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Chapter 1

GENERAL POLICY AND RESPONSIBILITIES

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DISCLAIMER

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Chapter 1

GENERAL POLICY AND RESPONSIBILITIES

"Good research needs both the GENIUS to make new discoveries and the DISCIPLINE to do it safely."

Charles V. Shank, Director
Ernest Orlando Lawrence
Berkeley National Laboratory

1.1 BACKGROUND

VISION 2000

The Ernest Orlando Lawrence Berkeley National Laboratory's (Berkeley Lab) Vision 2000 establishes the overarching goals of the Lab's strategic planning effort. The four major goals of Vision 2000 are as follows:

- Distinguish ourselves as a premier DOE multiprogram national laboratory by performing research of the highest scientific quality. Build our educational and technical resources to gain a competitive advantage for addressing problems of national significance and advancing the mission of DOE.
- Create value for the economy, enhance education, and contribute to the community through partnerships with industry, universities, and other laboratories.
- Make Berkeley Lab the location of choice for facilities and programs. Our operational, administrative, and technical resources will integrate seamlessly with the research and engineering programs to make a Berkeley Lab that works. **All of our activities will be conducted with full regard for the environment, health, and safety.**
- Commit to developing our people to their fullest potential. We value and seek diversity in our work force. We will create an environment that respects the individual, encourages leadership, stimulates innovation, fosters integrity, and demands excellence.

1.2 POLICY

It is the policy of the Ernest Orlando Lawrence Berkeley National Laboratory to provide a safe and healthful working environment for its employees, participating visitors, and other visitors; to prevent any harm to the health and safety of the general public or to the environment as a result of the Laboratory's activities; and to protect its property from damage or loss due to accidents or other causes. Berkeley Lab employees, contractors, casual, and participating visitors at the Lab or its off-site locations are required to be familiar with and observe Lab safety (Work Smart) standards. The Berkeley Lab articulates this policy through its Integrated Environment, Safety and Health (ES&H) Management Plan.

1.3 ENVIRONMENT, SAFETY, AND HEALTH (ES&H) INTEGRATION

Like research integrity, scientific discipline, and fiscal responsibility, safety is a product of culture and sound management. To achieve a truly integrated systems approach to doing work safely, ES&H will need to be an integral part of work from initial planning through final execution.

The purpose of pursuing Integrated Safety Management (ISM) is to:

- consolidate progress in ES&H efforts and initiatives,
- establish clear lines of authority and accountability, and
- fulfill contractual obligations by integrating safety management practices with other institutional management practices.

Fundamental to the attainment of ISM are personal commitment and accountability, mutual trust, open communications, continuous improvement, worker involvement, and full participation of all interested parties. To achieve ISM, the Berkeley Lab has adopted the following seven guiding principles, discussed below, which are reflected in the detailed policies and procedures of the Laboratory. In addition, principal investigators, managers, and supervisors are expected to incorporate these principles into the management of their work activities. While these principles apply to all work, the exact implementation of these principles is flexible and can be tailored to the complexity of the work and the severity of the hazards.

1.3.1 LINE MANAGEMENT AUTHORITY AND ACCOUNTABILITY FOR ES&H

Line management is accountable for the protection of the public, the workers, and the environment. More specifically, laboratory line managers are responsible for integrating ES&H into work and for ensuring active, rigorous communication up and down the management line with the workforce.

The vision and goals are articulated by identifying specific targets, developing and implementing plans, securing resources, and operating and maintaining facilities and operations (including work activities and processes). Integration of ES&H considerations into all phases of planning and implementation through to the final work processes is critical to the success of the Lab. ES&H considerations must be part of the planning process, commencing with identification of what hazards may arise, what standards apply, what controls need to be integrated into the design and specification, and what competencies are required to work safely. While line management is responsible for assuring that ES&H concerns are addressed in work planning, implementation, and operation, the EH&S Division serves as a primary technical support resource through its EH&S Liaisons.

