid**:
    a) working alone with hazardous materials.
    b) performing hazardous operations in a locked laboratory.
    c) performing hazardous operations after normal working hours.

8.3.3 Personnel shall follow these general procedures for protection of the environment:

- Chemical operations should be conducted in such a way as to minimize generation of hazardous waste.
- Chemicals shall be disposed of properly.
- Chemicals shall never be poured into sinks without first obtaining a discharge permit. See Section 12.4 for additional information.
- Chemicals shall never be allowed to evaporate as a means of disposal.
- Personnel should properly dispose of experimental samples unless required for archival purposes.

8.3.4 In addition, personnel shall follow these procedures:

- Chemicals shall not be stored in fume hoods unless required for inhalation safety or allowed by SNL ES&H Corporate Procedures.
- Personnel shall know how to get MSDS documents and CIS inventories.
- Lab coats shall be obtained from and laundered by the Sandia JIT laundry contractor.
- All chemicals should be placed in storage overnight.

8.3.5 Gases

- The use of compressed gases regarding pressure safety is governed by MN471000, Pressure Safety Manual. Section 9.3 below has information on use of glassware in pressure/vacuum applications.
- Gases also can present chemical hazards.
    a) Appendix 14 lists common gases and their associated hazards.
    b) Use of gases that are toxic or corrosive requires an ES&H TWD – contact the 1100 ES&H Coordinator and the 1100 Customer Support Team Industrial Hygienist.
    c) Flammable gases should not be stored in a flammables cabinet unless the cabinet is mechanically vented.

8.3.6 Synthesized, Formulated, or Modified Chemical Materials

- Unique chemical compounds or chemical mixtures that have been formulated on site may require an MSDS.
- All personnel preparing such materials shall also be aware of the requirements of the Toxic Substances Control Act (TSCA). Laboratory workers who synthesize, formulate, or modify chemical materials should contact the 1100 Customer Support Team Industrial Hygienist for further information.

8.3.7 Medical Consultation

Members of the Workforce have the opportunity to receive medical consultation if:

- They develop signs and symptoms associated with a possible exposure to a hazardous chemical.
- An event (spill, leak, explosion, or other occurrence) in the work area results in the likelihood of a hazardous exposure.
- Exposure monitoring reveals exposure levels that routinely exceed the action level (or the OSHA PEL or ACGIH TLV in the absence of an action level) for OSHA-regulated substances requiring medical surveillance.

8.4 ENGINEERED PROTECTIVE CONTROLS and PERSONAL PROTECTIVE EQUIPMENT (PPE)

The manager of the individual chemistry laboratories in Center 1100 shall request and/or make available - and employees shall use – appropriate PPE for eye, face, head and extremity protection and respirators, shields and other barriers or engineered controls whenever work hazards could cause harm if the protective equipment was not used. See Appendix 19 for further information on glove selection.

Personnel working with hazardous chemicals should:

- review the associated MSDS and/or contact the 1100 Customer Support Team Industrial Hygienist for aid in determining the appropriate type of PPE.
- inspect all PPE for faults or deterioration before each use.
- ensure appropriate local exhaust ventilation (LEV) is used for operations which might result in release of toxic chemical vapors, gases, or aerosols.

8.4.1 Local Exhaust Ventilation (LEV)

- For corporate guidance on laboratory ventilation and use of fume hoods, see ESH100.2.IH.15, Control Hazards Using Local Exhaust Ventilation and High Efficiency Particulate Air Filters.
- Fume hoods shall be used for experiments that could emit airborne contaminants from hazardous substances in any form (gases, dusts, mists, vapors, or fumes).
- To provide the proper protection, Fume Hoods must be operated in a prescribed fashion. Review Appendix 17 for Fume Hood basics use requirements.
- To minimize potential inhalation of hazardous chemicals when a potential exists for air dispersion, personnel shall work with these hazardous (i.e. chemicals) in a laboratory hood. This is especially important when the chemical is volatile or a fine powder.
- If there is a concern whether a potential exists for exposure at or above an exposure limit (Permissible Exposure Limit [PEL], Threshold Limit Value [TLV], action limit) and/or whether

respiratory protection is necessary, SNL personnel should contact the 1100 Customer Support Team Industrial Hygienist to arrange for a walk-through or an Exposure Assessment (EA).
- Personnel should only wear respirators if an exposure cannot be controlled through feasible engineering controls. Note: Respirator Training and Fit Testing are required prior to use.

8.4.2 PPE/Controls for DERMAL CONTACT Hazards
- If contact with chemicals can reasonably be anticipated, SNL personnel should review the associated material safety data sheet (MSDS) and/or contact the1100 Customer Support Team Industrial Hygienist to determine the appropriate type of equipment to be worn.
- Protective Gloves
  It is expected that MOW will limit intentional contact of the gloved hands with chemicals. This means that intentional immersion of gloves in liquids will be avoided. Use tweezers, tongs, or other implements to handle samples in chemicals.

NOTE: See Appendix 19 for additional guidance on selection of gloves for chemical use.

a) Glove types will depend on:
   - the performance characteristics of the glove material.
   - anticipated duration of contact with the chemical.
   - the properties of the chemical.
b) Gloves shall be
   - inspected before each use.
   - washed before removal, unless the gloves are disposable.
   - replaced periodically.
c) Personnel shall use additional personal protective equipment (PPE), such as laboratory aprons and gauntlets, if there is a possibility of large quantity splashes or spills of hazardous material.
d) Personnel shall remove gloves and wash areas of exposed skin before leaving a laboratory and returning to desk areas, and before eating, drinking, smoking, or applying cosmetics or medications.
e) SNL personnel shall use insulating gloves and/or tools (e.g., tongs) if a potential exists for dermal contact with temperature extremes (e.g., cryogenics, ovens, furnaces).

8.4.3 PPE/Controls for INGESTION Hazards

Personnel shall not:
- eat, drink, use tobacco products, chew gum, or apply cosmetics in areas where hazardous chemicals are present.
- store, handle, or consume food or beverages in chemical storage areas or refrigerators.
- use glassware or utensils with food that are also used for laboratory operations.
- Personnel should wash their hands before eating, drinking, using tobacco products, chewing gum, or applying cosmetics.

8.4.4 PPE/Controls for EYE PROTECTION
- All personnel present in chemical work areas when hazardous chemicals are in use shall use as appropriate:
  a) protective glasses (ANSI Z87.1A approved).
  b) goggles.
  c) face shields.
- Adequate quantities of plastic safety glasses or goggles should be conveniently available for visitors.
- If there is a potential for irritants or corrosive chemicals splashing in an operation, then splash-resistant safety goggles (i.e., with baffled vents) or face shields shall be worn.
- Whenever possible, contact lenses should not be worn in a chemical work area, but should be replaced by safety glasses. If this is not possible, unvented goggles should be used to cover the eyes.

8.4.5 EYE WASH/SAFETY SHOWER STATIONS
- Safety eyewash and/or safety shower stations are required when specified in MSDS documents For Center 1100 chemistry laboratories:
  a) Safety eyewash stations shall be flow tested on a weekly basis.
  b) Safety showers shall be flow tested at least every month.

c) Flow testing shall be documented using a tag such as Brady #76195 “Emergency Shower & Eye Wash Test Record”. In some instances a comparable method shall be used to collect compliance information. If the flow is not adequate, the lab owner shall ensure the eyewash/safety shower is repaired.

8.5 Working with PARTICULARLY HAZARDOUS SUBSTANCES

- When working with **lead**, (including elemental lead, all inorganic lead compounds, and organic lead soaps) and **cadmium** (including cadmium and cadmium compounds, in all forms) workers should contact the 1100 ES&H Coordinator and/or the 1100 Customer Support Team Industrial Hygienist for assistance in obtaining an IH survey of your operations for these OSHA regulated materials.
- When deciding to work with **Particularly Hazardous Substances**, lab personnel and management should consider the following:
  a) Quantities and concentrations of materials.
  b) Physical properties and chemical reactivity.
  c) Exposure Limits.
  d) Methods to lower potential exposure to these toxic chemicals.
  e) The number of persons who could be exposed.
  f) The worker’s reproductive capability if reproductive toxins are involved.
- Particularly Hazardous Substances include select carcinogens, reproductive toxins, and substances that have a high degree of acute toxicity.
  - select carcinogens - Any substance which meets one of the following criteria:
    - Regulated by OSHA as a carcinogen.
    - Listed under the category, "known to be carcinogens," in the Annual Report on carcinogens published by the National Toxicology Program (NTP)(latest edition).
    - Listed under Group 1 ("carcinogenic to humans") by the International Agency for research on Cancer Monographs (IARC)(latest editions); or
    - 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.
      c) After oral dosages of less than 50 mg/kg of body weight per day.
  - reproductive toxins - Chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).
  - acute toxicity - Those substances defined in 29 CFR 1910.1450 as highly toxic or toxic which may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration.
- Managers shall ensure that sufficient personnel protection is available to lab personnel for work with particularly hazardous substances. These could include:

  a) **PPE:** At a minimum, personnel shall wear a lab coat, safety glasses, and gloves.
  b) **Containment devices**: When feasible, containment devices such as laboratory hoods or glove boxes shall be used when work involves the use of particularly hazardous substances.
  c) **Procedures for safe removal of contaminated waste**: Waste from work with particularly hazardous substances shall be disposed of as hazardous waste.
  d) **Establishing a “Designated Area”**.
     - A designated area:
       a) may be a hood, glove box, portion of a laboratory, or an entire laboratory.
       b) shall be posted and its boundaries clearly identified.
       c) may be un-designated when the particularly hazardous substance is no longer in use and decontamination has occurred.
     - When potential exists for exposure to carcinogens, only authorized and instructed personnel are allowed to work in, or have access to Designated Area.
     - Other personnel working in the vicinity of the Designated Area shall be informed of the work involving particularly hazardous substances.

- A sign with the following terminology shall be placed at all locations where particularly hazardous substances are used (storage areas for particularly hazardous substances do not require this posting). Magnetic signs can be used to post fume hoods as designated areas. There signs are available from the 1100 ES&H Coordinator.

DESIGNATED AREA
FOR WORK WITH
PARTICULARLY HAZARDOUS SUBSTANCES
AREA MAY CONTAIN: 'SELECT CARCINOGENS',
REPRODUCTIVE TOXINS, OR SUBSTANCES WITH
A HIGH DEGREE OF ACUTE TOXICITY

- **An Activity-specific ES&H TWD** may be required when working with Particularly Hazardous Substances – contact the 1100 Customer Support Team Industrial Hygienist for specific requirements.

- **Decontamination procedures** for DESIGNATED AREAS that are no longer required include:
  a) Decontamination shall be commensurate with use and/or release of the particularly hazardous substance (i.e., decontamination is unnecessary if there has not been a release).
  b) Decontamination may involve removing the particularly hazardous substance from the area or cleaning contaminated surfaces.
  c) Surface cleaning should include the use of damp towels or other methods to minimize air dispersion of particularly hazardous substances.
  d) When feasible, SNL personnel should remove all visual contamination while wearing appropriate PPE (e.g., impervious gloves) during decontamination procedures.
  e) Request a review by Customer Support Team Industrial Hygienist for completeness of decontamination process.
- SNL personnel should contact the 1100 Customer Support Team Industrial Hygienist for assistance in defining procedures for working with particularly hazardous substances.

8.6 Working with Nanomaterials

- Personnel shall follow the requirements in ESH100.2.IH.16, Evaluate and Control Unbound Engineered Nanoscale Particles (UNP).

- When working with nanomaterials, workers shall contact the 1100 Customer Support Team Industrial Hygienist for assistance in obtaining an IH survey of your operations.

- When deciding to work with Nanomaterials, lab personnel and management should consider the following:
  - The hazardous properties of any precursors, intermediates, or waste as well as those of the resulting nanomaterial.
  - The higher reactivity of some UNP and treat them as potential sources of ignition, accelerants, and fuel that could result in fire or explosion.
  - Exposures to UNP may occur through inhalation, dermal contact, and ingestion.

9.0 SUPPLEMENTAL REQUIREMENTS and INFORMATION

9.1 TAX-FREE ALCOHOL (non-denatured ethanol) – PROCUREMENT, STORAGE, AND USE

The purchase and use of non-denatured ethanol has several requirements that lab personnel must adhere to in order to ensure SNL operates within the scope of the ATF's regulatory requirements.

Note: Sandia National Laboratories, as a Government agency, is in possession of a permit for the purchase of tax-free alcohol. The Bureau of Alcohol, Tobacco and Firearms, ATF, oversees the authorization of the permit and the oversight of the associated regulatory requirements.

