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Safe Handling of Carcinogenic Materials

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Safe Handling of Carcinogenic Materials

1.0 Introduction

Carcinogens may only be used in Laboratory operations when it is not possible to use a noncarcinogenic material. Any use of carcinogens requires stringent controls to be in place to prevent exposures to workers, the public, and the environment.

This document contains controls for carcinogens used in laboratories and nonlaboratories (defined in Appendix A).

- Brazing with cadmium-containing alloys or grinding of cadmium-coated workpieces.
- Work that generates or involves contact with soots and tars, including coal gasification; use of mineral oil products that may contain polyaromatic hydrocarbons; work performed in close proximity to diesel engines running indoors; electric arc discharge machining; and discharging of gas propellants in a vacuum.
- Handling refractory ceramic fibers.
- Welding stainless steels (due to the formation of hexavalent chromium compounds and nickel oxide).
- Chromium plating and other operations that disperse hexavalent chromium compounds or irritatingly strong concentrations of sulfuric acid into the air.
- Generating hard wood dust including carpentry and cabinet making.
- Spray application of hexavalent chromium compounds including, but not limited to, primers, paints, and sealants containing barium, calcium, sodium, strontium, or zinc chromate.
- Handling inorganic arsenic compounds and arsenic metal, including gallium arsenide, in a manner that can result in an exposure to arsenic.
- Animal handling in research activities involving carcinogens.
- Use or synthesis of carcinogens in chemistry or biochemistry laboratories.

The controls in this document do not apply to activities involving the materials listed below.

- **Asbestos.** Detailed procedures for asbestos work can be found in Document 14.9, "Safe Handling of Asbestos-Containing Material during Construction Work," in the *ES&H Manual*.
- **Beryllium.** Precautions for this material are given in Document 14.4, "Implementation of the Chronic Beryllium Disease Prevention Program Requirements," in the *ES&H Manual*.
- **Laser dyes.** These are sometimes treated as potential carcinogens, based on in vitro testing and structure-activity relationships. Precautions for laser dyes are given in Document 14.11, "Laser Dyes," in the *ES&H Manual*.
- **Lead and lead compounds, except lead acetate and lead phosphate when they are used in laboratories.** Metallic lead is not a carcinogenic hazard if exposures are held to levels that prevent toxic effects. Precautions for lead work are specified in Document 14.10, "Safe Handling of Lead and Lead Compounds in General Industry and Construction Operations," in the *ES&H Manual*.

This document does not apply to pharmaceuticals used as such or food flavorings or additives.

It is recognized that the scientific basis for establishing controls for carcinogens is incomplete and that OSHA standards-setting process is influenced by nonscientific considerations. These constraints were taken into consideration during development of the controls specified in this document.

2.0 Hazards

Carcinogens are materials or agents capable of causing or producing cancer in mammals, including humans.

3.0 Controls to be Implemented prior to Beginning Work with Carcinogens

People who work in laboratories may encounter small quantities of many materials, including carcinogens, while those who work in nonlaboratories may encounter larger quantities of fewer materials and carcinogens. Therefore, specific controls apply to laboratories and nonlaboratories (see Section 5.0 and 6.0, respectively).

The Responsible Individual (RI) shall ensure that all controls specified in this document and summarized in Appendix B are in place before starting work with carcinogens. Note that some limitations and exceptions may be permitted as defined in a governing safety plan (Facility Safety Plan, FSP, or Integration Work Sheet with Safety Plan, IWS/SP).

3.1 Identify Carcinogens

The sources listed below are used to identify carcinogens. They are updated annually, and copies can be obtained from Hazards Control Department.

- Table 1 contains OSHA-regulated materials that have specific work practices and handling requirements. The area ES&H Team can provide compliance information if any of these materials are to be used in circumstances where exposure to airborne particles or vapor is possible.

Table 1. OSHA-regulated materials.^a

Materials requiring exposure monitoring	Materials that <i>do not</i> require air monitoring ^b
Acrylonitrile	2-Acetylaminofluorene
Arsenic, inorganic	4-Aminodiphenyl
Asbestos ^c	Benzidine
Benzene	Bis(chloromethyl) ether
1,3-Butadiene	3,3'-Dichlorobenzidine (and its salts)
Cadmium	4-Dimethylaminoazobenzene
Coal tar pitch volatiles ^d	Ethyleneimine
1,2-Dibromo-3-chloropropane	Methyl chloromethyl ether
Ethylene oxide	1-Naphthylamine
Formaldehyde	2-Naphthylamine
Lead ^e	4-Nitrobiphenyl
Methylene chloride	N-nitrosodimethylamine
4,4'-Methylene dianiline	
Vinyl chloride	
2-Propiolactone ^f	

^a OSHA requires exposure monitoring for the materials in the first column but not for the materials in the second. For more details about these materials, contact the area ES&H Team or refer to 29 CFR 1910.1001–1048. 2-Propiolactone in the first column and the materials in the second column are addressed by one standard, 29 CFR 1910.1003. There are comparable OSHA regulations for construction in 29 CFR 1926, Subpart Z.

^b Glove boxes may be needed to handle the materials listed in this column as well as 2-propiolactone. The original intent of OSHA was to reduce exposures to as close to zero as possible.

^c Document 14.9 of the *ES&H Manual* contains guidance about asbestos.

^d Similar chemistry applies to coal gasification, oil-shale research, or burning of gun propellants in vacuum.

^e Document 14.10 of the *ES&H Manual* contains guidance about lead.

^f OSHA did not establish a permissible exposure limit or monitoring requirements for this substance, but an ACGIH threshold limit value for it was subsequently adopted.

- The LLNL-controlled Carcinogen List for Laboratories contains OSHA-select carcinogens (see Appendix A for definition) and materials rated as A1 or A2 carcinogens by the American Conference of Governmental Industrial Hygienists (ACGIH).
- The LLNL-controlled Carcinogen List for Nonlaboratories includes the following:
 - Materials listed in Table 1, which are addressed by OSHA material-specific regulations.
 - Materials rated by the ACGIH as A1, "Confirmed Human Carcinogen," and A2, "Suspected Human Carcinogen" carcinogens.
 - Materials rated by the International Agency for Research on Cancer (IARC) as Group 1, "Carcinogenic to Humans" carcinogens. Note that the IARC Group 4 agent or an ACGIH category A5 agent is probably not carcinogenic to humans.
 - Materials rated by the National Toxicology Program (NTP) that are "known to be carcinogenic."
 - Other materials for which substantial evidence shows that they are a carcinogen hazard.

Materials can be added to (or deleted from) the LLNL-controlled Carcinogen List for Nonlaboratories, except for those listed in Table 1, based on a technical review conducted by the Hazards Control Department.

The following controls shall be implemented for the materials in Table 1 and those on both the LLNL List of Controlled Carcinogens for Nonlaboratories and the LLNL List of Controlled Carcinogens for Laboratories:

- The controls for laboratories specified in Section 5.0.
- The controls for nonlaboratories specified in Section 6.0.
- Documentation requirements for hazardous waste disposal.
- An evaluation of any material on the LLNL-controlled Carcinogen List or any material in Table 1 with an Occupational Exposure Limit (OEL) to determine personnel exposure. This may include personal breathing and air sampling. See Sections 5.0 and 6.0 for details.

Internet addresses for organizations rating carcinogens as well as other carcinogen-related uniform resource locators (URLs) are given in Section 10.3 of this document.

3.2 Analyze the Hazards of the Work

RI in laboratories shall screen new materials using the LLNL List of Controlled Carcinogens for Laboratories. For nonlaboratories, use the information on the material safety data sheet (MSDS), product label, or vendor's literature to determine if a potential carcinogen is present as well as the LLNL List of Controlled Carcinogens for Nonlaboratories. OSHA requires that potential carcinogens in concentrations greater than 0.1% be listed on the MSDS. If the MSDS indicates that the material is a carcinogen, then it shall be screened using the LLNL-controlled Carcinogen List for nonlaboratories.

The RI shall analyze operations involving carcinogens to determine the hazard(s) involved and the applicable controls. The formality of the analysis depends on the type of carcinogen involved (e.g., human or other) and the complexity of the operation. Some operations may require a detailed analysis to determine if additional controls are necessary. An analysis is not required for carcinogens kept in storage if the reactive and physical hazards (e.g., flammability) and storage concerns (e.g., leaks due to corrosion of containers) are adequately addressed.