1.3.2 CLEAR ROLES AND RESPONSIBILITIES FOR ES&H

As a condition of employment, every employee, visiting scientist, student, or other person performing work at the Laboratory or at one of the Laboratory's off-site locations must be familiar with and implement applicable Laboratory safety standards. This responsibility includes taking the initiative to consult with resource groups when assistance or advice is needed to carry out operations safely. The Berkeley Lab organizational chart (http://www.lbl.gov/Workplace/Lab-Support/org-chart.html) presents the organizational structure at the Lab.

Clear and unambiguous lines of authority and responsibility for ensuring safety shall be established at all organizational levels. Institutional, functional, and individual responsibilities for environment, safety, and health at Berkeley Lab are defined below.

Laboratory Director

- Has the ultimate responsibility for safety at the Laboratory and, in particular, for the establishment and the administration of ES&H policies as prescribed in Work Smart Standards (WSS).
- Assures that environment, health, and safety policies meet the requirements of the Department of Energy as outlined in WSS.
- Is responsible for the implementation of the Berkeley Lab ISM plan.
- Carries out the ES&H policy under the terms of a contract between the University of California and the DOE.
- Delegates, in his or her absence, overall ES&H responsibility to senior management, in the normal chain of command.
- Delegates to the Deputy Director for Operations responsibility for ES&H policy-making, implementation, and daily operation of the ES&H program.

Deputy Director for Operations

- Is responsible for ES&H policy-making, implementation, and the daily operation of the ES&H program.
- Delegates to the EH&S Division Director responsibility for developing and publishing LBNL ES&H policy and developing and operating effective service and support programs to ensure that LBNL ES&H objectives and requirements are met.
- Delegates to the EH&S Division Director and his or her staff responsibility for stopping unsafe work activities in the absence of cognizant line management.
- Appoints the members and chairperson to the Safety Review Committee (SRC) and appoints SRC subcommittee chairpersons.
- Manages appeals for denials of variances on LBNL policy and requests for variances from DOE orders and regulations. (See Section 1.7, *Requesting a Variance from Berkeley Lab Safety Policy*.)

EH&S Division Director

- Develops and publishes the LBNL ES&H policy.
- Develops and operates effective service and support programs to ensure that LBNL ES&H ISM objectives and compliance requirements are met.
- Stops unsafe work activities in the absence of cognizant line management.
- May ask that a request for a variance be studied by the SRC and its appropriate subcommittees. (See Section 1.7, *Requesting a Variance from Berkeley Lab Safety Policy.*)
- Approves or denies in writing requests for variances. (See Section 1.7, *Requesting a Variance from Berkeley Lab Safety Policy.*)

Division Directors

- Ensure that the Laboratory's ES&H policies are being observed within their divisions. They are also responsible for adhering to the principles of the Laboratory's ISM plan.
- Ensure that, within their divisions, clear roles and responsibilities for compliance with all applicable ES&H policies are defined.
- Ensure that self-assessments are carried out, and identify safety deficiencies.
- Ensure that the division's research projects and unique activities are evaluated for potential hazards and that safety controls are specified and implemented.
- Approve Activity Hazard Documents (AHDs).
- Investigate the circumstances surrounding situations identified as imminent dangers, and assure that appropriate corrective actions and lessons learned are developed, implemented, and disseminated.
- Arrange for any required remediation, and prepare an investigation and remedial action report for immediate submission to the Director of EH&S.
- Ensure that all requests for programmatic funding include sufficient resources for ES&H support.
- Ensure that no work is conducted in their division under unsafe conditions.
- Ensure that all work conducted is performed in accordance with established controls.

Managers and Supervisors

- Ensure that the Laboratory's environment, health, and safety policies are being observed within their divisions. They are also responsible for adhering to the five core functions of the Laboratory's ISM plan.
- Take the initiative to consult with appropriate support organizations when safety-related assistance or advice is needed.