9.1.1 When purchasing tax-free ethanol:

- Upon request by a Chemical Vender (company supplying non-denatured ethanol to SNL) for a copy of SNL's Federal tax-free alcohol permit, requestors shall contact the 1100 Customer Support Team Industrial Hygienist for assistance with obtaining a copy of the permit from the Legal Organization.

9.1.2 Requirements for use:

Tax-free alcohol (non-denatured ethanol) shall:

- Only be used for scientific research.
- Only be used for Government purposes.
- Not be used for human consumption.
- Be recorded in the CIS system.

9.1.3 Tax-free alcohol shall be stored:

- In it's original container until used.
- In a locked cabinet when not in use or during transportation.
- Per Fire Protection requirements for flammables.

9.2 PEROXIDEABLE CHEMICALS – PROPER STORAGE AND USE

Note: The provisions within this section contain strict requirements regarding the use of peroxideable chemicals due to the high potential for adverse effects from inappropriate use and/or storage thereof.
Note: Further information on shock-sensitive chemicals can be found in the DOE Safety & Health Bulletin (Appendix 18).

9.2.1 Under a variety of conditions, certain organic and inorganic chemical compounds used at SNL are capable of reacting with atmospheric oxygen to form peroxide compounds. Many of these peroxides are highly flammable and may explode if exposed to heat, mechanical shock, friction or light. Serious injury may result if one is exposed to these peroxides should a container rupture.

Common peroxide-forming chemicals can be queried in CIS. Some of these are found in Appendix (15).
Autopolymerizable Substances Reports.
Peroxideable Substances
Peroxideable Substances (Concentrated)

Report names in CIS are:
AUTO_POL – CHEMICALS THAT MAY AUTOPOLYMERIZE DUE TO PEROXIDE FORMATION
PEROXIDE – CHEMICALS THAT FORM EXPLOSIVE LEVELS OF PEROXIDES WITHOUT CONCENTRATION
PERO_CON – CHEMICALS THAT FORM EXPLOSIVE LEVELS OF PEROXIDES ON CONCENTRATION

9.2.3 While these are the most commonly encountered peroxide-forming chemicals, these lists are not all inclusive and do not contain all potential peroxide-forming compounds. Consequently, chemical users should consult individual MSDS documents to ensure they are aware of all chemical hazards.

9.2.4 Peroxide-forming chemicals have different inherent potentials for forming peroxides, as designated by chemical groups, and therefore some are potentially more hazardous than others. Users can contact the

1100 Customer Support Team Industrial Hygienist for guidance regarding the relative potential for peroxide formation.

9.2.5 Chemical owners and users shall be responsible for the safe use and storage of any chemical and especially peroxide-forming chemicals.

9.2.6 Chemical owners and users shall implement one or more of the following controls to minimize the formation of peroxides and to affect proper handling and storage:

- Purchase chemicals that contain an oxidation inhibitor whenever possible.
- Limit quantities to the minimum amount that will be needed within the expiration period of the chemical. A better price for a larger quantity should never be considered.
- Review the MSDS for the chemical to determine proper handling and storage conditions for the material.
- Store in appropriate location in the original container whenever possible and ensure the lid is always air-tight.
- Store away from heat and light.
- Label all containers with the following:
  a) the date the material was received.
  b) the shelf life of the chemical and the expiration date (if not already listed on the manufacturer's label).
  c) the date the container was opened.
- If tested for peroxide buildup, include such information on the label.
- Chemical owners/users shall be responsible for conducting the testing of peroxide levels.
- For those chemicals that form peroxides on concentration, mark and date the liquid level on the bottle, if practical, after each use. This will allow personnel to note whether there has been leakage or evaporation from the bottle during storage. Leakage or evaporation may lead to build-up of peroxide forming compounds.
- Use or dispose of the containers by the expiration date. If an expressed interest exists to retain the chemical beyond the expiration date, a measurement of peroxide levels using an oxidizer test strip shall be taken and documented. This information should be kept in the laboratory LON.
- Containers of peroxide chemicals shall be retested at frequencies sufficient to assure that the peroxide levels will not exceed 30 ppm during continued storage. Peroxide levels of 30 ppm or greater require the chemical to be disposed of immediately.

9.2.7 Safe retention dates for chemicals are noted in Appendix (15).

9.2.8 No container may be kept beyond 2 years of purchase even with monitoring of peroxide levels unless a *Justification of Retention* form (Attachment A) is completed and approved.

9.2.9 Possibly Out-of-date Material

- Chemical owners and users shall treat containers of peroxideable chemicals that meet one or more of the criteria listed below as potentially explosive:
  a) Two years beyond purchase date.
  b) Of unknown history.
  c) Show visible discoloration, crystallization or liquid stratification.
  d) Show visible rust, (e.g., older steel containers).

- If any of the above conditions exist, lab owners/chemical users shall:
  a) Not move or open any container that meets one or more of the above conditions.
  b) Take appropriate actions to isolate or secure access to such containers.
  c) Immediately contact the:
    - 1100 ES&H Coordinator.
    - 1100 Customer Support Environmental Protection Liaison (to arrange for an inspection and disposal of the container).

9.3 OTHER THAN AMBIENT PRESSURE GLASSWARE – CONSTRUCTION AND SAFE OPERATIONS

9.3.1 Glass is the material of choice for a variety of vacuum and pressure operations in any chemical laboratory because it is typically chemically inert and transparent – allowing viewing of chemical actions. While glass

generally performs well, its reliability cannot be taken for granted. Failure, though rare, is unpredictable and could result in:

- an explosion (if contained pressure is greater than outside pressure).
- an implosion (if outside pressure is greater than contained pressure).

The resulting glass fragments could:

- injure nearby personnel.
- cause a cut that requires stitches.
- irreparably damage eyesight.
- cause severe injury or death, if a glass sliver were to strike a major artery.

Glass apparatus including:

- vacuum lines,
- rotary evaporators,
- Schlenk ware,
- desiccators, and
- other glass lab ware

are routinely evacuated in chemistry laboratory operations. Additionally, certain glass apparatuses are regularly pressurized.

Since glass is a brittle material, the safety of lab personnel must be ensured by positive protective means. The purpose of this information is to alert workers to the nature of the hazard and to detail required and recommended protective measures. Contact 1100 Customer Support Team Safety Engineer for guidance with pressure systems.

9.3.2 The following are pressure safety considerations that should be used when designing and using glass systems:

- For pressure safety considerations, "high-vacuum" and "low- vacuum" are equally hazardous. Where possible, glass apparatus should not have sharp edges or include large flat glass plates.
- Appropriate curvature enhances the strength and reliability of glass apparatus.
- Glass apparatus which will encounter pressures in excess of 5 psi above ambient should be made of thick-walled glass.
- Under no conditions shall the pressure in any glass apparatus exceed 10 psig. Glassware that will be used in systems above 10 psig must be specifically rated for the higher pressure.
- Lab workers shall consider the following possible scenarios where pressure increases could occur during operations with glass systems:
  a) direct pressurization with a compressed gas.
  b) temperature changes.
  c) increase in temperature of a gas.
  d) Increase in temperature of a liquid above its atmospheric boiling point.
  e) exothermic reactions.
  f) chemical reaction which could generate gaseous products.
- Generally:
  a) the use of glass apparatus involves chemicals.
  b) Failure of the glass could result in worker exposure to the vessel's contents.
  c) Mitigation of chemical hazards shall be evaluated for each glass apparatus operation.

9.3.3 The following are measures that should be considered when using glass components or systems:

- Glass apparatus shall be visually inspected for cracks and flaws prior to use.
- Direct clamping to glass should be avoided since it can generate localized stresses which may lead to failure.
- When mechanical clamping is unavoidable, care should be taken to avoid over-tightening the clamp(s).
- In use, the glass systems shall be externally shielded as much as is practical.

9.3.4 The following are measures that should be considered when using gas delivery systems or vacuum sources associated with glass systems:

- Requirements in the SNL Pressure Safety Manual (MN471000) shall be followed.
- Set pressure on pressure relief valves shall be below 10 psi and preferably no greater than the maximum pressure needed for the experiment.
- Regulators for gas cylinders used with glass pressure apparatus should be chosen such that the pressure delivery scale is the lowest possible for the planned use.
- Pressure relief valves should be used whenever possible.
- Incorrect (backwards) connection of vacuum pumps can result in over pressurization of a glass system. Verify that a working vacuum is applied to the glass apparatus.
- Contact 1100 Customer Support Team Safety Engineer for guidance with pressure systems.

9.3.5 The following describes protective equipment requirements and recommendations when using glass systems:

- Eye Protection -Safety glasses with side shields are required for all personnel working in any laboratory containing glass pressure or vacuum apparatus.
- Laboratory Coat - Use of a long-sleeved lab coat is recommended.
- Fume Hood - Whenever possible, the apparatus should be placed in a fume hood. The sash should be adjusted to maximize protection to those nearby.
- Portable Shield - A portable shield should be available.
- Plastic webbing should cover dewars, rotovaps, and other such apparatus. These can also be taped.
- Pressure safety gloves - Protective hand guard gloves should be available in any laboratory that uses glass pressure apparatus.

10.0 SAFE HANDLING OF CRYOGENIC FLUIDS

- For detailed information on cryogens, consult MN471000 – Pressure Safety Manual
- Refer to SOP1100.009: Center 1100 SOP for Handling of Liquid Nitrogen and Liquid Helium for Center-specific information and requirements.

10.1 Training

- Members of the Workforce whose activities involve cryogenics shall have completed **PRS115** before beginning operations involving cryogenics.
- Personnel should be trained on site-specific procedures for safe operations.
- Personnel should be aware of the hazards related to the equipment.

10.2 Personal Protective Equipment (PPE)

- Cryogenic burns can be serious, and members of the Workforce shall select the appropriate level(s) of protection commensurate with their application.
- Personnel should use appropriate PPE such as safety glasses, a full face shield if there is a splashing hazard, cryogen approved insulated gloves, and hearing protection ((if needed).

11.0 HOUSEKEEPING

11.1 Center 1100 lab personnel should NOT:

- Use bench tops, passageways, stairways, or hallways as storage areas for chemicals. Exceptions include non-hazardous gases, and valved dewars containing liquid nitrogen, or liquid helium.
- Use laboratory hoods as storage areas unless it is determined that safe storage of a particular hazardous chemical requires storage in a laboratory hood.
- If hazardous chemicals must be stored in a hood, SNL personnel should:
  a) Keep quantities to a minimum.
  b) Position chemicals to prevent blockage of vents or airflow.
  c) Place containers away from the hood sash.

11.2 SNL personnel should:

- Keep chemical work areas clean and uncluttered with hazardous chemicals and equipment properly labeled and stored.
- Clean up the work area on completion of an operation or at the end of each day.
- Never block access to exits, emergency equipment, or utility controls.
- Appropriately dispose of used or contaminated personal protective equipment (PPE).

12.0 WASTE DISPOSAL and RECYCLABLES

12.1 SNL personnel should:

Dispose of hazardous waste in accordance with ESH100.2.ENV.22, Manage Hazardous Waste at SNL/NM.

12.2 Center 1100 lab personnel should:

- take measures to minimize the generation of hazardous waste from work with hazardous chemicals which follows good Pollution Prevention (P2) practices and protects our environment.
- Contact the 1100 ES&H Coordinator or the 1100 Customer Support Environmental Protection Liaison for additional guidance on waste management practices.

12.3 Waste Addition Logs

In some cases in which different types of waste are compatible and have the same or very similar physical and chemical properties and contaminants, it is acceptable to combine these wastes in the same container if the waste generator maintains a SF 2001-WAL, "Waste Addition Log" (Word file/Acrobat file) or other means to ensure that waste contents are known. Contact the ECC Representative with any questions.

12.4 Waste Water Discharge Permits

- Members of the Workforce should submit documentation describing the amount, frequency, location, composition, and process associated with a discharge to the Water Quality, Discharge Permit contact from the Environmental Management Department for written approval for all process discharges to the sanitary sewer system, except sanitary waste.
- Place current copy of Waste Water Permit in Laboratory LON.

12.5 Effluent Discharges For Analytical Operations

- Effluent from chemical operations shall be considered hazardous waste.
- All effluent shall be discharged into a closed container except to actively add or remove waste. A closed container will not allow any waste to escape into the environment, or allow the effluent waste to evaporate. Employees shall not allow effluent waste to evaporate or disperse into the atmosphere.