Following are elements to consider during the analysis:

- Material
 - Physical properties that enhance the material's dispersion and its entry into the body by contaminating surfaces or being available as a gas, vapor, fume, mist, liquid, or dust. For example, use of block solid materials may not require a ventilated enclosure, but use of a fine powder or gas may require a working in a hood.
 - Other hazards of the material such as flammability, reactivity, or other toxic properties.
- Operation
 - The quantity of material involved.
 - Duration and frequency of exposures.
 - Route of exposure (inhalation, skin, ingestion, subcutaneous, or combination).
 - Aspects of the process that can increase exposure potential such as grinding a solid into a powder, heating a liquid to evaporate it, or spreading material on surfaces.
 - Parts of the body or portions of a person's clothing that could be splashed or become soiled during routine work or credible mishaps.

3.3 Required Documentation

Work procedures are required for certain activities involving carcinogens, as shown in Appendix B. Work with carcinogens beyond the scale and controls specified on the governing Hazard Assessment and Control (HAC) form or in the safety plan shall be reviewed by the ES&H Team industrial hygienist and documented in a revised hazard assessment. HAC forms are described in Document 11.1, "Personal Protective Equipment," in the *ES&H Manual*. Forms of documentation are described in the subsections following.

3.3.1 Integration Work Sheet

The IWS helps workers identify the hazards and controls for a specific activity. It also may address other hazards. Document 2.2, "Managing ES&H for LLNL Work," in the *ES&H Manual* contains a blank IWS with instructions for completing it.

An IWS shall be completed for any operation where a material listed on either the LLNL-Controlled Carcinogen List for laboratories or nonlaboratories will be used. The RI shall determine if a Safety Plan is needed when preparing the IWS. See Section 5.1.2 of this document for operations in laboratories that require only an IWS. An IWS is required for operations in nonlaboratories involving materials for which there is no OEL and for materials covered by an OEL if exposure could exceed 1/2 the established OEL.

3.3.2 Hazard Assessments

A HAC form, prepared by the area ES&H Team industrial hygienist and signed by the RI, can be used to document carcinogen operations. HAC forms are not work authorization documents; IWSs are used to authorize work. HACs are prepared to provide a more detailed description of the controls necessary for specific work activities. HAC forms shall be prepared in accordance with the requirements of Document 11.1. It is noted that the Work Authorization Level for an operation, as defined in Document 2.2 will be increased to level 4 if the HAC specifies controls beyond those specified in the *ES&H Manual*, and that these additional controls will need to be incorporated in the applicable IWS.

3.3.3 Safety Plan

A safety plan (FSP or IWS/SP) is required for carcinogen operations that have high hazard potential, as determined by the IWS or based on guidance developed by the authorizing organization. The characteristics that define a high hazard potential operation for laboratories are found in Section 5.0 of this document. The ES&H Team

industrial hygienist shall advise the RI about documentation requirements for carcinogen use in nonlaboratories.

3.3.4 Emergency Response Plan

An Emergency Response Plan is required for all operations involving carcinogens where there is a reasonable risk of exposure. Document 3.3, " Facility Safety Plans and Integration Work Sheets with Safety Plans," in the *ES&H Manual* specifies how Emergency Response Plans are incorporated in SPs. Emergency Response Plans shall contain instructions for

- Providing care for the injured or exposed personnel.
- Addressing spills, exposures, and accidents.
- Evacuating the area and contacting the Fire Department.
- Restricting access to the area.
- Showering, washing, and obtaining immediate medical attention. (A decontamination facility is located in the Health Services Department and is used to decontaminate workers who are transported there.)
- Eliminating hazards that may still exist.
- Decontaminating the area or equipment to ensure that all toxic or carcinogenic materials are destroyed or removed.

This plan can be included in HAC forms, or safety plans, as appropriate. Some of these plans may not be appropriate for certain nonlaboratory activities such as spill cleanup for rolls of cadmium brazing alloy wire (see Appendix A for definitions of "laboratory" and "nonlaboratory"). A statement indicating that the issue was considered and found to be inappropriate for inclusion in written documentation will suffice when placed in other ES&H documentation or, if such documentation does not exist, a memo to file. An Emergency Response Plan for carcinogens can be included as part of a broader emergency response plan, if appropriate.

3.4 Waste Disposal

An evaluation of the waste stream shall be conducted prior to the start of operations to determine if the waste to be generated needs to be managed as hazardous. The State of California regulates 16 carcinogens as hazardous wastes if any are present in a waste in excess of 0.001 percent by weight (10 ppm). In addition, other substances which have "...been shown through experience or testing to pose a hazard to human health or environment because of its carcinogenicity" need to be managed as hazardous waste. For assistance in this determination, contact your area ES&H Team environmental analyst.

If the determination is made that the waste is hazardous, it shall be managed and handled in accordance with Document 36.1, "Hazardous, Radioactive, and Biological Waste Management Requirements," in the *ES&H Manual*.

3.5 Training

Carcinogen workers shall receive training in accordance with Document 14.2, "LLNL Chemical Hygiene Plan for Laboratories," and Document 10.2, "LLNL Health Hazard Communication Program," in the *ES&H Manual*.

Prior to beginning work and when a new carcinogen hazard is introduced, RIs shall review the applicable IWS, HAC form or safety plan for carcinogens with their workers. They also shall assure that workers are aware of the following:

- The carcinogens in use.
- The existence and availability of OSHA substance-specific standards for the carcinogens listed in Table 1, if applicable.
- The exposure limits for any materials which are covered by an OEL.

New hires shall receive carcinogen training as part of their work familiarization process.

Personnel who generate waste that contains a carcinogen that has been determined to be hazardous waste need to take the training course EP0006-COR, Hazardous Waste Generation and Certification Core Training. After the initial training, such individuals are required to annually complete the training course EP0006(HZRW), Hazardous Waste Generation and Certification Module Refresher. These courses will train waste generators on the proper method for managing hazardous waste including proper collection, labeling, and documentation.

3.6 Prestart Review

A documented management prestart review is required to authorize carcinogen work described in a safety plan (see Document 2.2 for details). A prestart review shall be conducted for all operations involving carcinogens in accordance with Chapter 2.

Once authorized, continued routine use of carcinogens is generally permitted, provided that the controls specified on the HAC form, in the safety plan, and in *ES&H Manual* are followed and classes of hazards are not added or the operation scaled up. Periodic reviews should be conducted to confirm continued implementation of controls.

3.7 Medical Surveillance

Medical surveillance shall be conducted for workers involved in planned carcinogen operations who may be potentially exposed above applicable OELs. Other personnel who have unusual exposure conditions also may require medical surveillance. The RI, on advice from the area ES&H Team, shall notify Health Services of these workers in accordance with organizational Integrated Safety Management (ISM) practice. The RI also shall contact Health Services if a worker is exposed to or there is a mishap that involves a carcinogen. The payroll supervisor is responsible for ensuring that workers receive medical surveillance in accordance with Document 10.1, "Occupational Medical Program," in the *ES&H Manual*.

Examinations and consultations are available to workers with work-related health concerns upon request.

4.0 Controls Common to both Laboratories and NonLaboratories

4.1 Administrative Controls

4.1.1 Acquiring and Purchasing Carcinogens

Acquisition limitations for Table 1 carcinogens have been established to ensure that prospective users adhere to ES&H requirements. Procurement and Materiel's Controlled Items List contains items that require review by an ES&H Team industrial hygienist. For online requisitions and releases, Procurement and Materiel electronically forwards the procurement action to Hazards Control for review by Industrial Hygiene prior to purchase. Industrial Hygiene has one day to review the procurement request and, if necessary, deny the purchase. For Unicard purchases, the Technical Release Representative (TRR) shall request approval directly from Hazards Control.

Procurement and Materiel's Controlled Items List can be found at the following Internet address:

<http://www-r.llnl.gov/pm/trr/html/controlitem.html>

4.1.2 Receiving Carcinogens

Carcinogens shall enter the Livermore site through the Receiving Section of the Materials Distribution Division (MDD), Procurement and Materiel Department.

Carcinogens shipped to Site 300 shall enter through MDD's Shipping and Receiving Group.