- Ensure that employees and casual and participating visitors are properly trained in safety and emergency procedures and are provided with a safe and healthy workplace, and that worker competence is commensurate with their ES&H responsibilities.
- Ensure that all employees' performance expectations include specific ES&H expectations and that annually (usually as part of the P2R process) the employee Job Hazards Questionnaire (JHQ) is reviewed and updated if necessary.
- Ensure that operations under their control meet all ES&H requirements.
- Ensure that safety deficiencies identified through inspections are corrected in a timely manner.
- Ensure that before new work is commenced, associated hazards are identified and funding is secured to ensure that controls appropriate to the hazard are implemented.
- Ensure that personnel exposure to ionizing radiation is maintained as low as reasonably achievable.
- Ensure that personnel exposure to toxic chemicals and contaminants is maintained within prescribed standards.
- Ensure that all processes generating waste are reviewed on a regular basis for waste minimization.

Employees, Contractors, and Casual and Participating Visitors

- Must attend the *New Employee Safety Orientation* (EH&S-10) class within a month of being hired. This applies to visitors if, in the judgment of the LBNL supervisor, the visitor's activities will involve entering accelerators or workshops, or exposure to hazards.
- Must complete a Job Hazards Questionnaire (JHQ) and fulfill all identified training requirements.
- Must be familiar with the sections of PUB-3000 that relate to the work they are performing at the Lab.
- Must be knowledgeable of the Lab "Stop Unsafe Work Policy" whenever they encounter or become aware of an imminent danger situation.
- Must not perform any work where there exists any existing or previously unrecognized hazards that are inherently dangerous to themselves, their co-workers, the public, or the environment. If employees, contractors, and casual and participating visitors encounter such a situation, they are to bring it to the attention of their supervisor or Lab ES&H coordinator immediately. Work will not commence until the hazard(s) is/are resolved through elimination or control (either administrative or engineering controls).
- Owners of hazard control equipment, personnel protection, and hazard monitoring equipment shall ensure that the equipment is in good order and working within operational parameters. Any equipment failing to satisfy operational requirements shall be taken out of commission and repaired or replaced. All equipment necessary for hazard control and

monitoring shall be maintained in conformance with LBNL Notebook requirements set forth in PUB-3111, *Operating and Assurance Program Plan*, Appendix C.

- Proceed with work only after ensuring that appropriate ES&H procedures have been implemented.
- Perform all work safely, and be aware of potentially hazardous operations and conditions.
- Minimize the volume and toxicity of LBNL-generated waste, and maintain chemical inventories as low as reasonably achievable.

Building Managers

- Ensure that the required building management functions are staffed properly by one or more qualified individuals, and that building duties are carried out effectively.
- Ensure the safety and emergency preparedness of their respective buildings.
- Coordinate construction and maintenance activities.
- Oversee the space management of their respective buildings.
- Act as the liaison with visitors and regulatory agencies visiting the respective buildings.

Division ES&H Coordinators

- Reporting directly to their Division Director, they are responsible for serving as point of contact within their division for all matters concerning the implementation and interpretation of the Lab's ES&H policies. Division ES&H Coordinators typically interface with the designated EH&S Division Liaison.
- Responsible for general administration of their division ES&H program. Coordinators carry out designated activities to promote ES&H awareness and compliance within their division. Coordinators must attend appropriate LBNL meetings that address ES&H activities.
- Responsible for coordination and management of required documentation. Documentation will include, but not be limited to, training records, SAR/NEPA/CEQA reports, ES&H inspection reports and corrective actions, tracking and trending of appropriate ES&H performance indicators, and building manager and emergency team appointments.
- Responsible for hazard identification. Coordinators are familiar with the potential hazards in their division facilities; they inform the responsible person or organization with the authority to take actions to mitigate the effects of the hazards. Coordinators must also monitor the modifications to mitigate the hazards.
- Coordinators schedule division self-assessments, and constitute peer review teams from division personnel and EH&S Division technical support. They report assessment findings to the cognizant Division Director and ensure that corrective actions are closed out and validated.