- An appropriate method for effluent containment is a safety ecological funnel. Information about this product can be obtained at: http://www.ecofunnels.com/Merchant2/merchant.mv

13.0 EMERGENCY PROCEDURES

13.1 Accidents and Medical Emergencies

In the event of an accident or medical emergency, personnel shall take the following actions:

- Dial 911. The appropriate medical, ES&H, and security personnel will be contacted simultaneously.
- If injuries are the result of hazardous substances, remove the source of the injury (e.g., set chemical container upright, close valve) **if this can be accomplished without further risk to personnel.**

- Remove the victim to a safe area if circumstances and injuries allow such action **safely**.
- As soon as possible, Notify:
  a) The respective Department Manager.
  b) The 1100 ES&H Coordinator.

13.2 Following a chemical accident or spill that results in a personal contact with a hazardous chemical, Center lab personnel shall:

- Immediately use an eyewash, safety shower, or other source of water.
- Remove any contaminated clothing.
- Flush affected areas with copious amounts of water for fifteen minutes.
- Dial 911 and seek immediate medical attention, as needed.
- As soon as possible, Notify:
  a) The respective Department Manager.
  b) The 1100 ES&H Coordinator.

13.3 Following an accident or spill that results in an airborne exposure, Center lab personnel should promptly:

- Remove affected individuals from the area if it can be done safely.
- Dial 911 for assistance.
- As soon as possible, Notify:
  a) The respective Department Manager.
  b) The 1100 ES&H Coordinator.

13.4 Chemical Spills

For guidance on reporting and cleaning up chemical spills

- See ESH100.3.1, Prepare and Manage Emergencies.
- Personnel generating a small spill (<500 ml), are allowed to clean it up unless they lack training or equipment or they do not feel comfortable doing so.
- Personnel may request advice or assistance from the Non-Emergency Hotline (844-6515).
- For large spills personnel shall call the Non-Emergency Hotline (844-6515) for spill response and cleanup. If human health or the environment is threatened, call 911 for emergency spill response and cleanup.
- Call the 1100 ES&H Coordinator or the 1100 Customer Support Environmental Protection Liaison for assistance on spill cleanup and reporting.

APPENDICES

Note: Many of the appendices consist of tables of chemicals that are known or considered to present a variety of chemical hazards. **These lists must be used with caution** because:

- these lists **may not reflect the complete listing of chemicals related to the respective subject.**
- in general, exposure quantities or paths that produce the effects indicated are not noted in the tables.

The original references for these tables should be consulted for more complete information when evaluating risks presented by particular laboratory operations.

These APPENDICES are intended to serve only as a preliminary source of information for evaluating existing or anticipated chemical laboratory hazards and/or risks. Final determinations should be after consultation with the Center 1100 IH and/or ES&H Coordinator

Appendix (1) - Sensitive Chemicals

Appendix (2) - Classification of Toxins, Probable Lethal Dose (Human)

Appendix (3) - Container Sizes for Flammable and Combustible Liquids

Appendix (4) - Flash Points of Class 1A, 1B, and 1C Flammable Liquids

Appendix (5) - Explosive Chemicals

Appendix (6) - Incompatible Chemicals

Appendix (7) - Deteriorating Chemicals

Appendix (8) - International Agency for Research on Cancer (IARC) – List of Chemical Carcinogens

Appendix (9) - National Toxicology Program (NTP) – List of Chemical Carcinogens

Appendix (10) - Chemicals “Known to the State of California to Cause Cancer”

Appendix (11) - Compounds Found to cause Spontaneous Abortion of Teratology in Humans

Appendix (12) -Chemicals “Known to the State of California to be Reproductive Toxins”

Appendix (13) -Chemicals of Acute Toxicity

Appendix (14) -Hazardous Properties of Some Gases

Appendix (15) -Peroxideable Chemicals

Appendix (16) – Solvent contaminated Materials Exemption

Appendix (17) – Proper Use of Laboratory Fume Hoods

Appendix (18) – Safe Management of Shock-Sensitive Chemicals

Appendix (19) – Common Glove Chart

APPENDIX (1) - SENSITIVE CHEMICALS

Reference: GN470094 Revision Date: Aug 5, 2003

Chemical Name	Type of Control	
	California	Federal
N-Acetylanthranilic acid	X	
Amphetamine		X
Anthranilic acid	X	
Barbituric acid	X	
Cocaine		X
Diethyl malonate	X	
Ephedrine	X	
Ergotamine tartrate	X	
Ethylamine	X	
Ethyl malonate	X	
Fentanyl		X
D-Lysergic acid	X	X
Lysergic acid diethylamide (LSD)		X
Malonic acid	X	
Methamphetamine		X
Methaqualone		X
Methaqualude		X
Methylamine	X	
3,4-Methylenedioxyamphetamine		X
3,4-Methylenedioxymethamphetamine		X
Morpholine	X	
Norpseudoephedrine	X	
Pentobarbital		X
Phencyclidine (PCP)		X
Phenylacetic acid	X	
Phenylpropanolamine	X	
1-Phenyl-2-propanone (P2P)	X	X
Piperidine	X	X
Pseudoephidrine	X	
Pyrrolidine	X	
Secobarbital		X

APPENDIX (2) - CLASSIFICATION OF TOXINS, PROBABLE ORAL LETHAL DOSE (HUMAN)*

Reference: GN470094 Revision Date: Aug 5, 2003

Toxicity Rating	Dose	For 70kg (150-lb) Person
6, super toxic	Less than 5 mg/kg	A taste (less than 7 drops)
5, extremely toxic	5 to 50 mg/kg	Between 7 drops and 1 teaspoon
4, very toxic	50 to 500 mg/kg	Between 1 teaspoon and 1 ounce
3, moderately toxic	0.5 to 5 g/kg	Between 1 ounce and 1 pint
2, slightly toxic	5 to 15 g/kg	Between 1 pint and 1 quart
1, practically nontoxic	More than 15 g/kg	More than 1 quart (or 1 kg)

*C. D. Klaassen, M. O. Amdur, J. Doull, ed., *Casarett and Doull's TOXICOLOGY: The Basic Science of Poisons*, Third Edition, Macmillan Publishing Company, 1986, p. 13.

APPENDIX (3) - CONTAINER SIZES FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS

Reference: GN470094 Revision Date Aug 5, 2003

Flammable Liquids:

Type of Container	Class IA		Class IB		Class IC	
	Liters	Gallons	Liters	Gallons	Liters	Gallons
Glass	0.5	0.12	1	0.25	4	1
Metal (other than DOT drums)	4	1	20	5	20	5
Safety cans	7.5	2	20	5	20	5
Metal drums (DOT specifications)[a]	225	60	225	60	225	60
Approved portable tanks[b]	2500	660	2500	660	2500	660

Combustible Liquids:

Type of Container	Class II		Class IIA	
	Liters	Gallons	Liters	Gallons
Glass	4	1	4[c]	1[c]
Metal (other than DOT drums)	20	5	20	5
Safety cans	20	5	20	5
Metal drums (DOT specifications)[a]	225	60	225	60
Approved portable tanks[b]	2500	660	2500	660

[a]Maximum size permitted in a laboratory for class I materials is 20 liters (5 gallons); drum size is permitted only in an inside storage room
[b]Permitted only outside of buildings
[c]OSHA limitation

APPENDIX (4) –

Reference: GN470094 Revision Date August 5, 2003

FLASH POINTS OF COMMON CLASS IA FLAMMABLE LIQUIDS*

*Flash point less than 73°F; boiling point less than 100°F

Flammable Liquid	Flash Point (°F)
Ethyl chloride	-58
Pentane	-57
Ethyl ether	-49
Acetaldehyde	-36

Flammable Liquid	Flash Point (°F)
Isopropylamine	-35
Ethyl formate	-2
Ethylamine	0

FLASH POINTS OF COMMON CLASS IB FLAMMABLE LIQUIDS*

*FLASH POINT LESS THAN 73°F; BOILING POINT GREATER THAN OR EQUAL TO 100°F

Flammable Liquid	Flash Point (°F)[a]
Naphtha[b]	-40 to 68
Allyl chloride	-25
Carbon disulfide	-22
Isopropyl ether	-18
Acrolein	-15
Ethyl bromide	-9
Hexane	-7
Cyclohexane	-4
Nickel carbonyl	-4
Acetone	1.4
1,1-Dimethylhydrazine	5
Tetrahydrofuran	6

Flammable Liquid	Flash Point (°F)[a]
Butyl amine	10
Benzene	12
Methyl acetate	14
Methyl ethyl ketone	21
Ethyl acetate	24
Heptane	25
Acrylonitrile	30
Butyl mercaptan	35
Toluene	40
2-Pentanone	45
Methyl methacrylate	50 (oc)
Methanol	52

Flammable Liquid	Flash Point (°F)[a]
Isopropanol	53
Dioxane	54
Ethylene dichloride	55
Octane	56
Propanol	59
sec-butyl acetate	62
Pyridine	68
Allyl alcohol	70
Butyl acetate	72

[a]Closed-cup values are given unless where denoted by "oc" (open cup)
[b]Borderline class IA

FLASH POINTS OF COMMON CLASS IC FLAMMABLE LIQUIDS*

*Flash point greater than or equal to 73°F, but less than 100°F

Flammable Liquid	Flash Point (°F)
Methyl isobutyl ketone	73
2-Butanol	75
n-Amyl acetate	77
2-Hexanone	77
Isoamyl acetate	77
Xylene	81
Butyl alcohol	84
Chlorobenzene	84
p-Ansidine	86
sec-Amyl acetate	89
Styrene	90

Ethylene diamine	93
Flammable Liquid	**Flash Point (°F)**
Morpholine	95
Turpentine	95

APPENDIX (5) - EXPLOSIVE CHEMICALS

Reference: GN470094 Revision Date: August 5, 2003

The following may be supplied as laboratory reagents, pharmaceuticals, or polymer components. However, they are in fact explosives. Appropriate care should be taken in storage and disposal, especially if they have deteriorated in any way.

Acetylene
Acetyl peroxide
Ammonium nitrate
Ammonium picrate
Benzoyl peroxide
Cumene peroxide
Dinitrophenylhydrazine
Dipicrylamine
Dipicryl sulphide
Ethylene oxide
Lauric peroxide
Methyl ethyl ketone peroxide
Nitrogen trifluoride
Nitroglycerin
Nitroguanidine
Nitromethane
Picramide
Picric acid
Picryl chloride
Picryl sulphonic acid
Propargyl bromide
Succinic peroxide
Trinitroanisole
Trinitrobenzene
Trinitrobenzene sulphonic acid
Trinitrobenzoic acid
Trinitrocresol
Trinitronaphthalene
Trinitrophenol
Trinitroresorcinol
Trinitrotoluene
Urea nitrate

APPENDIX (6) - INCOMPATIBLE CHEMICALS

Reference: GN470094 Revision Date: August 5, 2003

Classes of Incompatible Chemicals[a]:

Class A	Class B
Acids	**Bases**
Alkali and alkaline earth metals Carbides Hydrides Hydroxides Oxides Peroxides	Water Acids Halogenated organic compounds Oxidizing agents[b] Chromates, dichromates, CrO_3 Halogens Halogenating agents Hydrogen peroxide and peroxides Nitric acid, nitrates Perchlorates and chlorates Permanganates Persulfates
Inorganic azides	Acids Heavy metals and their salts Oxidizing agents[b]
Inorganic cyanides	Acids, strong bases
Inorganic nitrates	Acids Metals Nitrites Sulfur
Inorganic nitrites	Acids Oxidizing agents[b]
Inorganic sulfides	Acids
Organic compounds Organic acyl halides Organic anhydrides Organic halogen compounds Organic nitro compounds	Oxidizing agents[b] Bases Organic hydroxy compounds Bases Organic hydroxy compounds Aluminum metal Strong bases
Powdered metals	Acids Oxidizing agents[b]

APPENDIX (6) - INCOMPATIBLE CHEMICALS (CONTINUED)

Specific Chemical Incompatibilities[a]:

Chemical A	Chemical B
Acetylene and monosubstituted acetylene R - C __ C-H	Halogens Group IB and IIB metals and their salts
Ammonia and NH_4OH	Halogens Halogenating agents Silver Mercury
Carbon, activated	Oxidizing agents[b]
Hydrogen peroxide	Metals and their salts
Nitric acid	Metals Sulfuric acid Sulfides Nitrites, other reducing agents Chromic acid and chromates Permanganates
Mercury and its amalgams	Ammonia and NH_4OH Nitric acid Acetylene Sodium azide
Oxalic acid	Silver Mercury
Phosphorus (yellow)	Oxygen Oxidizing agents[b] Strong bases
Phosphorus pentoxide	Water Halogenating agents
Sulfuric acid	Metals Chlorates Perchlorates Permanganates Nitric acid

[a]Chemicals in columns A and B should be kept separate.
[b]Oxidizing agents include the types of compounds listed in the entry for alkali and alkaline earth metals, etc.