4.1.3 Labeling, Packaging, and Storing Carcinogens

Labeling. Carcinogen containers shall be labeled indicating their contents. Note that the manufacturer's original label on these containers usually includes a cancer hazard warning that shall be sufficient for this purpose. The ChemTrack label is also attached to the container label. Carcinogen labels shall be placed on all primary and secondary containers with carcinogens, whenever feasible. The label shall be applied on the tray the container is in, affixed to the container with a wire, etc., if it is not feasible to place it on the primary or secondary container.

Packaging and Storage. Carcinogens shall be packaged to withstand shocks, pressure changes, or any other condition that may cause leakage of contents. These materials shall be stored in designated areas, cabinets, or refrigerators within the primary work or storage area. Precautions also shall be taken to protect the materials from rodents, weather, incompatible chemicals, and spillage. Additional storage requirements (e.g., use of double containers) may be necessary for highly potent carcinogens with physical properties that enhance spontaneous release and exposure (e.g., highly dispersible powders or volatile materials). The physical and reactive properties of the carcinogen shall be foremost in establishing storage conditions. See Sections 5.1.2, 5.2.2, 5.3.2, and 6.2.2 for guidance on packaging and storing carcinogens, or contact your area ES&H Team for more information.

4.2 Engineered Controls

Engineered controls shall be used to minimize exposure to carcinogens, whenever practical. Controls specific to laboratories and nonlaboratories can be found in Sections 5.0 and 6.0 of this document, respectively.

Ventilation is an important engineered control for both laboratories and nonlaboratories. See the following documents in Volume II of the *ES&H Manual* for details:

- Document 12.2, "Ventilation".
- Document 12.3, "Evaluation and Control of Facility Airborne Effluents".
- Document 12.4, "Work Enclosures and Local Exhaust Systems for Toxic and Radioactive Materials".
- Document 12.5, "High-Efficiency Particulate Air (HEPA) Filter System Design for LLNL Applications".

4.3 Access Limitation

Access limitation requirements in Sections 5 and 6 in this document shall not be taken as grounds to exclude ES&H personnel from access to carcinogen work areas.

5.0 Controls Specific to Laboratories

The material's ability to penetrate through intact skin, chemical properties that affect the material's toxic action in the body due to its solubility in water or lipids, and the ability of the carcinogen or materials it is mixed with to permeate through protective clothing materials shall be considered.

Hazard Potential of Carcinogen Operations. Carcinogen operations performed in laboratories are classified as having a low, medium, or high hazard potential. The controls specified in this section are based on hazard analyses conducted for such operations and shall be applied using a graded approach—with the highest consideration given to OSHA-regulated and known human carcinogens. The hazard potential of the operation is used to select controls using a tailored approach based on these considerations, as described in Table 2:

- Complexity: The operation involves multiple steps and/or complex manipulations in which the risk of error is substantially increased.
- Quantity of carcinogens.
- Risk of exposure/release: The chance of worker or public exposure or release into the working or general environment is increased by the use or creation of dispersible forms of carcinogenic materials or by increasing the risk of skin exposure. Solid manufactured articles that will remain intact and have little potential for exposure usually are exempt from medium-hazard and high-hazard potential controls.

Additional controls shall be required for operations involving additional hazards such as flammability or reactivity.

The RI shall determine the hazard potential category and necessary documentation of a planned operation involving carcinogens with the concurrence of the area ES&H Team industrial hygienist during the process of completing the IWS.

Table 2. Criteria for hazard levels of carcinogen operations in laboratories.

Hazard Potential Category	Criteria ^a
Low hazard	<ul style="list-style-type: none"> • Simple operations involving a few easily performed steps. • Extremely small quantities of carcinogens other than those listed in Table 1 are in use. • Extremely limited exposure hazard: <ul style="list-style-type: none"> — inhalation hazard: Material is in solid form or is a low vapor pressure (nonvolatile) liquid and will not be changed to dust, mist, fume, vapor, or gas. — Extremely limited or no skin contact; no chance of being cut by material; material cannot penetrate through intact skin.
Medium hazard	<ul style="list-style-type: none"> • Modestly complex operations involving more than a few steps and/or moderately difficult steps. • Extremely small or small quantities of materials listed in Table 1 or small quantities of the LLNL List of Controlled Carcinogens for Laboratories are in use • Limited exposure hazard: <ul style="list-style-type: none"> — Inhalation hazard: Material is a coarse solid or moderate vapor pressure liquid; operation will not increase dispersability of the material nor will wet methods decrease dispersability. — Skin contact or risk of being cut by material is limited; material cannot penetrate through intact skin.
High hazard	<ul style="list-style-type: none"> • Highly complex operations involving many steps and/or difficult procedures. • Moderate or large quantities of materials listed in Table 1 or the LLNL List of Controlled Carcinogens for Laboratories are in use. • Moderate exposure hazard: <ul style="list-style-type: none"> — Inhalation hazard: Fine dust, mist, gas, or vapor from high vapor pressure liquid; operation increases dispersability or material is handled/processed in a manner that increases dispersability. — Skin contact or risk of being cut by material is moderate; material can penetrate through intact skin.

^a The terms "extremely small," "small," "moderate," "large," "extremely limited," "limited," "moderate," and "high" are left undefined so judgment can be applied. Call the area ES&H Team industrial hygienist for assistance if in doubt.

5.1 Low-hazard Potential Operations

5.1.1 Engineered Controls

Any of the following controls shall be used if it will reduce exposures:

- Use ducted hoods; avoid using "ductless" hoods.
- Design any containment device for carcinogens to minimize worker exposure to carcinogens while performing work, including maintenance and decontamination activities.

- Minimize or eliminate potential leak points (e.g., line breaks, container openings, and gaps in equipment housings), or provide spill-catching pans and splash shields for liquids when such gaps cannot be avoided as well as exhaust ventilation for gases and vapors. Use secondary containment trays.
- Use the lowest practical operating pressures for carcinogenic liquids and gases.
- Make sure that the following are available:
 - An area for workers to wash their hands and face, as well as a shower/eyewash station. Requirements for training the users of eyewashes/safety showers are found in Section 3.1.3 of Document 10.2 (for non-laboratory situations), and Section 3.2.6 of Document 14.2 (for laboratory situations). Requirements for the testing safety showers/eyewashes are specified in Appendix B of Document 14.1, "LLNL Chemical Safety Management Program," in the *ES&H Manual*. Engineering specifications are found in LLNL Facility Standard PEL-M-11610, "Emergency Eyewash & Shower Units."
 - A minimum general ventilation of 20 cfm of fresh air per person. Note that this air should not be recirculated.
- Select surfaces for easy cleanup and decontamination. Minimize cracks, crevices, seams, porous surfaces, and places that are hard to reach with cleaning equipment.

5.1.2 Administrative Controls

Documentation

Activities that fall in the Low-hazard Potential category require only an IWS. Table 3 lists activities that have been identified as only requiring an IWS. A HAC form may be prepared to supplement the IWS, if needed. Specific handling procedures may also be developed, as needed, in accordance with Document 3.4, "Preparation of Work Procedures," in the *ES&H Manual*.

Signs and Warning Labels

- Post appropriate warning signs at entrances while carcinogen operations are in progress. See Appendix C for examples of signs used for this purpose.

The carcinogen box shall be filled in on the Health Hazard Communication Notice Door Sign, as a minimum. Warning signs shall be conspicuously posted on or near entrances to carcinogen work areas when the Hazard Notice Door Sign cannot be used to designate carcinogen areas within the

room covered by the Hazard Notice Door Sign. (See Document 10.2 for details.)

- Apply carcinogen warning signs to all storage cabinets (see Appendix C) unless the entire room has been posted with signs advising that the room is a carcinogen work area.
- See Section 4.1.3 for container labeling requirements.