- Coordinators participate in division external reviews such as the SRC Triennial Review and ES&H functional appraisals such as the Integrated Functional Appraisal (IFA), and DOE/LBNL Operational Awareness (OA) activities. Coordinators also track and validate corrective actions.

EH&S Division Liaison

EH&S Division Liaisons (primary and associate) have been designated for each Laboratory organization. These individuals are considered the primary points of contact between a customer division (typically via the Division Safety Coordinator) and the EH&S division and function as the troubleshooter and problem resolution facilitator. This relationship does not preclude any Laboratory employee from directly approaching an EH&S professional/subject matter expert to address a particular issue or need. The EH&S liaison:

- Serves as prime technical point of contact to assigned divisions. The EH&S liaison interfaces primarily but not exclusively with the customer Division Safety Coordinator. The Liaison is responsible for ensuring that the appropriate technical support is provided to implement and interpret Lab ES&H policies. This does not preclude division personnel from contacting other EH&S personnel directly; it is intended to provide a convenient single point of EH&S contact for customer divisions.
- Is responsible for participating in customer division self-assessments and other ES&H assessments as required.
- Is responsible for ensuring that all open ES&H issues or concerns that a customer division identifies are resolved and closed out.
- The EH&S Liaison is familiar with the customer division work activities, personnel, and associated hazards. The Liaison assists in hazard identification and the development of controls appropriate to the hazard and work being performed.
- Develop and foster a cross-functional team approach when necessary to provide assessment and consultation on potential hazards control issues, complex operations, and equipment.
- Assist with problem/issue identification and resolution at various levels of division organization to achieve reasonable safety and health solutions with minimal impact on schedules, costs, and research objectives.
- Meet periodically with customer Division ES&H Coordinator; identify issues for resolution.
- Serve as team member to coordinate integrated EH&S support for the customer Division; this includes assembling teams of functional specialists to provide coordinated support to deal with the broad spectrum of customer ES&H issues.
- Participate in the customer division's self-assessment program, as requested by the division, as well as participate in EH&S IFA and OA activities.
- Conduct accident (SAAR) and occurrence (ORPS) investigations, and make recommendations to prevent recurrence and reduce incidents, injuries, and/or illnesses.

- Assume the lead coordinator role in EH&S incident investigations affecting assigned customer division.

Functional Organizations and Institutional Committees

- **EH&S Division**
  - Reviews the Lab's ES&H programs, policies, and procedures against the ISM principles and core work functions, and provides necessary course corrections at the appropriate level to assure that the ISM Plan is being implemented properly.
  - Assesses all LBNL activities independently for compliance with the applicable safety rules and standards, and provides appropriate technical services.
  - Publishes and revises PUB-3000, LBNL's environment, health, and safety manual. See Appendix A, *Process for Revising the LBNL Health & Safety Manual* (PUB-3000).
  - Reviews Activity Hazard Documents (AHDs) and hazardous operations.
  - Inspects all LBNL activities for compliance with applicable safety rules and standards.
  - Provides technical expertise and services in EH&S issues.
  - Monitors closely experimental operations for which a variance has been granted for the duration of the variance. Ensures that the conditions of the variance are met and that safety is not compromised. (See Section 1.7, *Requesting a Variance from LBNL Safety Policy.*)
  - Conducts with division representatives inspections for earthquake, emergency preparedness, electrical, industrial, and hazardous material safety.
  - Provides technical support to customer division in the form of consultation and training.
  - Performs integrated functional appraisals.
  - Develops and manages the LBNL Self-Assessment Program.
- **Facilities Department**

  Is charged with the safe operation and maintenance of LBNL's physical plant and facilities, including removing from service unsafe facilities and equipment maintained by the Facilities Department and repairing such.

- **Internal Audit Services and Assessments (IASA)**
  - Coordinates certain external audit functions.
  - Manages "EthicsLine"/Employees Concerns reporting program.