APPENDIX (7) - DETERIORATING CHEMICALS

Reference: GN470094 Revision Date: August 5, 2003

The following is a selection of chemical substances which can deteriorate to a dangerous condition with age under common storage conditions. The degree of the hazard will vary considerably with age and the exact situation, but it is advisable to take precautions when discarding, recycling, or otherwise handling old samples. The chemical name is followed by a code indicating the deterioration description (see below) **THIS SHOULD NOT BE CONSIDERED A COMPLETE LIST**

Acetal (3)
Acetaldehyde diethyl acetal (3)
2-Acetyl furan (3)
Acetyl peroxide (1)
Aluminium chloride (5)
Aluminium lithium hydride (5)
Ammonia solution (5)
Ammonium dichromate (4)
Ammonium hyroxide (5)
Ammonium persulphate (5)
Anethole (3)
Anisaldehyde (3)
Anisole (3)
Anisyl chloride (5)
Aqua regia (5)
Benzenesulphonyl chloride (5)
Benzoyl peroxide (1)
Bleach (5)
Bleaching powder (5)
2-(2-Butoxyethoxy)ethyl acetate (3)
2-Butoxyethyl acetate (3)
t-Butyl hydroperoxide (4)
iso-Butyl ether (2)
n-Butyl ether (3)
n-Butyl glycidyl ether (3)
Calcium carbide (5)
Calcium hydride (5)
Calcium hypochlorite (5)
Cellosolve (3)
Chloroform (5)
Chromic acid (5)
Chromium trioxide (4)
Cleaning mixtures (5)
Cumene (3)
Cumene hydroperoxide (5)
Cyclohexene (3)
Cyclopentadiene (3)
Cyclopentene (3)
Decahydronaphthalene (3)
Decalin (3)
Di-allyl ether (3)
Di-iso-amyl ether (3)
Dibenzyl ether (3)
Di-iso-butyl ether (2)
Di-n-butyl ether (3)
Dicyclopentadiene (3)
1,1-Diethoxyethane (3)
Diethylacetal (3)
Diethyl azidoformate (4)
Diethyl azodicarboxylate (1)
Diethylene glycol dimethyl ether (3)
Diethyl ether (3)
Diglyme (3)
Dihydropyran (3)
1,2-Dimethoxyethane (3)
Dimethoxymethane (3)
Dimethylamine (5)
2,4-Dinitrophenol (1)
2 ,4-Dinitrophenylhydrazine (1)
1,4-Dioxan (3)
Diphenyl ether (3)
Di-iso-propyl ether (2)
Di-n-propyl ether (3)
Ether (3)
Ethyl cellosolve (3)
Ethylene glycol dimethyl ether (3)
Ethylene glycol ethyl ether acetate (3)
Ethylene glycol monobutyl ether (3)
Ethylene glycol monoethyl ether (3)
Ethylene glycol monomethyl ether (3
Ethyl ether (3)
2-Ethoxyethanol (3)
2-Ethoxyethyl acetate (3)
Ethyl vinyl ether (2)
Formic acid (100%) (5)
Furan (3)
Glycidyl n-butyl ether (3)
Glyme (3)
Hydrogen peroxide (5)
Iodine pentoxide (4)
Isoamyl ether (3)
Isobutyl ether (2)
Isopentyl ether (3)
Isopropyl alcohol (3)
Isopropyl ether (2)
Isopropyl benzene (3)
Lauroyl peroxide (5)
Lithium aluminium hydride (5)
Lithium hydride (5)
Magnesium perchlorate (4)
Mercury fulminate (1)
2-Methoxyethanol (3)
Methylal (3)
Methyl cellosolve (3)
Methyl iso-butyl ketone (3)
Methyl ethyl ketone peroxide (1)
Methyl vinyl ketone (3)
Nitric acid (5)
Nitromethane (1)
Nitrosoguanidine (5)
Peracetic acid (1,4,5)
Perchloric acid (4)
Phosphorus trichloride (5)
Picric acid (1)
Picryl chloride (1)
Picryl sulphonic acid (1)
Potassium (metal) (1)
Potassium amide (1)
Potassium chlorate (4)
Potassium perchlorate (4)
Potassium persulphate (5)
Propan-2-ol (3)
Propargyl bromide (1)
Propargyl chloride (1)
Silicon tetrachloride (5)
Silvering solution (1)
Sodamide (1)
Sodium amide (1)
Sodium borohydride (5)
Sodium chlorate (4)
Sodium chlorite (4)
Sodium dithionite (5)
Sodium hydride (5)
Sodium hydrosulphite (5)
Sodium hypochlorite (5)
Sodium metal dispersions (1)
Sodium perchlorate (4)
Sodium peroxide (5)
Sodium persulphate (5)
Styrene (3)
Tetrahydrofuran (3)
Tetralin (3)
Thionyl chloride (5)
Trinitrobenzene (1)
Trinitrobenzene sulphonic acid (1)
Urea nitrate (4)
Urea peroxide (5)
Vinyl acetate (3)
Vinylidene chloride (1)
Vinyl pyridine (3)
Zinc (5)

Key codes:

(1) Can deteriorate to a shock-sensitive explosive. Take exceptional care if there is evidence of drying out, crystallization or contamination. It may be very dangerous to attempt to open the container.

(2) Forms peroxides, especially on exposure to air and light, making the material liable to explode. This class is so dangerous that it should not normally be distilled unless it has been very well controlled. Material more than one year old should be discarded, even if unopened. Containers should not be opened if there is any solid visible around the closure or any evidence of crystals inside.

(3) Also forms peroxides. If very old or obviously in poor condition, treat as (2). Otherwise, take care to test for peroxides before use or recovery procedures.

(4) High energy materials which are sensitive to the presence of dust. Clean the outside of containers before opening. If in doubt, do not open. Mixtures of the material with dust, paper, or organics may ignite or detonate when exposed to friction, e.g. on the threads of a screw-capped container.

(5) Containers may have a high internal gas pressure owing to decomposition. Open carefully behind a safety shield in a fume hood.

APPENDIX (8) - INTERNATIONAL AGENCY FOR RESEARCH ON CANCER (IARC) - LIST OF CHEMICAL CARCINOGENS

NOTE: these lists **may not reflect the complete listing of chemicals related to the respective subject.** For updated information consult IARC.

Reference: GN470094 Revision Date: August 5, 2003

Group 1: Causally associated with cancer in humans

Industrial processes and occupational exposures:

Auramine manufacture
Boot and shoe manufacture and repair (certain occupations)
Furniture manufacture
Isopropyl alcohol manufacture (strong-acid process)
Nickel refining
Rubber industry (certain occupations)
Underground haematite mining (with exposure to radon)

Chemicals and groups of chemicals:

4-Aminobiphenyl
Analgesic mixtures containing phenacetin[a]
Arsenic and arsenic compounds[a]
Asbestos
Azathioprine
Benzene
Benzidine
N,N-Bis(2-chloroethyl-2-naphthylamine (Chlornaphazine)
Bis(chloromethyl)ether and technical-grade chloromethyl methyl ether
1,4-Butanediol dimethanesulphonate (Myleran)
Certain combined chemotherapy for lymphomas[a] (including MOPP[b])
Chlorambucil
Chromium and certain chromium compounds[a]
Conjugated oestrogens[a]
Cyclophosphamide
Diethylstilboestrol
Melphalan
Methoxsalen with ultraviolet A therapy (PUVA)
Mustard gas
2-Naphthylamine
Soots, tars and oils[a,c]
Treosulphan
Vinyl chloride

Group 2: The following 61 chemicals, groups of chemicals, or industrial processes are probably carcinogenic to humans

Group 2A

Acrylonitrile
Aflatoxins
Benzo[a]pyrene
Beryllium and beryllium compounds[a]
Combined oral contraceptives[a]
Diethyl sulphate
Dimethyl sulphate
Manufacture of magenta[a]
Nickel and certain nickel compounds
Nitrogen mustard
Oxymetholone
Phenacetin
Procarbazine
ortho-Toluidine

Group 2B

Actinomycin D
Adriamycin
Amitrole
Auramine (technical grade)
Benzotrichloride
Bischloroethyl nitrosourea (BCNU)
Cadmium and cadmium compounds
Carbon tetrachloride
Chloramphenicol
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)
Chloroform
Chlorophenols (occupational exposure to) [a]
Cisplatin
Dacarbazine
DDT
3,3'-Dichlorobenzidine
Dienoestrol
3,3'-Dimethoxybenzidine (*ortho*-Dianisidine)
Dimethylcarbamoyl chloride
1,4-Dioxane
Direct Black 38 (technical grade)
Direct Blue 6 (technical grade)
Direct Brown 95 (technical grade)
Epichlorohydrin
Ethinyloestradiol
Ethylene dibromide
Ethylene oxide
Ethylene thiourea
Formaldehyde (gas)
Hydrazine
Mestranol
Metronidazole
Norethisterone
Oestradiol-17b
Oestrone
Phenazopyridine
Phenytoin
Phenoxyacetic acid herbicides (occupational exposure to) [a]
Polychlorinated biphenyls
Progesterone
Propylthiouracil
Sequential oral contraceptives[a]
Tetrachlorodibenzo-*para*-dioxin (TCDD)
2,4,6-Trichlorophenol
Tris(aziridinyl-*para*-benzoquinone (Triaziquone)
Tris(1-aziridinyl)phosphine sulphide (Thiotepa)
Uracil mustard

Notes:

[a]The compound(s) responsible for the carcinogenic effect in humans cannot be specified.
[b]Procarbazine, nitrogen mustard, vincristine, and prednisone.
[c]Mineral oils may vary in composition, particularly in relation to their content of carcinogenic polycyclic aromatic hydrocarbons.

APPENDIX (9) - NATIONAL TOXICOLOGY PROGRAM (NTP) LIST OF CHEMICAL CARCINOGENS

(2 pages)

NOTE: These lists **may not reflect the complete listing of chemicals related to the respective subject.** For updated information consult NTP.

Reference: GN470094 Revision Date: August 5, 2003

Substances or groups of substances, and technical processes that are known to be carcinogenic:

4-Aminobiphenyl
Analgesic mixtures containing phenacetin
Arsenic and certain arsenic compounds
Asbestos
Azathioprine
Benzene
Benzidine
N,N-bis(2-chloroethyl)-2-naphthylamine (chlornaphazine)
Bis(chloromethyl)ether and technical grade chloromethyl methyl ether
1,4-Butanediol dimethylsulfonate (myleran)
Certain combined chemotherapy for lymphomas
Chlorambucil
Chromium and certain chromium compounds
Coke oven emissions
Conjugated estrogens
Cyclophosphamide
Diethylstilbestrol
Hematite underground mining
Isopropyl alcohol manufacturing (strong-acid process)
Manufacture of auramine
Melphalan
Methoxsalen with ultraviolet A therapy (PUVA)
Mustard gas
2-Naphthylamine
Nickel refining
Rubber industry (certain occupations)
Soots, tars, and mineral oils
Thorium dioxide
Vinyl chloride

Substances or groups of substances that may reasonably be anticipated to be carcinogens:

2-Acetylaminofluorene
Acrylonitrile
Adriamycin
Aflatoxins
2-Aminoanthraquinone
1-Amino-2-methylanthraquinone
Amitrole
o-Anisidine and o-anisidine hydrochloride
Aramite (Reg TM)
Benz(a)anthracene
Benzo(b)fluoranthene
Benzo(a)pyrene
Benzotrichloride
Beryllium and certain beryllium compounds
Bischloroethyl nitrosourea
Cadmium and certain cadmium compounds
Carbon tetrachloride
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)
Chloroform
4-Chloro-o-phenylenediamine
p-Cresidine
Cupferron
Cycasin
Dacarbazine
DDT
2,4-Diaminoanisole sulfate
2,4-Diaminotoluene
Dibenz(a,h)acridine
Dibenz(a,j)acridine
Dibenz(a,h)anthracene
7H-Dibenzo(c,g)carbazole
Dibenzo(a,h)pyrene
Dibenzo(a,i)pyrene
1,2-Dibromo-3-chloropropane
1,2-Dibromoethane (EDB)
3,3'-Dichlorobenzidine
1,2-Dichloroethane
Diepoxybutane
Di(2-ethylhexyl)phthalate
Diethyl sulfate
3,3'-Dimethoxybenzidine
4-Dimethylaminoazobenzene
3,3'-Dimethylbenzidine
Dimethylcarbamoyl chloride
1,1-Dimethylhydrazine
Dimethyl sulfate
1,4-Dioxane
Direct Black 38
Direct Blue 6
Epichlorohydrin
Estrogens (not conjugated): 1. Estradiol 17b
Estrogens (not conjugated): 2. Estrone
Estrogens (not conjugated): 3. Ethinylestradiol
Estrogens (not conjugated): 4. Mestranol
Ethylene oxide
Ethylene thiourea
Formaldehyde (gas)
Hexachlorobenzene
Hexamethylphosphoramide
Hydrazine and hydrazine sulfate
Hydrazobenzene
Indeno(1,2,3-cd)pyrene
Iron dextran complex
Kepone (Reg TM) (Chlordecone)
Lead acetate and lead phosphate
Lindane and other hexachlorocyclohexane isomers
2-Methylaziridine (propyleneimine)
4,4'-Methylenebis(2-chloroaniline) (MBOCA)
4,4'-Methylenebis(N,N-dimethyl)benzenamine
4,4'-Methylenedianiline and its dihydrochloride