Table 3. Small-scale laboratory activities that only require an IWS.*

Activity	Analytical and scale limitations	Synthesis
Chemical digestion of metal carcinogen samples	<20 Samples/day	N/A
Liquid-liquid extraction with solvent carcinogen	<200 ml/extraction <500 ml/week	2 l/week
GC, GC/MS, AA, ICP analysis of samples containing carcinogens	No specific limit-must be laboratory scale work	N/A
Synthesis using carcinogens	<100 ml/week <100 grams/week	4 l/week
Evaporation of carcinogenic solvents	<50 ml at a time <500 ml/week	<500 ml/week
Preparation of carcinogen standards	<10 grams per carcinogen per week	N/A
Routine analytical or preparative procedure involving carcinogens	<100 ml or grams/week	1 l/week
Weighing of carcinogens in a ventilated enclosure	<100 grams per week per carcinogen	250 g/week

* Applies to all carcinogens except for those listed on the right hand column of Table 1. A HAC and, if necessary, other documentation such as Safety Plans, shall be prepared in addition to the IWS for the materials listed in the right hand column of Table 1.

Access

- Close doors when operations are in progress. Limit access only to essential personnel. Note that nothing in this document shall be used to exclude ES&H personnel from visiting rooms or operations in order to study or evaluate the performances of hoods or other control devices, work practices, worker exposures, or emissions.
- Keep minors out of carcinogen work areas, unless carcinogens are stored in inaccessible places (e.g., a closed cabinet provided a responsible person is in the area).
- Advise maintenance and emergency personnel of potential hazards and the proper precautions.

Work Practices

- Perform low-hazard operations on an open bench only if it is appropriate to do so. Otherwise, conduct work in a ventilated enclosure or with an engineered close-capture exhaust system.

Use of a carcinogen outside a ventilated system shall be reviewed by the ES&H Team industrial hygienist, and the review shall be documented on a HAC form and, if warranted, in a safety plan. This requirement does not apply if the carcinogen will not release airborne material, if handling dilute carcinogens solutions less than 0.1%, or if weighing less than a gram per day of dry carcinogenic powder in a balance with a closeable door.

- Avoid or minimize operations that create aerosols such as dusts, mists, or vapors, when practical; minimize pouring heights.
- Package carcinogens to withstand shocks, pressure changes, and any other conditions that may cause release or leakage of contents. Additional storage requirements may be necessary for carcinogens with physical properties that enhance spontaneous release and exposure (e.g., highly dispersible powders or volatile materials).
- Minimize the quantities of carcinogens in storage and in use. Dispose of excess quantities, and consolidate and control storage areas. This reduces hazardous waste-related costs at the end of the operation and minimizes the severity of emergencies resulting from spills.
- Prohibit dry sweeping and the use of compressed air for housekeeping. Housekeeping, maintenance, and janitorial tasks shall be done using wet cleaning or high-efficiency particulate air-filtered (HEPA) vacuums to prevent aerosols from forming or contamination from spreading. Clean up work surfaces after carcinogen operations or spills prior to resuming routine activities in the area affected by the spill.
- Do not eat, drink, smoke, chew gum or tobacco, apply cosmetics, or store utensils, food, food containers, drinks, cosmetics, or tobacco products in areas where carcinogens are stored or used.
- Document methods for the special clean-up of spilled carcinogens as part of the emergency plan, as needed.
- Wash hands and face after each task and before leaving the work area.
- Require personnel to wash or, if appropriate, shower the affected area immediately after skin contact or emergency exposure to a carcinogen.
- Clean all work surfaces upon completing each task and after a spill; use proper janitorial and maintenance practices and any applicable procedures.

- Do not mouth pipette; use mechanical devices only.
- Avoid using hypodermic needles; use them only if there is no feasible alternative. Do not recap or cut used needles; dispose of the entire needle and syringe in an appropriate sharps container.
- Maintain and periodically inspect liquid-waste retention systems in accordance with Document 30.1, "Waste Minimization and Pollution Prevention," in the *ES&H Manual*.
- Properly dispose of all excess chemicals and unusable equipment at the end of a project. Chemicals can be recycled through the CHEW Program and equipment can be reused if decontaminated and testing proves the decontamination was successful.

Workplace and Personnel Monitoring

The RI shall contact the area ES&H Team to arrange for monitoring of personnel exposures, general work areas and work processes, surfaces, and equipment and other supplies. Worker exposure to any material regulated by a specific standard (see first column in Table 1) or any material on the LLNL-controlled Carcinogen List covered by an OEL shall be evaluated by air sampling if exposure levels for that substance could exceed one-half the OEL.

Exposure monitoring is *not* needed if

- Exposure to airborne material at concentration above one-half the OEL is precluded by extremely reliable means without using respiratory protection or operation-specific administrative controls. The ES&H Team industrial hygienist shall evaluate the use of the materials listed in the second column of Table 1.
- Air sampling of a comparable operation elsewhere at LLNL shows airborne concentrations cannot exceed the action level for the contaminant.
- The material is neither an ACGIH A1 or A2 carcinogen nor an OSHA-regulated carcinogen. In these cases, workplace monitoring or an analysis conducted by the area industrial hygienist and documented on a HAC form, or written memo reporting the results of a workplace evaluation, or equivalent can be used to estimate worker exposure and the appropriate controls.

The Ames bioassay test may be used to determine the extent of surface contamination and to verify if the work area is adequately clean for normal use, provided the material is mutagenic in the *Salmonella* organisms used in the Ames test. The decision to continue or end monitoring shall be based on work activities and the measured levels of contaminants found in the work area.

5.1.3 Personal Protective Equipment

- Don personal protective equipment (PPE) before entering a carcinogen work area. Doff the equipment, gloves last, before leaving the area.
- Use, as a minimum, a fully fastened lab or shop coat, safety glasses, and closed-toe shoes to safeguard regular clothing and the skin from contact with carcinogens. Wear lab coats only within a posted carcinogen work area, not outside of it. Remove contaminated clothing immediately and properly dispose of it in designated containers.
- Select chemical handling gloves considering the carcinogen as well as the diluent, solvent, or other materials in use. Multiple layers may be necessary to prevent skin contact through permeation. Contact the area ES&H Team for further guidance about glove selection.

Additional requirements can be found in Document 11.1.

5.2 Medium-hazard Potential Operations

The controls in Sections 5.1 apply to medium-hazard operations in addition to those listed below.

5.2.1 Engineered Controls

Any of the following controls shall be used if it will reduce exposures:

- Conduct work in a ventilated enclosure or with an engineered close-capture exhaust system. See Document 12.2 for detailed requirements on ventilation systems.
- Make arrangements for the area ES&H industrial hygienist to evaluate vertical laminar-flow hoods (e.g., biosafety cabinets) before using for carcinogen operations. These devices are rarely suitable because they recirculate or release exhaust air into the workplace.
- Connect analytical instruments and other equipment that produce vapors or aerosols to a mechanical exhaust system.
- Maintain a negative pressure in the workrooms in relation to access corridors.
- Exhaust air from the primary containment to the outside after appropriate air cleaning. Do not recirculate exhaust air from primary containment equipment. See Document 12.3 and Document 12.5.
- Protect house vacuum lines with appropriate filters and liquid traps.

5.2.2 Administrative Controls

Documentation

- A HAC form shall be prepared in addition to the IWS.

Access Control

- Prohibit public access.

Work Practices

- Ensure that the engineered barrier and sign controls are properly used.
- Do not work on an open bench when performing medium-hazard operations.
- Conduct all work within chemical fume hoods or within other equivalent containment devices.

5.3 High-hazard Potential Operations

The controls in Sections 5.1 and 5.2 apply to high-hazard operations in addition to those listed below.

5.3.1 Engineered Controls

Any of the following controls shall be used if it will reduce exposures:

- Provide areas where personnel can doff personal garments, store food, drinks, and smoking and chewing materials. Don and doff PPE when entering or leaving work areas.
- Ensure that all floors and walls are sealed to facilitate cleanup and decontamination.
- Ensure that the concentrations of effluents at the point of discharge will result in exposure below the applicable air quality criteria.
- Filter or clean exhaust air before releasing it into the environment, if necessary.
- Provide a place or places where tools and equipment can be cleaned or packaged before being sent out of the contaminated area.

5.3.2 Administrative Controls

Documentation

- A Safety Plan shall be prepared.

Access

- Control worker access. Isolate the work area from the general traffic pattern of the building, and keep minors out of the area.
- Advise maintenance and emergency personnel of potential hazards in the area and the proper precautions for entering and leaving the area.

Work Practices

- Conduct all work in gloveboxes or comparable isolated containment.
- Store carcinogens in break-resistant primary containers or use secondary containers to avoid personnel exposure in case of accidental container breakage.