- **Engineering Division**

  Ensures that all non-Facilities equipment, structures, and engineered experimental apparatus, with which Engineering Division personnel at LBNL are connected, are designed, engineered, and maintained in a safe manner and in conformance with all applicable EH&S requirements.

- **Facilities Construction Managers**

  Instruct, before construction work begins, construction subcontractors and their employees to stop work immediately if their activities are identified as constituting an imminent danger.

- **Safety Review Committee (SRC)**
  - Reports to and advises the Deputy Director for Operations on matters of health and safety.
  - Performs research for and makes recommendations to the Deputy Director for Operations on matters of policy, guidelines, codes, and regulatory interpretation.
  - Conducts reviews of special safety problems and provides recommendations for possible solutions, if requested to do so by the EH&S Division Director.
  - Has members who represent all divisions and are selected on the basis of their scientific activity, balance of technical knowledge, and safety expertise.
  - Forms subcommittees that handle specific science- and technology-related safety problems for which no published guidelines, codes, or regulations exist.
  - Reviews appeals from divisions when a division and EH&S do not agree on the interpretation or application of criteria, rules, or procedures, and advises the Deputy Director for Operations on options for a resolution.
  - Appoints subcommittees to address specific health and safety matters.
  - Conducts triennial reviews of the safety programs of LBNL divisions.

  Membership terms in the SRC are renewable for up to three years. The participation of active experimental scientists is important to the functioning of the SRC.

1.3.3 COMPETENCE COMMENSURATE WITH RESPONSIBILITIES

Personnel need to possess the experience, knowledge, skills, and abilities to discharge their responsibilities. Competency is demonstrated through education, experience, qualifications, training, and fitness for duty. The minimum requirements for staff competency are set forth in the OAP (Section 1.4) and RPM (Chapter 2). However, Lab supervisors shall ensure that all employees, contractors, visitors, and guests possess sufficient knowledge, skills, and experience to perform work safely. As a minimum, all employees, contractors, visitors, and guests:

- Must be knowledgeable of the hazards associated with a work activity and the appropriate controls in place to minimize the hazard.
- If necessary, must know how to operate the controls. Operational knowledge includes training, certification, and/or experience, as determined by the immediate supervisor. As part of identifying the hazard and establishing controls for any activity, the supervisor should identify the appropriate level of training and experience (including certification, if required by applicable standards). Employees, contractors, visitors, and guests must not perform work unless they have satisfied the training, experience, and/or certification requirements identified by the supervisor.
- Must know how to recognize a failure of the hazard control system, cease work immediately, and take necessary steps to re-establish appropriate hazard controls. Failure of any hazard control system should be reported to the immediate supervisor or LBNL contact person as soon as possible. (If failure constitutes an imminent-danger situation, then the Stopping Unsafe Work Policy must be followed.)
- Be familiar with the all sections of PUB-3000 that relate to the work being performed.

1.3.4 BALANCED PRIORITIES

Priorities need to be established and resources effectively allocated to address safety, programmatic, and operational considerations. Work cannot be carried out unless there is appropriate consideration of ES&H resource needs in the work process. ES&H resource needs must be taken into account during planning, design and specification, implementation, and ongoing conduct of the work. No work will be conducted at LBNL where there are recognized hazards until controls tailored to the work being performed are in place. Before each new project or significant change to any process or work activity (including research) is commenced, a work process analysis for hazards to workers, the public, and the environment is to be conducted in accordance with Chapter 6 of PUB-3000. The objective is to ensure that hazard controls enhance and further the nature of research and all other work activities, and not impede it.