Methyl iodide
Metronidazole
Michler's ketone
Mirex

Nickel and certain nickel compounds
Nitrilotriacetic acid
5-Nitro-o-anisidine
Nitrofen
Nitrogen mustard
2-Nitropropane
N-Nitrosodi-n-butylamine
N-Nitrosodiethanolamine
N-Nitrosodiethylamine
N-Nitrosodimethylamine
p-Nitrosodiphenylamine
N-Nitrosodi-n-propylamine
N-Nitroso-N-ethylurea
N-Nitroso-N-methylurea
N-Nitrosomorpholine
N-Nitrosonornicotine
N-Nitrosopiperidine
N-Nitrosopyrrolidine
N-Nitrososarcosine
Norethisterone
Oxymetholone
Phenacetin
Phenazopyridine hydrochloride
Phenytoin and sodium salt of phenytoin
Polybrominated biphenyls
Polychlorinated biphenyls
Procarbazine and procarbazine hydrochloride
Progesterone
1,3-Propane sultone
b-Propiolactone
Propylthiouracil
Reserpine
Saccharin
Safrole
Selenium sulfide
Streptozotocin Sulfallate
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)
Thioacetamide
Thiourea
Toluene diisocyanate
o-Toluidine and o-toluidine hydrochloride
Toxaphene
2,4,6-Trichlorophenol
Tris(1-aziridinyl)phosphine sulfide
Tris(2,3-dibromopropyl)phosphate
Urethane

APPENDIX (10) – CHEMICALS 'KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER" (3 pages)

Reference: GN470094 Revision Date: August 5, 2003

Acetaldehyde
Acetochlor
Acetylaminofluorene
Acrylonitrile
Adriamycin
AF-2; [2-(2-fluryl)-3-(5–nitro-2-furyl)]acrylamide
Aflatoxins
Alachlor
Alcoholic beverages (when associated with alcohol abuse)
Aldrin
ortho-Aminoazotoluene
2-Amino-5-(5-nitro-2-furyl) -1,3,4-thiodiazole
4-Aminobiphenyl
Amitrole
ortho-Anisidine and ortho-Anisidine hydrochloride
Analgesic mixtures containing phenacetin
Aramite (Reg TM)
Arsenic (inorganic arsenic compounds)
Asbestos
Auramine
Asaserine
Asathioprine
Benz[a]anthracene
Benzene
Benzidine (and its salts)
Benzo[b]fluoranthene
Benzo[j]fluoranthene
Benzo[k]fluoranthene
Benzo[a]pyrene
Benzotrichloride
Benzyl violet 4B
Beryllium and beryllium compounds
Bis(2-chloroethyl)ether
N,N-Bis(2-chloroethyl)-2-naphthylamine
Bischloroethyl nitrosourea (BCNU)
Bis(chloromethyl)ether
1,3-Butadiene
1,4-Butanediol dimethanesulfonate (Myleran)
beta-Butyrolactone
Cadmium and cadmium compounds
Carbon tetrachloride
Certain combined chemotherapy for lymphomas
Chlorambucil
Chlordane
Chlordecone (Kepone [Reg TM])
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)
1-(2-Chloroethyl)-3-(4-methylcycloxyl)-1-nitrosourea (Methyl-CCNU)
Chlordimeform
Chloroform
Chloromethyl methyl ether (technical grade)
4-Chloro-ortho-phenylenediamine
Chlorothalonil
Chromium (hexavalent compounds)
Coke oven emissions
Conjugated estrogens
Creosotes
para-Cresidine
Cupferron
Cycasin
Cyclophosphamide
Dacarbazine
Daunomycin
DDD (Dichlorodiphenyldichloroethane)
DDE (Dichlorodiphenyldichloroethylene)
DDT (1,1,1-Trichloro-2,2-bis (p-chlorophenyl) ethane)
Degraded Carrageenan (not food grade)
2,4-Diaminoanisole sulfate
4,4'-Diaminodiphenyl ether
2, 4'-Dianinotoluene
Dibenz[a,h]acridine
Dibenz[a,j]acridine
Dibenz[a,h]anthracene
7H-Dibenzo[c,g]carbazole
Dibenzo[a,e]pyrene
Dibenzo[a,h]pyrene
Dibenzo[a, i]pyrene
Dibenzo[a,l]pyrene
1,2-Dibromo-3-chloropane (DBCP)
p-Dichlorobenzene
3,3'-Dichlorobenzidine
3,3'–Dichloro-4,4'-diaminodiphenyl ether
Dichloromethane (Methylene chloride)
1,3-Dichloropropene
Dieldrin
Diepoxybutane
Di(2-ethylhexyl) phthalate
1,2-Diethylhydrazine
Diethyl sulfate
Diethylstilbestrol
Dihydrosafrole
3,3'-Dimethoxybenzidine (ortho Dianiasidine)
4-Dimethylaminoazobenzene
trans-2-[(Dimethylamino) methylimino]-5-[2-5-nitro-2-furyl)vinyl]-1,3,4-oxadiazole
3,3'-Dimethylbenzidine (ortho Tolidine)
Dimethylcarbamoyl chloride
1,2-Dimethylhydrazine
Dimethyl sulfate
2,4-Dinitrotoluene
1,4-Dioxane
Diphenylhydrazine
Direct Black 38 (technical grade)
Direct Blue 6 (technical grade)
Direct Brown 95 (technical grade)
Epichlorohydrin
Erionite
Estradiol 17 B
Estrone
Ethinylestradiol
Ethylene dibromide
1,2-Dichloroethane (Ethylene dichloride)
Ethyleneimine
Ethylene oxide
Ethylene thiourea
Ethyl methanesulfonate
Folpet
Formaldehyde (gas)
Formylhydrozino-4-(5-nitro-2-furyl)thiazole
Glycialdehyde
Gyromitrin (acetaldehyde methylformylhydrazone)
Heptachlor
Heptachlor epoxide
Hexachlorobenzene

Hexachlorocyclohexane (technical grade)
Hexachlorodibenzodioxin
Hexamethylphosphoramide
Hydrazine and hydrazine sulfate
Hydrazobenzene
Indeno [1,2,3-cd]pyrene
Iron dextran complex
Lactofen
Lasiocarpine
Lead acetate
Lead phosphate
Melphalan
Merphalan
Mestranol
Methoxsalen wlth ultraviolet A therapy (PUVA)
2-Methylaziridine (propyleneimine)
Methylazoxymethanol
Methylazoxymethanol acetate
5-Methylchrysene
4,4'-Methylene bis(2-chloroaniline)
4,4'-Methylene bis(2-methylaniline)
4,4'-Methylenedianiline and its dihydrochloride
Methyl iodide
Methyl methanesulfonate
2-Methyl-1-nitroanthraquinone (of uncertain purity)
N-Methyl-N'-Nitro-nitrosoquanidine
Metronidazole
Michler's ketone
Mirex
Mitomycin C
Monocrotaline
5-(Morpholinomethyl)-3[(5-nitrofurfurylidene)-amino]-2-oxalolidinone
Mustard gas
Nafenopin
2-Naphthylamine
Nickel refinery dust from the pyrometallurgical process
Nickel carbonyl
Nickel subsulfide
Niridazole
Nitrilotriacetic acid
4–Nitrobiphenyl
5-Nitroacenaphthene
Nitrofen (technical grade)
1-[(5 Nitrofurfurylidene)-amlno]-2-imidazolidinone
N-[4-(5-Nitro-2-furyl)-2-thiazolyl]acetamide
Nitrogen mustard
Nitrogen mustard hydrochloride
Nitrogen mustard N-oxide and its hydrochloride
2-Nitropropane
N-Nitrosodi-n-butylamine
N-Nitrosodiethanolamine
N-Nitrosodiethylamine
N-Nitrosodimethylamine
p-Nitrosodiphenylamine
N-Nitrosodi-n-propylamine
N-Nitro-diphenylamine
N-Nitroso-N-ethylurea
N-Nitroso-N-methylurea
N-Nitroso-N-methylurethane
N-Nitrosomethylvinylamine
N-Nitrosomorpholine
N-Nitrosonornicotine
N-Nltrosopiperidine
N-Nitrosapyrrolidine
N-Nitrososarcosine
Orange Oil SS
Oxymetholone
Panfuran S
Phenacetin
Phenazopyridine and its hydrochloride
Phenoxybenzamine and its hydrochloride
Phenytoin and sodium salt
Polybrominated biphenyls
Polychlorinated biphenyls (containing 60 or more percent chlorine by molecular weight)
Ponceau MX
Ponoeau 3R
Procarbazine and its hydrochloride
1,3-Propane sultone
Propylene oxide
b-Propiolactone
Propylthiouracil
Sodium saccharin
Safrole
Silica, crystalline (airborne particles of respirable size)
Soots, tars, and lubricant base oils and derived products, specifically vacuum distillates, acid treated oils, aromatic oils, mildly solvent-refined oils, mildly hydrotreated oils, and used engine oils; and mineral oils, when used in occupations such as mulespinning, metal machining, and jute processing.
Sterigmatocystin
Streptozotocin
Styrene oxide
Sulfallate
Testosterone and its esters
2,3,7,8-Tetrachlorodibenzo-para-dioxin (TCDD)
Tetrachloroethylene (Percloroethylene)
Thioacetamide
4,4'-Thiodianiline
Thiourea
Thorium dioxide
Tobacco, oral use of smokeless products
Tobacco smoke
ortho-Toluidine and its hydrochloride
Taxaphene (polychorinated camphenes)
Treosulfan
2,4,6-Trichlorophenol
Trichloroethylene
Tris(1-aziridinyl)phosphine sulride (thiotepa)
Tris(2,3-dibromopropyl)phosphate
Trp-P-1 (Tryptophan-P-1)
Trp-P-2 (Tryptophan-P-2)
Unleaded gasoline
Uracil mustard
Urethane (Ethyl carbamate)
Vinyl bromide
Vinyl chloride

APPENDIX (11) - COMPOUNDS SHOWN IN EPIDEMIOLOGICAL STUDIES TO CAUSE SPONTANEOUS ABORTION OR TERATOLOGY IN HUMANS*

Reference: GN470094 Revision Date: August 5, 2003

Compound Category	Compound Name	Effect(s)
Metals	Lead	Abortion, mental retardation
	Methylmercury	Teratology-nervous system
	Lithium	Teratology-heart defect
	Aluminum	Teratology-nervous system
	Arsenic	Abortion, teratology
Drugs	Diethylstilbestrol	Adenocarcinoma
	Thalidomide	Teratology-limbs
	Antieoplastic drugs	Abortion
	Anesthetics	Abortion
	Alcohol	Fetal alcohol syndrome
	Anticonvulsants	Teratology
	Retinoids	Teratology
	Smoking	Low birth weight
Chemicals	Chlorinated pesticides	Abortion
	Polychlorinated biphenyls	Teratology
	Ethylene oxide	Abortion
	2,4,5,T (dioxin)	Abortion, teratology
Solvents	Benzene Xylene Cyclohexanone Propylene glycol Alkane sulfones Glycol ethers Acetamides Formamides	Teratology, embryotoxic

*B. S. Shane, *Human Reproductive Hazards*, Environmental Science & Technology, Volume 23, Number 10, 1989, p. 1187. The table is taken directly from this reference. Exposures that produce the effects listed are described in the reference.