5.3.3 Personal Protective Equipment

- Remove protective clothing and equipment and wash hands before leaving the facility. Showering may be required in some cases.
- Use other precautions (e.g., respiratory protection) as specified on the HAC form or in other documentation.

6.0 Controls Specific to NonLaboratories

Carcinogens shall not be used in nonlaboratory operations when a noncarcinogenic substitute is available. If a chemical must be used, the controls in Section 3.0 and 4.0 apply in addition to those listed below. These controls shall be tailored based on the severity and type of exposure possible during the operation to ensure the OEL is not exceeded and to keep exposure as low as reasonably achievable.

Engineered controls shall be used, when practical, in accordance with 29 CFR 1910.1000, a Work Smart Standard (WSS). Administrative controls shall be used to supplement, but not in place of engineering controls. Administrative controls are used to implement engineered or personal protective equipment controls. Applicable guidance about controls is found in Document 12.2 and Document 11.1. More guidance is available from the ES&H Team industrial hygienist.

6.1 Engineered Controls

Any of the following controls shall be used if it will reduce exposures:

- Make sure that work surfaces are impermeable to the carcinogen in use and that the area is as free as possible of cracks, crevices, and hard-to-clean sections.
- Enclose the operation as much as practical and use exhaust ventilation. Note that exhaust ventilation is more effective and less costly when combined with an enclosure.
- Use hoses or, preferably, durable rigid pipes or tubes to transfer materials.
- Use less dispersible forms such as coarse dusts in lieu of fine dusts, solids instead of liquids or gasses, or liquids instead of gases, whenever practical.
- Avoid or minimize using techniques that create aerosols such as dusts, mists, or vapors, and minimize pouring heights.
- Minimize or eliminate potential leak points (e.g., line breaks, container openings, and gaps in equipment housings), or provide spill-catching pans and splash shields for liquids when such gaps cannot be avoided as well as exhaust ventilation for gas and vapor leak points.
- Minimize operating pressures for carcinogenic liquids and gases.
- Provide areas where personnel can doff personal outer garments (e.g., coats and sweaters), store food, drinks, and smoking and chewing materials. PPE shall be donned and doffed just before entering or leaving work areas.
- Provide places where tools and equipment can be cleaned or packaged before being sent out of the contaminated area when contamination of equipment is predictable.
- Consider providing showers and lockers for personal and work clothing in situations where overexposures to carcinogens would occur if workers did not use respirators.

6.2 Administrative Control

6.2.1 Work Practices

- Wash hands immediately upon completing a task involving a carcinogen and before leaving the work area. Immediately after skin contact or emergency exposure to a carcinogen, wash or, if appropriate, shower the affected area.
- Never dry sweep carcinogen work areas. Develop special clean-up processes for spilled carcinogens as part of the Emergency Plan.

- Do not eat, drink, smoke, chew gum or tobacco, apply cosmetics, or store utensils, food, food containers, cosmetics, or tobacco products in areas where carcinogens are used or stored.

6.2.2 Container Labeling

When materials are transferred from their original container, the secondary container (e.g., safety cans, bottles, or plastic jars) shall have a label with the identity of the hazardous chemical(s) and the appropriate hazard warning, including a cancer hazard warning. See Section 4.1.3 for labeling requirements. Adhesive-backed peel off labels for this purpose are available from your ES&H Team.

6.2.3 Workplace and Personnel Monitoring

Initial Monitoring. RIs shall contact the area ES&H Team to arrange for monitoring of personnel exposures, general work areas and work processes, surfaces, and equipment and other supplies related to a new operation or process. Workplace and personnel monitoring shall be carried out in accordance with OSHA substance-specific regulations for the materials listed in the first column of Table 1. Monitoring also is required for materials with an OEL on the LLNL-controlled Carcinogen List for Nonlaboratories if personnel exposures could exceed one-half the OEL. Personnel monitoring shall be performed before beginning new operations involving carcinogens to determine the potential for exposure and the need for medical consultation or surveillance.

Initial personnel exposure monitoring is *not* needed if

- Exposure to airborne material is precluded by extremely reliable means without the use of PPE or operation-specific administrative controls.
- Air sampling of the same operation using similar controls elsewhere at LLNL shows airborne concentrations cannot exceed the action level for the contaminant.

In these two cases, workplace monitoring or an analysis conducted by the area industrial hygienist and documented on a HAC form, written memo reporting the results of a workplace evaluation, or equivalent can be used to determine or estimate worker exposures and define appropriate controls.

Periodic Monitoring. Periodic monitoring shall be performed if exposure levels for a material exceed the action level, typically one-half the OEL. This requirement applies to materials covered by an OSHA substance-specific regulation or a WSS and to those materials listed in the first column of Table 1 and any material for which an OEL has been established that is on the LLNL-controlled Carcinogen List for Nonlaboratories.

Periodic monitoring also shall be performed triennially if exposure levels are below the action level for these materials. Monitoring usually involves air sampling using personal sampling devices for many of the materials in Table 1 and for work involving the materials on the LLNL-controlled Carcinogen List for Nonlaboratories that is performed without engineered controls (e.g., evaluating chromium exposure from unventilated stainless steel welding).

Periodic (triennial) monitoring is not needed if the following conditions are met:

- Initial monitoring results are below the action level, without the use of respirators, when engineered controls in place during the initial monitoring are still in place.
- Performance of the engineered control(s) has not deteriorated.

The frequency of periodic monitoring can be increased or reduced based on experience, unless an OSHA regulation or a WSS has defined a specific schedule. The ES&H Team industrial hygienist shall evaluate operations involving any material on the LLNL-controlled Carcinogen List for Laboratories to determine personnel protection and monitoring programs necessary.

6.2.4 Establishing Carcinogen Work Areas

Only authorized personnel have access to carcinogen work areas, which are established in the following situations:

- Wherever the OSHA standard for a regulated material requires them.
- Where workplace levels of other materials on the LLNL-controlled Carcinogen List for Nonlaboratories could exceed the established action level or one-half the prescribed exposure limit.
- Where significant exposures to carcinogens without an OEL are possible.
- Where significant skin exposure is possible.

The ES&H Team industrial hygienist shall determine the controls for maintaining exposure below these limits based on the quantity, hazards, and physical properties of the material involved in the operation. Specifying controls other than those listed in the *ES&H Manual* will make the operation a Work Authorization Level 4 activity.

Following are required minimum controls for carcinogen work areas:

- Post warning signs (e.g., the LLNL Hazard Notice Door Poster) at all entrances to carcinogen work areas.

- Provide safety devices (barriers) if the operation is expected to be highly hazardous.
 - Tape, stanchions, and rope, or other barriers should be used to demarcate carcinogen work areas.
 - Barriers shall be used in conjunction with signs specifying the access limitations and advising of carcinogen(s) in the area.
- Design or lay out the carcinogen work area in a manner that will ensure access and associated hazards (e.g., arc flashes) are controlled. Allow access only to authorized workers. A curtained-off welding area, posted with applicable carcinogen warning signs, meets the requirements of this document.

6.3 Other Controls for Certain Chemical Materials

OSHA-regulated Substances. OSHA has promulgated regulations that require the following:

- Worker air sampling for the carcinogens listed in the first column of Table 1. Air sampling is not mandated for the carcinogens listed in the second column of Table 1.
- A glovebox may be needed for some operations involving the materials in the second column, including 2-propiolactone, while operations involving 2-propiolactone require air sampling because an OEL exists for this material.
- Workplace monitoring for brazing, grinding, and abrading operations involving cadmium alloys and cadmium-plated work pieces. Cadmium is found in silver solders and is used to plate metal articles.

Contact your area ES&H Team industrial hygienist for an evaluation of planned use of a material containing an OSHA-regulated carcinogen before using it to assure compliance with regulations and to determine the necessary precautions.

Hexavalent Chromium. The area ES&H industrial hygienist shall assess operations that generate airborne hexavalent chromium compounds, such as electroplating with chromic acid and spray-painting chromate primers or topcoats. Routine operations shall be addressed in safety plans. Modestly soluble hexavalent chromium compounds (e.g., zinc or strontium chromate) shall not be used unless it is infeasible to find a substitute material or process.

7.0 Controls for Animal Facilities

The precautions in Sections 3.0, 4.0, and 6.0 apply to animal facilities in addition to those listed below. Note that animal facilities are not laboratories as defined in this document or in Document 14.2.

- Equipment, materials, or other items shall be carried in and out of a carcinogen area in a manner that prevents contamination of nonregulated areas or the outside environment.
- Showering and washing facilities shall be available close to exit points. Workers shall remove all protective clothing before exiting the lab area of facilities. Workers shall wash their hands and forearms upon leaving a regulated area and before engaging in other activities.
- Only animals involved in a biological experiment shall be allowed in the facility.
- A pest control program shall be in place for operations involving animals.
- All work surfaces shall be cleaned upon completing each task and after a spill; use proper janitorial and maintenance practices and any applicable procedures. Contaminated areas also shall be sanitized using the appropriate agents.
- Workplace and worker monitoring shall be conducted in accordance with applicable Work Smart Standards and at the discretion of the area ES&H industrial hygienist.

8.0 Responsibilities

The responsibilities of individuals and organizations with regard to handling carcinogens are listed under each title below.

8.1 Workers

- Conduct work in accordance with applicable controls (e.g., FSPs, SPs, IWSs, and HAC forms).
- Complete required training.
- Participate in medical surveillance when required.
- Use PPE as required.

8.2 Responsible Individual

- Review activities to identify potential uses of the carcinogens and for acquisition or procurement.
- Analyze the hazards of all carcinogen operations using the ES&H Team hazard review process.
- Develop safe work procedures or safety plans for activities involving carcinogens, including FSPs; SPs; and emergency, waste disposal, and decontamination plans.
- Prepare IWSs and other documentation and arrange for prestart reviews.
- Ensure workers
 - Have sufficient information and training prior to beginning any operation involving carcinogens.
 - Know and follow safe work practices.
 - Are familiar with work requirements for the area.
 - Use appropriate protective measures.
- Contact the area ES&H Team to arrange for monitoring of personnel exposures, general work areas, work processes, and equipment.
- Determine which workers are required to participate in medical surveillance and provide a list of these individuals to the payroll supervisor and to Health Services before job assignment.
- Ensure equipment specified for the job is clean and in good working condition before providing it to workers.
- Ensure that workers use and store the equipment properly.
- Ensure that proper engineered and administrative controls are established and implemented.
- Inform the ES&H Team when controlled carcinogens will be used so that the area ES&H industrial hygienist can observe and, if necessary, monitor operations.

8.3 Payroll Supervisor

Payroll supervisors shall ensure workers receive medical surveillance, when required.

8.4 Health Services Department

- Identify carcinogen workers with Hazards Control's assistance.

- Provide the following to identified carcinogen workers:
 - Medical surveillance in accordance with OSHA and DOE requirements.
 - Decontamination support and medical consultation for significant accidental exposures.
 - Physical examinations and consultation upon request.
- Maintain the medical records of carcinogen workers (e.g., medical examination results and accident reports).
- In collaboration with Hazards Control, identify carcinogens (other than OSHA carcinogens) and the level of exposure that require medical surveillance.

8.5 Hazards Control Department

- Maintain records of worker-exposure monitoring results.
- Forward workplace monitoring results to the RI, the worker who was monitored, and, when exposures warranting medical surveillance are found, to Health Services and the employee's payroll supervisor.
- Review purchases of carcinogens and, if necessary, reject or delay them.
- Assist the RI in identifying controls not included in the *ES&H Manual* for incorporation into the Safety Plan.

8.5.1 Industrial Hygienist

- Assist with identifying carcinogens and their category (e.g., OSHA-regulated, human, or other), as well as workers who handle carcinogenic materials.
- Assist the RI with analyzing hazards and selecting controls.
- Prepare written HAC forms upon request or as needed.
- Determine the need for and frequency of workplace monitoring. If necessary, request assistance from the RI.
- Notify workers, their supervisors, and Health Services if monitoring data indicate an overexposure to a material. Subcontractors will be notified through the subcontracting agency and the LLNL contract monitor.
- Provide carcinogen-specific training to programs upon request.

- Determine if the controls in place are adequate and appropriate.
- Provide feedback about improving controls or reducing exposures to the RI and facility point of contact, when appropriate.

8.5.2 Environmental Analyst

- Provide carcinogen workers guidance on how to implement environmental controls and properly manage waste contaminated with carcinogens. This is to be done in accordance with environmental regulations.
- Provide specific training to programs and divisions upon request.

8.5.3 Radioactive and Hazardous Waste Management Technician

- Provide carcinogen workers specific guidance on how to properly segregate, package, and label solid and liquid wastes contaminated with carcinogens. This is to be done in accordance with the Radioactive and Hazardous Waste Management Waste Acceptance Criteria http://www.llnl.gov/es_and_h/wac_rev2/wac_contents.html
- Coordinate the disposal of waste generated in the area.

8.6 Procurement and Materiel Department

Forward purchase requisitions for controlled carcinogens to Industrial Hygiene for review.

9.0 Work Smart Standards

29 CFR 1910, Subpart Z, "Toxic and Hazardous Substances," (1910.1000 to 1910.1450 App B), January 1999.

29 CFR 1926, Subpart Z, "Toxic and Hazardous Substances," (1926.1100 to 1910.1152), January 1999.

ACGIH TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents, 2002 (excluding Biological Exposure Indices, TLVs for Physical Agents, and Biologically Derived Airborne Contaminants).

DOE Order 440.1A, "Worker Protection Management for DOE Federal and Contractor Employees," Attachment 2, "Contractor Requirement Document," Section 1–11, 13–18, (delete item 18.a), 19 (delete item 19.d.3) and 22.

10.0 Resources for More Information

10.1 Contacts

For more information about the topics described in this document, contact the following:

- ES&H Teams
- Health Services Department
- Chemical and Biological Safety Section, Hazards Control Department
- Environmental Protection Division

10.2 Lessons Learned

Lessons learned applicable to carcinogen use can be found at the following Internet address:

http://www-r.llnl.gov/esh_and_h/lessons/lessons.shtml

10.3 Other Sources

Furr, A., *Handbook of Laboratory Safety*, 4th ed. (CRC Press, Boca Raton, Fla., 1995).

Industrial Hygiene Group, "LLNL List of Controlled Carcinogens for Laboratories" Hazards Control Department, Lawrence Livermore National Laboratory (updated annually). This list can be found on the Internet at the following address:

http://www.llnl.gov/es_and_h/misc/contcarcinlist.pdf

Industrial Hygiene Group, "LLNL List of Controlled Carcinogens for Nonlaboratories" Hazards Control Department, Lawrence Livermore National Laboratory (updated annually). This list can be found on the Internet at the following address:

http://www.llnl.gov/es_and_h/misc/nonlabcontcarlist.pdf

Lewis, R., *Carcinogenically Active Chemicals: A Reference Guide* (Van Nostrand Reinhold, N.Y., 1991).

Lunn, G. and E. B. Sansone, *Destruction of Hazardous Chemicals in the Laboratory* (Wiley—Interscience, N.Y., 1990).

National Research Council, *Prudent Practices for Handling Hazardous Chemicals in Laboratories* (National Academy Press, Washington, D.C., 1980).

National Toxicology Program Report on Carcinogens can be reached directly. Refer to the following Internet address for more information:

<http://ntp-server.niehs.nih.gov/NewHomeRoc/CurrentLists.html>

The Environmental Protection Department's ChemTrack system maintains a home page with a summary of carcinogen ratings and a link to the National Toxicology Program at the following Internet address:

<http://ctmsds.llnl.gov:1650/livehtml/Frame.html>

The International Agency for Research on Cancer (IARC)'s Monographs. Refer to the following Internet address for more information:

<http://193.51.164.11/monoeval/grlist.html>

Applicable guidance about controls is found in Document 2.2 and Document 11.1. Additional information and guidance about this rapidly evolving area are available from the ES&H Team industrial hygienist.