APPENDIX (12) - CHEMICALS "KNOWN TO THE STATE OF CALIFORNIA TO BE REPRODUCTIVE TOXINS"

Reference: GN470094 Revision Date: August 5, 2003

All-trans retinoic acid
Aminopterin
Busulfan
Chlorambucil
Chlorcyclizine hydrochloride
Chlordecone (Kepone [Reg TM])
Cycloheximide
Cyclophosphamide
Cyhexatin
Cytarabine
1,2-Dibromo-3-chloropropane (DBCP)
Diethylstilbestrol (DES)
Dinoceb
Diphenylhydantoin
Ethyl alcohol in alcoholic beverages
Ethylene glycol monoethyl ether
Ethylene glycol monomethyl ether
Ethylene oxide
Etretinate
Fluoroaracil
Hexachlorobenzene
Iodine-131
Isotretinoin
Lead
Mechlorethamine
Methotrexate
Methyl mercury
Thalidomide
Tobacco smoke (not environmental tobacco smoke)
Valproate
Warfarin

APPENDIX (13) - CHEMICALS OF ACUTE TOXICITY (3 PAGES)

Reference: GN470094 Revision Date: August 5, 2003

CAS Number	Name
107-20-0	Acetaldehyde, chloro-
591-08-2	Acetamide, N-(aminothioxomethyl)-
640-19-7	Acetamide, 2-fluoro-
62-74-8	Acetic acid, fluoro-, sodium salt
591-08-2	1-Acetyl-2-thiourea
107-02-8	Acrolein
116-06-3	Aldicarb
309-00-2	Aldrin
107-18-6	Allyl alcohol
20859-73-8	Aluminum phosphide
2763-96-4	5-(Aminomethyl)-3-isoxazolol
504-24-5	4-Aminopyridine
7803-55-6	Ammonium vanadate
506-61-6	Argentate(1-), bis(cyano-C)-, potassium
7778-39-4	Arsenic acid H_3AsO_4
1327-53-3	Arsenic oxide As_2O_3
1303-28-2	Arsenic oxide As_2O_3
1303-28-2	Arsenic pentoxide
1327-53-3	Arsenic trioxide
692-42-2	Arsine, diethyl-
696-28-6	Arsonous dichloride, phenyl-
151-56-4	Aziridine
75-55-8	Aziridine, 2-methyl-
542-62-1	Barium cyanide
106-47-8	Benzenamine, 4-chloro-
100-01-6	Benzenamine, 4-nitro-
100-44-7	Benzene, (chloromethyl)-
122-09-8	Benzeneethanamine, alpha,alpha-dimethyl-
108-98-5	Benzenethiol
81-81-2†	2H-1-Benzopyran-2-one, 4-hydroxy -3-(3-oxo-1-phenylbutyl)-, & salts
100-44-7	Benzyl chloride
7440-41-7	Beryllium
598-31-2	Bromoacetone
357-57-3	Brucine
39196-18-4	2-Butanone, 3,3-dimethyl-1 -(methylthio)-, O-[(methylamino) carbonyl] oxime
592-01-8	Calcium cyanide
75-15-0	Carbon disulfide
75-44-5	Carbonic dichloride
107-20-0	Chloroacetaldehyde
106-47-8	p-Chloroaniline
5344-82-1	1-(o-Chlorophenyl)thiourea
CAS Number	**Name**
542-76-7	3-Chloropropionitrile
544-92-3	Copper cyanide
n/a	Cyanides (soluble cyanide salts), not otherwise specified
460-19-5	Cyanogen
506-77-4	Cyanogen chloride
131-89-5	2-Cyclohexyl-4,6-dinitrophenol
542-88-1	Dichloromethyl ether
696-28-6	Dichlorophenylarsine
60-57-1	Dieldrin
692-42-2	Diethylarsine
311-45-5	Diethyl-p-nitrophenyl phosphate
297-97-2	O,O-Diethyl O-pyrazinyl phosphorothioate
55-91-4	Diisopropylfluorophosphate (DFP)
309-00-2	1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexa-chloro-1,4,4a,5,8,8a,-hexahydro-,(1alpha,4alpha,4abeta, 5alpha,8alpha,8abeta)-
465-73-6	1,4,5,8-Di methanonaphthalene, 1,2,3,4,10,10-hexa-chloro-1,4,4a,5,8, 8a-hexahydro-,(1alpha,4alpha,4abeta, 5beta,8beta,8abeta)-
60-57-1	2,7:3,6-Dimethanonaphth [2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7, 7a-octahydro-,(1aalpha,2beta,2aalpha, 3beta,6beta,6aalpha,7beta,7aalpha)-
72-20-8†	2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7, 7a-octahydro-,(1 aalpha,2beta,2abeta, 3alpha,6alpha,6abeta,7beta,7aalpha)-, and metabolites
60-51-5	Dimethoate
122-09-8	alpha,alpha-Dimethylphenethylamine
534-52-1†	4,6-Dinitro-o-cresol, & salts
51-28-5	2,4-Dinitrophenol
88-85-7	Dinoseb
152-16-9	Diphosphoramide octamethyl-
107-49-3	Diphosphoric acid, tetraethyl ester
298-04-4	Disulfoton
541-53-7	Dithiobiuret
115-29-7	Endosulfan
145-73-3	Endothall

CAS Number	Name
72-20-8	Endrin
72-20-8	Endrin & metabolites
51-43-4	Epinephrine
460-19-5	Ethanedinitrile
16752-77-5	Ethanimidothioic acid, N-[[(methylamino)carbonyl]oxy]-, methyl ester
107-12-0	Ethyl cyanide
151-56-4	Ethyleneimine
52-85-7	Famphur
7782-41-4	Fluorine
640-19-7	Fluoroacetamide
62-74-8	Fluoroacetic acid, sodium salt
628-86-4	Fulminic acid, mercury(2+) salt
76-44-8	Heptachlor
757-58-4	Hexaethyl tetraphosphate
79-19-6	Hydrazinecarbothioamide
60-34-4	Hydrazine, methyl-
74-90-8	Hydrocyanic acid
74-90-8	Hydrogen cyanide
7803-51-2	Hydrogen phosphide
465-73-6	Isodrin
2763-96-4	3(2H)-Isoxazolone, 5-(aminomethyl)-
62-38-4	Mercury, (acetato-O)phenyl-
628-86-4	Mercury fulminate
62-75-9	Methanamine, N-methyl-N-nitroso-
624-83-9	Methane, isocyanato-
542-88-1	Methane, oxybis[chloro-
75-70-7	Methanethiol, trichloro-
115-29-7	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexacloeo-1 ,5,5a,6,9,9a -hexahydro-, 3-oxide
76-44-8	4,7-Methano-1H-indene, 1,4,5,6,7,8, 8-heptachloro-3a,4,7,7a-tetrahydro-
16752-77-5	Methomyl
60-34-4	Methyl hydrazine
624-83-9	Methyl isocyanate
75-86-5	2-Methyllactonitrile
298-00-0	Methyl parathion
86-88-4	alpha-Naphthylthiourea
13463-39-3	Nickel carbonyl
557-19-7	Nickel cyanide
54-11-5†	Nicotine & salts
10102-43-9	Nitric oxide
100-01-6	p-Nitroaniline
10102-44-0	Nitrogen dioxide
62-75-9	N-Nitrosodimethylamine
4549-40-0	N-Nitrosomethylvinylamine
152-16-9	Octamethylpyrophosphoramide
20816-12-0	Osmium tetroxide
145-73-3	7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid
56-38-2	Parathion
131-89-5	Phenol, 2-cyclohexyl-4,6-dinitro-
51-28-5	Phenol, 2,4-dinitro-
534-52-1†	Phenol, 2-methyl-4,6-dinitro-, & salts
88-85-7	Phenol, 2-(1-methylpropyl)-4,6,-dinitro-
62-38-4	Phenylmercury acetate
103-85-5	Phenylthiourea
298-02-2	Phorate
75-44-5	Phosgene
7803-51-2	Phosphine
311-45-5	Phosphoric acid, diethyl 4-nitrophenyl ester
298-04-4	Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio)ethyl] ester
298-02-2	Phosphorodithioic acid, O,O-diethyl S-[(ethylthio)methyl] ester
60-51-5	Phosphorodithioic acid, O,O-dimethyl S-[2-(methylamino)-2-oxoethyl] ester
55-91-4	Phosphorofluoridicacid, bis (1-methylethyl) ester
56-38-2	Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl) ester
297-97-2	Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester
52-85-7	Phosphorothioicacid, O-[4-[(dimethylamino)sulfonyl]phenyl] O,O-dimethylester
298-00 0	Phosphorothioic acid, O,O-dimethyl O-(4-nitrophenyl) ester
78-00-2	Plumbane, tetraethyl-
51-50-8	Potassium cyanide
06-61-6	Potassium silver cyanide
16-06-3	Propanal, 2-methyl-2-(methylthio)-, O-[(methylamino)carbonyl]oxime
107-12-0	Propanenitrile
542-76-7	Propanenitrile, 3-chloro-
75-86-5	Propanenitrile, 2-hydroxy-2-methyl-
598-31-2	2-Propanone, 1-bromo-
107-19-7	Propargyl alcohol
107-02-8	2-Propenal
107-18-6	2-Propen-1-ol
75-55-8	1,2-Propylenimine
107-19-7	2-Propyn-1-ol
504-24-5	4-Pyridinamine
54-11-5†	Pyridine, 3-(1- methyl-2-pyrrolidinyl)-, (S)-, & salts

CAS Number	Name
12039-52-0	Selenious acid, dithallium(1 +) salt
630-10-4	Selenourea
506-64-9	Silver cyanide
26628-22-8	Sodium azide
143-33-9	Sodium cyanide
1314-96-1	Strontium sulfide SrS
157-24-9	Strychnidin-10-one, & salts
357-57-3	Strychnidin-10-one, 2,3-dimethoxy-
57-24-9†	Strychnine & salts
7446-18-6	Sulfuric acid, dithallium(1+) salt
3689-24-5	Tetraethyldithiopyrophosphate
78-00-2	Tetraethyl lead
107-49-3	Tetraethyl pyrophosphate
757-58-4	Tetraphosphoric acid, hexaethyl ester
1314-32-5	Thallic oxide
1314-32-5	Thallium oxide Tl_20_3
12039-52-0	Thallium(l) selenite
7446-18-6	Thallium(l) sulfate
3589-24-5	Thiodiphosphoric acid, tetraethyl ester
39196-18-4	Thiofanox
541-53-7	Thioimidodicarbonic diamide $[(H_2N)C(S)]_2NH$
108-98-5	Thiophenol
79-19-6	Thiosemicarbazide
5344-82-1	Thiourea, (2-chlorophenyl)-
86-88-4	Thiourea, 1-naphthalenyl-
103-85-5	Thiourea, phenyl-
8001-35-2	Toxaphene
75-70-7	Trichloromethanethiol
7803-55-6	Vanadic acid, ammonium salt
1314-62-1	Vanadium oxide V_20_5
314-62-1	Vanadium pentoxide (V_20_5)
549-40-0	Vinylamine, N-methyl-N-nitroso-
81-81-2†	Warfarin & salts
557-21-1	Zinc cyanide
557-21-1	Zinc cyanide $Zn(CN)_2$
1314-84-7	Zinc phosphide Zn_3P_2

† CAS number for parent compound only.