Appendix A

Terms and Definitions

Action level	An airborne concentration of hazardous material that triggers implementation of health and safety controls such as workplace surveillance, monitoring, training, and medical examinations. The action level is set at 50% of the occupational exposure limit unless there are substantial reasons to do otherwise.
Ames assay	A test used to determine if a substance is a "mutagen" or capable of altering (mutating) genetic material (DNA). The first step in causing cancer is often causing a genetic mutation. A test that identifies mutagens is useful because mutagens may also be carcinogens in mammals, including humans. The Ames test uses special strains of <i>Salmonella</i> bacteria to test for mutagenicity in a convenient manner.
Animal carcinogen	A material that shows sufficient evidence of causing cancer in animals. However, insufficient data are available to show a causal relationship to human cancer.
Carcinogen	A material that causes the development of cancerous growth in living tissue.
Carcinogen work area	Nonlaboratory areas where <ul style="list-style-type: none"> • Airborne concentrations of carcinogens exceed, or can reasonably be expected to exceed, the occupational exposure limits. • Significant exposures to airborne concentrations of carcinogens not covered by an OEL are possible. • Dermal exposures to carcinogens are possible.
Carcinogen worker	A worker that has the potential to either <ul style="list-style-type: none"> • Be exposed to levels of OSHA carcinogens listed in Table 1 or LLNL carcinogens above either the action level specified in an OSHA substance-specific standard or over one-half the OEL for other substances,

Carcinogen worker
(cont'd)

OR

- Do work with chemicals that have not been rated by ACGIH, IARC, or NTP, but which may reasonably be expected to be carcinogenic based on chemical structure and/or the results of in vivo or in vitro testing.

Close-capture system

A type of high-velocity exhaust ventilation system in which hazards or contaminants are controlled at their point of origin using ducts, funnels, cones, and flanges. The system may partially enclose the contaminant.

Designated area

An OSHA term for a laboratory area that may be used for working with select carcinogens, reproductive toxins, or materials that are quickly and highly toxic. Such area may be an entire laboratory, an area within a laboratory, or a device such as a hood or glovebox. The term "designated area" applies only to a laboratory, as described in this appendix. For other workplaces, see "carcinogen work area."

Feasible

Capable of being implemented without significant economic or productivity penalties.

Hazard

A material or agent that can be harmful or create a nuisance to personnel.

A chemical or physical property of a material or agent that can be harmful or create a nuisance.

Human carcinogen

A material for which sufficient evidence of carcinogenicity from studies of humans indicates a causal relationship between the agent and human cancer.

In vitro

"In glass." A test using a system or organism that is not used in a live animal. Cultures of bacteria, yeast, or mammalian cells can be used.

Laboratory

A facility where relatively small quantities of hazardous chemicals are used on a nonproduction basis, operations are designed to be easily and safely performed by one person, multiple chemical procedures are conducted, and where protective practices are commonly used and equipment is available (from 29 CFR 1910.1450.) For the purpose of OSHA regulations, laboratories are places where all of the following occur:

- Chemical manipulations are carried out on a laboratory scale.
- Multiple chemical procedures or chemicals are used.
- The procedures involved are neither part of a production process nor simulate one.
- Protective laboratory practices are commonly used and equipment is available to minimize the potential for worker exposure to hazardous chemicals.

For the purpose of this document, "laboratories" also includes any chemistry or biochemistry laboratory not engaged in pilot plant or production-type work. Medical, Physics, and Engineering laboratories are *not* laboratories for the purpose of this document.

Laboratory scale

Work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. "Laboratory scale" excludes those workplaces whose function is to produce commercial quantities of materials.

LLNL-controlled carcinogens

For laboratories, these include materials listed in Table 1 that are addressed by OSHA substance specific regulations, ACGIH A1, "Confirmed Human Carcinogen," and A2, "Suspected Human Carcinogen, and materials covered by the "select carcinogen" definition found in this appendix.

For nonlaboratories, these include

- Materials listed in Table 1 that are addressed by OSHA material-specific regulations.

LLNL-controlled carcinogens (cont'd)

- ACGIH A1, "Confirmed Human Carcinogens", or A2, "Suspected Human Carcinogens", carcinogens.
- Materials rated by the International Agency for Research on Cancer (IARC) as Group 1, "Carcinogenic to Humans" carcinogens.

Note: IARC Group 4 agent is probably not carcinogenic to humans.

- Materials rated by the National Toxicology Program (NTP) that are "known to be carcinogenic."
- Other materials for which substantial evidence shows that they are a carcinogenic hazard.

Medical surveillance

A regulatory or institutionally prescribed examination protocol for specified occupational hazards.

Nonlaboratory

A place other than a laboratory (see definition above). Generally, this is a place where chemistry and biochemistry work is not performed (e.g., shops, maintenance facilities, physics and engineering laboratories, and biological experiment facilities where animals are handled).

Occupational exposure limit (OEL)

The maximum concentration of an air contaminant to which working people can be exposed for a specified time interval, usually the maximum average exposure allowed throughout an entire eight-hour shift. OELs are typically PELs or TLVs, which are also defined in this appendix.

OSHA-expanded standard

A regulation that specifies detailed requirements for workplace controls, worker training, and medical examinations.

Other carcinogen

A carcinogenic material that does not meet the definitions of a controlled carcinogen, including materials rated as follows:

- A3 or A4 by ACGIH.
- Reasonably anticipated to be human carcinogens by NTP.
- 3 or 4 by IARC.
- Being potentially carcinogenic by other means.

Practical	Capable of being implemented without or with only minor economic or productivity penalties.
Permissible exposure limit (PEL)	The OSHA permissible exposure limit for an airborne concentration of a hazardous chemical in the workplace. Permissible exposure limits are listed in 29 CFR 1910, Subpart Z and 29 CFR 1926, Subpart Z.
Regulated area	An OSHA term for a workplace that has specified engineered controls and work practices. Entry and exit to regulated areas are restricted and controlled.
Responsible individual	The first-level supervisor or manager directly responsible for an operation or activity. The RI may be at any level within the organization and is formally identified by the authorizing individual of the activity.
Select carcinogen	<p>An OSHA term for a material used in a laboratory and that meets one of the following criteria:</p> <ul style="list-style-type: none">• Regulated by OSHA as a carcinogen.• Listed under the category "known to be carcinogens" in the <i>Annual Report on Carcinogens by the National Toxicology Program (NTP)</i> (latest edition).• Listed in Group 1 (carcinogenic to humans) in <i>International Agency for Research on Cancer (IARC) Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man</i> (latest edition).• Listed in either Group 2A or 2B by IARC, or listed by the NTP under the category "reasonably anticipated to be carcinogens," and causes statistically significant tumor incidence in experimental animals based on the following:<ul style="list-style-type: none">— After inhalation exposure of 6 to 7 hours per day, 5 days per week for a significant portion of a lifetime, to dosages of less than 10 mg/m³.— After repeated skin application of less than 300 mg/kg of body weight per week.— After oral dosages of less than 50 mg/kg of body weight per day (from 29 CFR 1910.1450).

Substance-specific standard	An OSHA standard that addresses the precautions to be applied to a specific material or small group of materials. Substances covered by OSHA substance-specific standards are listed in Table 1.
Threshold Limit Values (TLVs)	Time-weighted average concentrations of materials for a normal eight-hour workday to which nearly all workers may be repeatedly exposed without adverse effect. These values are developed and published by the ACGIH.
Tumorigenic dose 50 (TD ₅₀)	The dose of material that will induce tumors in 50% of animals exposed to it.

Appendix B

Summary of Safety Controls

The following table contains controls for carcinogens.

Table B-1. Safety controls for carcinogens used in laboratories.

Safety controls	Hazard level of operation		
	Low	Medium	High
Engineered Controls			
Avoid using "ductless" hoods.	Required (when used)	Required	Required
Design containment devices to minimize exposure during maintenance/decontamination.	Required	Required	Required
Minimize potential leak points.	Required	Required	Required
Use secondary containment trays.	Required	Required	Required
Use the lowest practical operating pressures for carcinogenic liquids/gases are at the lowest practical pressure.	Required	Required	Required
Establish places for donning/doffing PPE.	—	Recommended	Required
Establish places where tools and equipment can be cleaned/packaged before leaving the contaminated area.	—	Recommended	Required
Select surfaces for easy cleanup and decontamination. Minimize cracks, etc.	Required	Required	Required
Provide a place for workers to wash their hands and face, as well as a safety shower and eyewash station.	Required	Required	Required
Make sure workers have access to change rooms and showers.	—	Required	Required

Table B-1. Safety controls for carcinogens used in laboratories (cont'd).

Safety controls	Hazard level of operation		
	Low	Medium	High
Engineered Controls (cont'd.)			
Provide proper ventilation. <ul style="list-style-type: none"> • At least 20 cfm of fresh air /person. • Negative pressure in work area. • Do not recirculate air from primary containment equipment. • Filter (or clean) exhaust air. 	Required — Recommended —	Required Required Required —	Required Required Required Required
Special IH evaluation of ventilation systems.	Optional	Required (vertical laminar flow benches and biological safety cabinets where carcinogens are used).	Required (vertical laminar flow benches and biological safety cabinets where carcinogens are used).
Exhaust from analytical instruments.	Optional	Must be connected to mechanical exhaust ventilation system.	Must be connected to mechanical exhaust ventilation system.
House vacuum <ul style="list-style-type: none"> • Use a filter trap. 	Optional	Required	Required
Work surfaces <ul style="list-style-type: none"> • Design for easy cleaning and decontamination. • Ensure all walls, floors, and ceilings are sealed. 	Required —	Required —	Required Required
Administrative Controls: Signs and Labels			
Post appropriate warning signs at entrances.	Required	Required	Required
Label all containers and storage cabinets with warning labels.	Required	Required	Required

Table B-1. Safety controls for carcinogens used in laboratories. (cont'd).

Safety controls	Hazard level of operation		
	Low	Medium	High
Administrative Controls: Signs and Labels (cont'd.)			
Install substantial barriers such as beacons, interlocked entrances, etc.	—	Consider	Recommended
Administrative Controls: Work Practices			
Access—General <ul style="list-style-type: none"> • Close doors while working. • Post signs in area. • Prohibit public Access. • Isolate area from building traffic. 	Required Required — —	Required Required Required —	Required Required Required Required
Access—Public	Limit to access	Prohibit entry	Prohibit entry
Minors	Keep out or make carcinogen inaccessible.	Keep out or make carcinogen inaccessible.	Keep out
Workers	Same as above	Limit access	Control; maintain written log
Maintenance/ emergency workers	Advise of hazards and precautions to be taken.	Advise of hazards and precautions to be taken.	Advise of hazards, precautions, and entry/exit procedures.
Open bench	Permitted, but only when appropriate.	Prohibited. Use close-capture exhaust ventilation or a lab hood.	Prohibited. Use a glovebox or equivalent containment.
Use engineered controls.	As needed	Required	Required
Avoid or minimize operations that create aerosols, if possible.	Required	Required	Required
Storage <ul style="list-style-type: none"> • Store/use minimal amount; eliminate excess. Consolidate storage. Label containers and cabinets. 	Required	Required	Required

Table B-1. Safety controls for carcinogens used in laboratories. (cont'd).

Safety controls	Hazard level of operation		
	Low	Medium	High
Administrative Controls: Work Practices (cont.)			
Container packaging <ul style="list-style-type: none"> • Use break-resistant primary containers or secondary containment. • Pack to avoid damage due to impact, pressure changes, etc. 	Required	Required	Required
Dry sweeping/compressed air nozzles prohibited. Clean using wet methods or HEPA vacuum. Decontaminate after spills.	Required	Required	Required
Prohibit the use or storage of food, beverages, and cosmetics.	Required	Required	Required
Prepare special cleanup procedures.	If needed	If needed	Required
Wash hands and face before leaving the area.	Required	Required	Required (note that showering may be required in some cases).
Wash or, if needed, shower affected area immediately.	Required	Required	Required
Clean up area at the end of each task and after a spill.	Required	Required	Required
Do not mouth pipette. Use mechanical devices.	Required	Required	Required
Use syringes only if no other substitute is available. Do not cut or recap needles. Dispose of entire item in sharps container.	Required	Required	Required

Table B-1. Safety controls for carcinogens used in laboratories. (cont'd).

Safety controls	Hazard level of operation		
	Low	Medium	High
Administrative Controls: Work Practices (cont'd.)			
Prepare a Waste Disposal Plan for disposal of waste chemicals and equipment.	Required	Required	Required
Segregate and label waste container.	Required	Required	Required
Maintain and inspect retention tanks regularly.	Required	Required	Required
Properly dispose of all excess chemicals and unusable equipment at end of projects.	Required	Required	Required
Personal Protective Equipment			
Use eye protection.	Required (safety glasses at a minimum)	Required	Required
Use body protection (lab or shop coat and closed-toe shoes). Doff PPE, then wash hands and face before leaving the area.	Required	Required	Required. Use fully fastened, disposable lab coat or coveralls and safety glasses while handling carcinogens. Use disposable lab coats whenever possible.)
Use gloves selected for the chemicals in use.	As needed	Recommended	Recommended. (Gloves probably will be required.)
Avoid laundering contaminated clothing.	Required	Required	Required
Use other personal protective equipment.	As needed	As needed	As needed. (Whole body and foot coverings probably will be required).

Appendix C

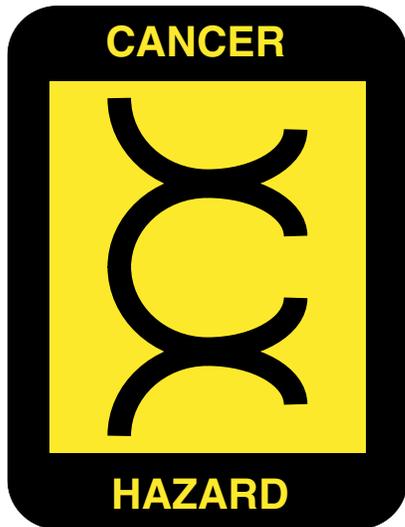
Warning Signs and Labels

Notes: Mutagens are often treated like carcinogens. Therefore the signs and labels in this appendix can be used for carcinogens and carcinogens/mutagens.

The legends are typical legends and can be adapted to meet local needs.



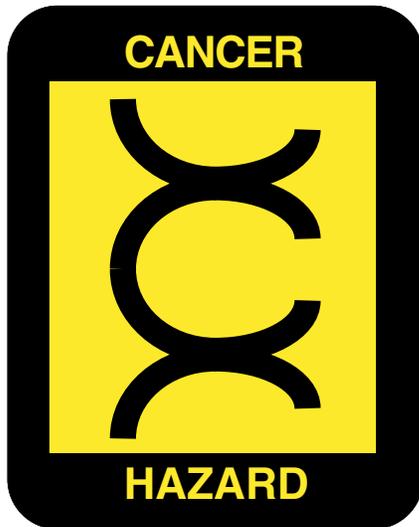
Figure C-1. Example of a carcinogen work area sign and label. The sizes are 6 1/8" wide × 5 1/4" high and 5 3/8" wide × 3 1/4" high, measured from cutting guide crosses.



**Chemical carcinogen/
mutagen work area**

**Authorized personnel
only**

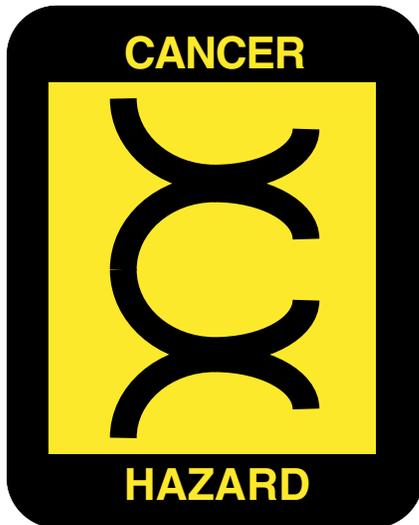
Figure C-2. Example of a carcinogen and/or mutagen work area sign and label. The sizes are 6 1/8" wide × 5 1/4" high and 5 3/8" wide × 3 1/4" high, measured from cutting guide crosses.



**Chemical carcinogen
storage area.**

**Authorized personnel
only**

Figure C-3. Example of a carcinogen storage area sign and label. The sizes are 6 1/8" wide × 5 1/4" high and 5 3/8" wide × 3 1/4" high, measured from cutting guide crosses.



**Chemical carcinogen/
mutagen storage area.**

**Authorized personnel
only**

Figure C-4. Example of a carcinogen and/or mutagen storage area sign and label. The sizes are 6 1/8" wide x 5 1/4" high and 5 3/8" wide x 3 1/4" high, measured from cutting guide crosses.