APPENDIX (14) - HAZARDOUS PROPERTIES OF SOME GASES (2 PAGES)

Reference: GN470094 Revision Date: August 5, 2003

Gas Name	Hazardous Properties*	Gas Name	Hazardous Properties*
acetylene	F, (C)	1,1-difluoroethylene	F, (T)
allene	F, (C)	dimethylamine	F, C
ammonia	C	dimethylether	F, (T)
argon	-	2,2-dimethylpropane	F
arsine	T, F	ethane	F
boron trichloride	C	ethylacetylene	F, (C)
borontrifluoride	C	ethylamine	F, C
bromomethane	T, (C)	ethyl chloride	F, (T)
bromotrifluoroethylene	F, T, (C)	ethylene	F
bromotrifluoromethane	(T)	ethylene oxide	F, T
1,3 butadiene	F, (T)	ethyl fluoride	F, (T)
butane	F	fluorine	C
1-butene	F	fluoromethane	F, (T)
cis-2-butene	F	fluoroethane	F, T
trans-2-butene	F	Freon	(T)
1-butyne	F, (C)	germane	F, T
carbon dioxide	(T)	halocarbon (halon), chlorodifluoroethane	F, (T)
carbon monoxide	T, F	halocarbon (halon), chlorotrifluoroethylene	F, (T)
carbon tetrafluoride	(T)	halocarbon (halon), difluoroethane	F, (T)
carbonyl fluoride	C	halocarbon (halon), difluoroethylene	F, (T)
carbonyl sulphide	F, T	halocarbon (halon), methyl fluoride	F, (T)
chlorine	C	halocarbon (halon), tetrafluoroethylene	F, (T)
chlorine trifluoride	C	halocarbon (halon), vinyl chloride	F, (T)
1-chloro-1,1-difluoroethane	F, (T)	halocarbon (halon), vinyl fluoride	F, (T)
chlorodifluoromethane	(T)	halocarbon (halon), others	(T)
chloroethane	F, (T)	helium	-
chloromethane	F, C	hexafluoroacetone	T
chloropentafluoroethane	(T)	hexafluoroethane	(T)
2-chloropropene	F, (T)	hexafluoropropene	T
chlorotrifluoroethylene	F, T	hydrogen	F
chlorotrifluoromethane	(T)	hydrogen bromide	C
cyanogen	T, F	hydrogen chloride	C
cyclopropane	F, T	hydrogen cyanide	T, F
deuterium	F	hydrogen fluoride	C
diborane	F, T	hydrogen iodide	C
dibromodifluoromethane	(T)	hydrogen selenide	T, F
dichlorodifluoromethane	(T)	hydrogen sulfide	T, F, (C)
dichlorofluoromethane	(T)	hydrogen telluride	T, F
1,2-dichlorotetrafluoroethane	(T)	iodine pentafluoride	C

Gas Name	Hazardous Properties*	Gas Name	Hazardous Properties*
difluorodiazine	T	isobutane	F
1,1-difluoroethane	F, (T)	isobutylene	F, (T)
krypton	-	propene	F
MAPP gas	F	propylene	F
methane	F	propylene oxide	T, F
methanethiol	T, F	propyne	F, (C)
methyl acetylene	F, (C)	silane	F, T
methylamine	F, C	silicon tetrachloride	C
methyl bromide	T, (C)	silicon tetrafluoride	C
2-methyl-1-butene	F, (T)	stibine	T, F
2-methyl-2-butene	F, (T)	sulphur dioxide	C
3-methyl-1-butene	F, (T)	sulphur hexafluoride	(T)
methyl chloride	F, C	sulphur tetrafluoride	C
methyl fluoride	F, T	sulphurylfluoride	T, (C)
methyl mercaptan	T, F	tetrafluoroethylene	F, (T)
2-methylpropane	F	tetrafluorohydrazine	F, T
2-methylpropene	F	town gas	F, T
methyl vinyl ether	F, (T)	trichlorofluoromethane	(T)
natural gas	F	trifluoroiodomethane	T
neon	-	trifluoromethyliodide	T
nitric oxide	C	trifluoromethane	(T)
nitrogen	-	trimethylamine	F, (T), (C)
nitrogen dioxide	C	tungstenhexafluoride	T
nitrogen trifluoride	C, I	vinyl bromide	F, (T), (C)
nltrogen trioxide	C	vinyl chloride	F, T, (C)
nitrousyl chloride	C	vinyl fluoride	F, (T), (C)
nitrous oxlde	(T)	vinyl methyl ether	F, (T)
octafluoro-2-butene	(T)	xenon	-
octafluorocyclobutane	(T)	* **Legend:** C - corrosive (C) - corrosive to a few materials F - flammable T - toxic (T) - toxic in larger amounts	
octafluoropropane	(T)		
oxygen	-		
ozone	T, C		
perfluoro-2-butene	T		
perfluoropropane	(T)		
phosgene	T, C		
phosphine	T, F		
phosphorus pentafluoride	C		
propane	F		

Extracted from: Martin J. Pitt and E. Pitt, *Handbook of Laboratory Waste Disposal*, Ellis Horwood, Ltd., 1985.

APPENDIX (15) – PEROXIDEABLE CHEMICALS

Reference: GN470094 Revision Date: August 5, 2003

Chemicals that can form explosive levels of peroxides without concentration.

Container disposal date is 3 months from open date.

ButadieneaChloropreneb
Divinyl acetyleneIsopropyl ether
Potassium amidePotassium metal
Sodium amideTetrafluoroethylenea
Vinylidene chloridea
When stored as an inhibited liquid monomer (see Table 3 for additional concerns).
When stored as a liquid monomer.

Chemicals that can form explosive levels of peroxides when concentrated (such as by evaporation or distillation).

Container disposal date is 12 months from open date.

AcetalAcetaldehyde
Benzyl alcohol2-Butanol
ChlorofluoroethylenelCumene (isopropylbenzene)
2-Cyclohexen-1-olCyclohexene
CyclopenteneDecahydronaphthalene (decalin)
Diacetylene (butadiyne)Dicyclopentadiene
Diethyl etherDiethylene glycol dimethyl ether (diglyme)
DioxanesEthylene glycol ether acetates (cellosolves)
Furan4-Heptanol
2-HexanolMethyl acetylene
3-Methyl-1-butanol4-Methyl-2-pentanol
Methyl-isobutyl ketone2-Pentanol
4-Pentene-1-ol1-Phenylethanol
2-PhenylethanolTetrahydrofuran
TetrahydronaphthaleneVinyl ethers
Other secondary alcohols
Note: Where potentially peroxideable alcohols are used for purposes that DO NOT involve heating, chemical reaction, bulk evaporation or other activities that may stress the peroxidizable material, (e.g., cleaning optics, laser dye mixing), it is not necessary to track and test the containers for peroxidation.

Chemicals that may autopolymerize (and thus explode) when relatively small quantities of peroxides are formed.

Container disposal date is 24 hours without inhibitor from open date.
Container disposal date is 12 months with inhibitor from open date.

Butadiene (stored as a gas)dChlorobutadiene
ChloroprenedChlorotrifluoroethylen
StyreneTetrafluoroethylened
Vinylidene chloridedVinyl acetate
Vinyl acetyleneVinyl chloride
Vinyl pyridine
Can form explosive levels of peroxides when stored as liquid without inhibitor. When stored as gas, peroxide accumulation may cause autopolymerization.

APPENDIX (16) – APPROVED SOLVENTS LIST

The solvents listed below are the "certain specific" solvents referred to in the Solvent-Contaminated Wipes Section of ESH100.2.ENV.22, "Manage Hazardous Waste at SNL", as "Wipes or rags contaminated with certain specific solvents and used until dry may not be hazardous waste and, therefore, can be thrown in the regular trash." Also listed are some commonly used solvents that are NOT approved.

Acceptable	**Acceptable**	**NOT ACCEPTABLE**
D001 Solvents	F003 Solvents	
ethyl alcohol (ethanol)	acetone	benzene
hexane	cyclohexanone	carbon tetrachloride
isopropyl alcohol (isopropanol)	ethyl acetate	methyl ethyl ketone
mineral spirits	ethyl benzene	methylene chloride
n-propyl alcohol (propanol)	ethyl ether	pyridine
	methanol	toluene
	methyl isobutyl ketone	
	n-butyl alcohol (butanol)	
	xylene	

Contact your Customer Support Team Environmental Protection Liaison for a determination on solvents not listed.

APPENDIX (17) – PROPER USE OF LABORATORY FUME HOODS (PAGE 1 OF 3)

Work Practices for Laboratory Chemical Fume Hoods

No fume hood with a low face velocity can provide complete safety against all events that may occur in the hood, nor provide protection for volatile airborne contaminants with a threshold limit value (TLV) in the low parts per billion range. For more ordinary exposures, a well-designed fume hood in a properly ventilated laboratory can provide adequate protection. However, certain work practices are necessary in order for the hood to perform capably. The following work practices should be followed; more stringent practices may be necessary under some circumstances.

Safe Practices

Members of the Workforce should observe the following safe work practices when using a laboratory fume hood:

- Understand the operation of the fume hood and how the controls function.
- Keep all apparatus at least 6 inches back from the face of the hood, and/or provide an elevated surface with pass through airflow underneath. A tape stripe on the bench surface is a good reminder.
- Be aware of indications that the exhaust hood is not functioning properly, such as low airflow, alarms, inappropriate odors, or other unusual situations. The airflow in fumes hoods is typically set to 100 fpm +/- 10 fpm. Ensure that the airflow is adequate before using the hood. If the air flow is inadequate, call Kirk-Air Co. at 292-6154 to report the situation. Do **not** use LEV equipment when an alarm or warning light activates. Do not mute the audible alarm, and continue to work in the hood when the air flow is below normal. Do not use the hood until it is repaired.
- Lower the hood sash to achieve optimal containment.
- Keep laboratory doors closed unless the laboratory design requires doors to be open.
- Do not store chemicals, equipment, or apparatuses in the hood.
- Keep the slots in the rear of the hood free of obstruction by apparatuses or containers.
- Move the sash slowly to maintain effective airflow.
- Keep the sash completely lowered anytime no “hands-on” part of an experiment is in progress or whenever the hood is unattended.
- Move objects, including hands, in and out of the hood slowly, so as to minimize disturbance to the airflow and consequent decrease in hazard containment.
- Minimize foot traffic past the face of the hood.
- Traps, scrubbers or incinerators should be used to prevent toxic and/or noxious materials from being vented in excessive amounts into the hood exhaust system or the associated house vacuum system (contact 1100 Customer Support Team Industrial Hygienist for guidance).
- Consult the appropriate Customer Support Team member to obtain specific guidance on using LEV equipment.

Members of the Workforce should **not**:

- Put their heads in a laboratory fume hood during generation of contaminants.
- Store chemicals or equipment in a laboratory fume hood.
- Place electrical receptacles or other spark sources inside a laboratory fume hood when flammable liquids or gases are present (**exception:** listed intrinsically safe equipment in accordance with the National Electric Code).
- Load a laboratory fume hood in a manner that could interfere with proper airflow.

APPENDIX (17) – PROPER USE OF LABORATORY FUME HOODS (PAGE 2 OF 3)

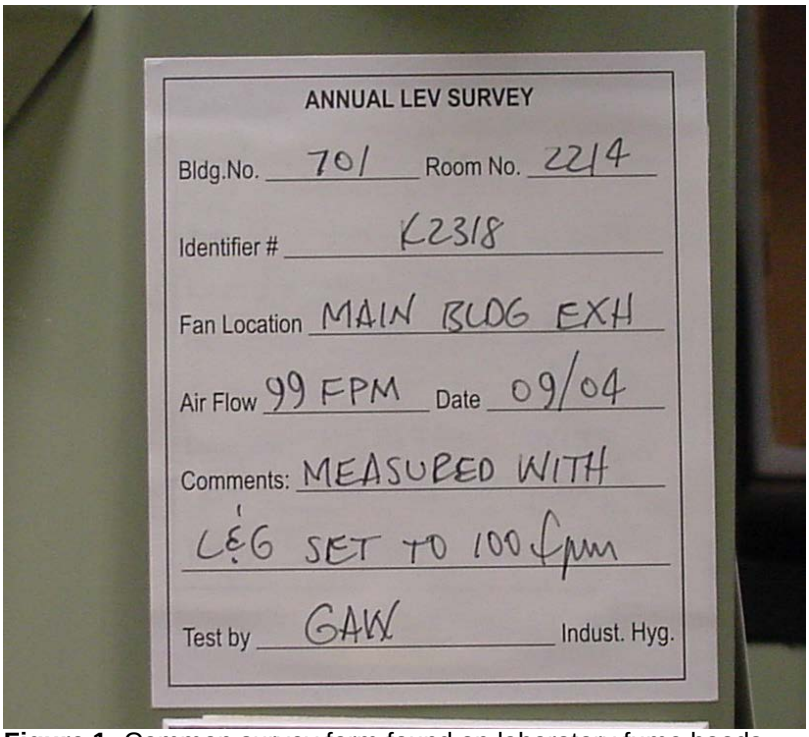

Figure 1: Common survey form found on laboratory fume hoods.
Note: Air flow and date tested (survey good for 1 year from that date).

Figure 2: Sash stop that is installed by the manufacturer on some hoods. This denotes the maximum safe working height of the hood.

APPENDIX (17) – PROPER USE OF LABORATORY FUME HOODS (PAGE 3 OF 3)

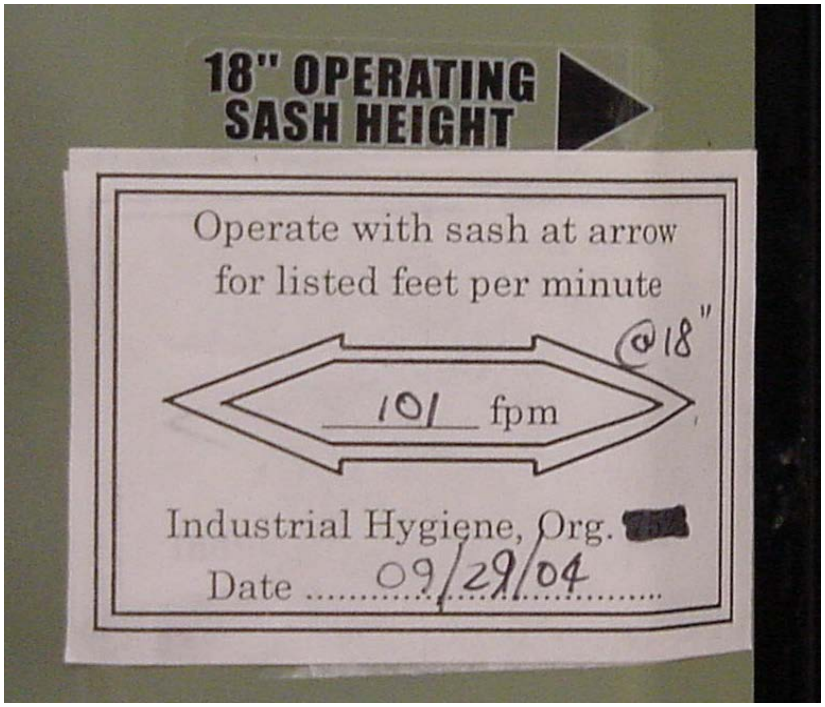

Figure 3: On hoods that do not have a mechanical stops, the safe maximum working height is designated by the arrow.

APPENDIX (18) – SAFE MANAGEMENT OF SHOCK-SENSITIVE CHEMICALS

ENVIRONMENT, SAFETY & HEALTH
SAFETY & HEALTH BULLETIN

Assistant Secretary for Environment, Safety & Health • U.S. Department of Energy • Washington, D.C. 20585
DOE/EH-0197 Issue No. 2003-02 September 2003

Safe Management of Shock-Sensitive Chemicals

What Are Shock- Sensitive Chemicals?

Shock sensitive chemicals may explode with movement, friction or heat. These chemicals have the potential to undergo a rapid reaction that may be violent enough to produce an explosive reaction. Some chemicals are shock sensitive by nature. Others become shock sensitive through drying, decomposition, or slow reactions with oxygen, nitrogen, or the container. Some chemicals that are or may become shock-sensitive will have this hazard noted on their MSDS.

What Can Happen?

Between 1980 and 2002 there were 167 accidents nationally involving shock-sensitive chemicals that killed 108 people.

- A technician used a pair of channel lock pliers to twist the rusty lid off a small, dark green, bottle to characterize the unknown chemicals inside. There was an immediate explosion and glass shards embedded in a nearby chair. Analysis showed that over time the picric acid in the bottle combined with the metal lid to form shock-sensitive metal picrates that lodged in the threads in the neck of the bottle.

- A technician was remotely handling an old, opened can of anesthesia grade ethyl ether to add more ethyl alcohol as an inhibitor. Enough inhibitor was thought to be present, so the ether was not considered hazardous. The liquid level in the small metal can was low so the technician tilted the can to pipette out an aliquot for the peroxide test strip. As the technician turned the can upright, an immediate explosion and fireball filled the fume hood. The slight handling of the can was enough of a mechanical shock to cause peroxide crystals in the top portion of the can to explode.

Tips to Control the Hazards

Respect the chemical and the dangers it presents:

- If you find shock-sensitive chemicals that are outdated or suspect, immediately contact your supervisor and your organization's ES&H or Hazardous Materials department. DO NOT TOUCH OR MOVE SUSPECT CHEMICALS.

- When working with shock-sensitive chemicals:
  - Closely follow approved work procedures and hazard controls.
  - Study the chemical's MSDS and label. Look for information about the chemical's reactivity, stability and hazards. If there is an NFPA diamond, look for a 2, 3, or 4 in the yellow reactivity section. Also use information from other chemical safety resources.
  - Check with your facility's chemical safety personnel.
  - Use appropriate personal protective equipment (PPE).
  - Protect the chemical from shock, friction or heating.

- Make sure that you have access to the MSDS, the chemical is labeled as required by your facility, and the container is entered into your facility's hazardous chemical management program.

Strategies to Improve the Management of Shock-Sensitive Chemicals

The two main types of shock-sensitive chemicals within the DOE complex are peroxide formers and peroxidizable organic chemicals. The chemistry and management of these and other shock-sensitive chemicals is not well understood. Effective management of these chemicals is a challenge because: 1) there is no absolute answer as to what should or should not be defined as being shock-sensitive, 2) detection methods for potentially explosive concentration levels are not definitive and 3) procedures for removing peroxides are not always effective.

Safe and healthful working environments at facilities that use or store shock-sensitive chemicals can be enhanced by an effective life-cycle management system that includes the following basic elements and written guidance:

- **Acquisition control:** 1) Prior to procurement – follow internal criteria to identify shock-sensitive chemicals; ensure that facilities are rated for explosives work, receivers are authorized and trained for work with shock-sensitive chemicals, and any required authorizations are in place; and determine the disposal path; 2) At procurement – limit to the quantity that can be used before shelf-life is reached.

- **MSDS and Labels:** Incorporate MSDS and label information about hazards and safe handling into work procedures. Add labeling that includes the date received, date opened, responsible person, expiration date, MSDS reference or other appropriate data.

- **Usage:** Implement procedures that define the parameters for testing and safe use of shock-sensitive chemicals.

- **Storage:** Adhere to the manufacturer's recommendations, noting any precautions on the MSDS and label. Ensure that systems are implemented for inspecting, testing and solvating the chemicals.

- **Tracking:** Maintain a current shock-sensitive chemical inventory that tracks locations, inspection dates, etc., from procurement through disposal. Include chemicals created on-site and those not acquired through the acquisition process. Provide for notification if threshold quantities are exceeded.

- **Training:** Ensure that employees are adequately trained on the hazards, safe working methods, and emergency procedures for shock-sensitive chemicals.

- **Disposal:** Establish criteria and procedures for the safe and timely disposal of shock-sensitive chemicals.

- **Review and Verification:** Develop a system to evaluate and verify that the program for managing shock-sensitive chemicals is effective.

For additional information or clarification on the content of this Bulletin, please contact:
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This Safety & Health Bulletin is one in a series of publications issued by EH to share occupational safety and health information throughout the DOE complex. For additional information regarding the publications, call Mary Cunningham at (301) 903-2072

APPENDIX (19) - COMMON GLOVE CHART

"What kind of glove should I wear?" Adapted from the University of California, San Diego

Hazard Assessment

The first step in choosing a glove is identifying the hazards involved in your work. If you have any questions about the hazards of the chemicals you work with, contact your Center ES&H Coordinator or the 1100 Customer Support Team Industrial Hygienist for help with identifying chemical hazards. They will help you find the information necessary to choose a glove that will provide adequate protection.

Disposable versus Re-usable Gloves

The first task is to decide if single use, surgical type gloves will provide adequate protection. Reusable gloves are necessary wherever there is heavy contact with chemicals, immersion in chemicals or potential for contact with extremely hazardous chemicals. Disposable gloves can provide protection against splashes and incidental chemical contact. There are a variety of disposable gloves suitable for use in laboratories, but in general the surgical type nitrile gloves are the best choice for general lab usage. These gloves provide good chemical protection from a variety of organic and inorganic chemicals. Latex gloves provide little chemical protection. REMEMBER: Surgical type gloves do not provide the same degree of chemical protection as reusable gloves.

Degradation, Permeation Rate, and Breakthrough Time

If your work involves heavy contact or immersion in chemicals, or if the materials are extremely hazardous, you should choose a re-usable glove that is effective for the materials you will be using. The effectiveness of a glove is measured in terms of:

- **Degradation** - a change in the physical characteristics of the glove caused by contact with the chemical

- **Permeation** - the speed at which a chemical penetrates the glove materials

- **Breakthrough time** - the elapsed time between initial contact and the first detection of the chemical inside the glove.

Each of these properties must be considered when selecting chemically protective gloves.

Manufacturers provide charts which lists the performance characteristics of a glove material to a given chemical. These charts can be found on the internet by searching for “glove compatibility”. Here is a typical link: http://www.ehs.ufl.edu/Lab/CHP/gloves.htm . No singe type of glove can provide 100% protection from all chemicals.

Degradation appears as swelling, softening, cracking, or other change in appearance. Degradation tests vary with each manufacturer and it is important to consult each manufacturer's glove chart. If the chemical has little degrading effects on the glove material, the manufacturer assigns an "Excellent" rating to the material. "Good", "Fair", "Poor", and "Not Recommended"

ratings are assigned depending on the degree of degradation. The permeation rate and breakthrough time are also provided by the manufacturer.

Once a chemical has begun to diffuse into a glove, it will continue to diffuse into the elastomer even after the chemical on the surface is removed because of the concentration gradient that develops within the protective glove. Extreme caution is advised when re-using any chemical protective clothing that has been exposed to highly toxic chemicals.

Inspection and Maintenance of Reusable Gloves

All gloves should be inspected before and after each use, and periodically while in use. The gloves should be examined for any holes or punctures, signs of degradation, or signs of prior contamination or breakthrough. If the integrity of the gloves is in question, they should be replaced immediately. The outside surface of the gloves should be washed after removal and air-dried in the laboratory. Disposable gloves should be changed frequently.
Major Glove Types and Uses:

Butyl Rubber	Good for many organics, ketones, esters; Poor for aliphatic, aromatic hydrocarbons, halogenated hydrocarbons, gasoline
Natural (Latex) Rubber	Good for very dilute acids and bases; Poor for organics
Neoprene	Good for acids and bases, peroxides, fuels, hydrocarbons, alcohols, phenols; Poor for halogenated and aromatic hydrocarbons
Polyvinyl chloride (PVC)	Good for acids and bases, some organics, amines, and peroxides; Poor for most organics
Polyvinyl alcohol (PVA)	Good for aromatic and chlorinated solvents; Poor for water-based solutions- water destroys the gloves!
Silver Shield™	Good for wide variety of toxic and hazardous chemicals; provides the highest level of chemical resistance. Flexible laminate glove; Poor fit- comes in small, medium, large
4H™	Good resistance to many chemicals; better dexterity than Silver Shield™
Nitrile	Good for wide variety of solvents, oils, greases, some acids and bases.
Viton	Exceptional resistance to chlorinated and aromatic solvents; good resistance to cuts and abrasions.

There is no protective glove that is impermeable. No one material affords protection against all chemicals. For certain chemicals, there are no materials that will protect for more than an hour after initial contact; AND, LATEX GLOVES PROVIDE LITTLE TO NO CHEMICAL PROTECTION. Even with these limitations, chemical protective gloves are still the most important type of personal protective equipment for laboratory workers. Appropriate glove use can protect workers from a range of exposures, but inappropriate glove use can sometimes be fatal.

Contact your Center ES&H Coordinator or Center Industrial Hygienist for assistance in selecting gloves if you are not able to determine the appropriate glove for your situation.

ATTACHMENT (A)

Center 1100

Justification for Retention of Peroxideable Chemicals Form

Area/Lab/Bld/Rm		***DATE***	
Owner		***Org***	
PHS #			

Barcode	***Chemical(s)***	***Justification/Mitigation***	***Estimated Disposal Date***
AQXXXXX	*Chemical Name*	*Justification for retention, explain why it is safe to do so*	

I certify that the chemicals listed above are in a safe condition and will continue to be stored and used in a safe manner. The material will be consumed, or disposed of as soon as it is no longer needed. Should any indication of degradation be seen, the Center ES&H Coordinator, the Division Environmental Protection team, and Emergency Operations Center (if needed) will be notified to assist with appropriate disposal.

_____ _____
Lab/Chemical Owner Date

_____ _____
Manager Signature Date

Submit signed form to Division ESS&H Office, MS0513 for final approval.

Retention Approved	☐	**REJECTED**	☐

_____ _____
Division ESS&H Manager Signature Date

File copy of Approved form in lab LON – copy to Center 1100 ES&H Coordinat

ATTACHMENT (B)

STANDARD OPERATING PROCEDURE for WORKING WITH HAZARDOUS and PARTICULARLY HAZARDOUS CHEMICALS in CENTER 1100 LABORATORIES

AUTHORIZED USERS' LIST for lab _____ Org _____

By my signature below, I affirm that I:

- have read and understand this operating procedure (SOP) entitled *Standard Operating Procedure for Working with Hazardous and Particularly Hazardous Chemicals in Center 1100.*
- will review MSDS documents associated with the chemicals that I will work with and follow the recommended requirements.
- will take CHM100 and CHM103 training before working in this laboratory or other Center 1100 laboratories.
- will take other ES&H training as specified by my manager or his delegate before working with the associated hazards in this laboratory or other Center 1100 laboratories, and I agree to operate within the stated constraints.

Name (printed)	Signature	Org	Date
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