A Project Coordination Committee is responsible for balancing priorities at the institutional level. The Project Coordination Committee is facilitated by the Facilities Department and consists of representatives from each of the Laboratory's resource divisions and the Office of Planning and Communications. The Committee performs two functions: (1) it informs all resource divisions of upcoming projects and allows for advance coordination when required, and (2) it provides a broad-based review of projects using a priority rating system. From the Committee review, a recommended list of prioritized projects is compiled. This in turn is submitted for collective review to the Facilities Manager and the Director of the Environment, Health & Safety Division, who in turn advise the Deputy Director for Operations regarding preparation of a final list. Projects that are not funded are periodically reviewed with the proposing division during the year, and may be resubmitted for funding during the next "Unified Call" process.

1.3.5 IDENTIFICATION OF ES&H STANDARDS AND REQUIREMENTS

All new work activities or changes to existing work (which introduce new hazards or increase the hazard level) need to be reviewed to analyze hazards, identify safety standards/requirements, and establish appropriate controls. Chapter 6 of PUB-3000, *ES&H Documentation and Approvals,* details the Lab process regarding identification of hazards and determination of requirements. The current set of standards identified in Appendix G shall be used as a basis to determine the appropriate requirements (web site address: http://llnl.gov/comix/comix/bfm/app_g.html). EH&S Division Liaisons are available to assist in identifying hazards, determining the applicable standards, and developing appropriate cost-effective controls that will meet LBNL ES&H policies. EH&S Division Liaisons need to be consulted if the scope of hazards exceeds the safety envelope established in the recognized standards.

1.3.6 ESTABLISHMENT OF HAZARD CONTROLS

Administrative and engineering controls to prevent and mitigate hazards should be appropriately tailored to the work being performed and the risk of harm and the extent or degree of harm that could occur.

The tailoring process should include:

- identifying controls for specific hazards
- establishing boundaries for safe operation
- implementing and maintaining controls.

EH&S professionals are available to assist in identifying the appropriate level of hazard control.

Examples of performing work within safety controls include:

- **Floor Loading Protection.** The rated floor load approved by the building official must not be exceeded. The loads approved by the facilities department in every building must be marked on plates made from an approved design. The plates must be in the area to which they pertain and be conspicuous.
- **Access to LBNL.** Access to LBNL and its facilities is controlled. Casual and participating visitors' access is set forth in PUB-201, *Regulations and Procedures Manual,* Section 1.06, *LBNL Site Access.* Children aged 18 and under are not allowed at LBNL except when part of a management-approved tour or accompanied by an employee or parent. Children must not be left unattended. Pets may not be brought to LBNL. Seeing-eye dogs may be brought on site by their owners.
- **Housekeeping.** All workplaces, passageways, storerooms, and service rooms must be kept clean, dry, orderly, and sanitary. Floors, workplaces, and passageways must be kept in safe condition. Debris from sweeping, solid and liquid wastes, and garbage must be removed as often as necessary to keep the workplace sanitary and to minimize the fire fuel loading.

- **Aisles and Passageways.** All required aisles and exit passages must be kept clear of storage items and obstructions. Permanent aisles and passageways must be marked appropriately. Aisles and passageways must be in good repair. Sufficient safe clearance for aisles, loading docks, doorways, and turns must be made where mechanical handling equipment is used.
- **Covers and Guardrails.** Covers and guardrails must be used to protect personnel from the hazards of open floors, tanks, ditches, elevated construction openings, and similar areas where a person may be injured falling through or into an opening or pit.

1.3.7 AUTHORIZATION BASIS

The safety conditions and requirements need to be formally established and in place before work is initiated. All activities involving potentially hazardous conditions shall be carried out in conformance with this manual and appropriate work authorizations. Chapter 6 of this manual outlines a protocol for ensuring the form and content of authorizations. Examples for Berkeley Lab include Radiation Work Authorizations (RWAs), Activity Hazard Documents (AHDs), Radiological Work Permits (RWPs), etc.

- **Activity Level Authorization.** Activities are authorized by either line management or by joint EH&S/line management. EH&S Division health and safety professionals provide guidelines in PUB-3000 indicating the authorization level. Lower hazard activities are determined by EH&S safety professionals to be activities where line management review is adequate. Higher hazard activities are determined by EH&S safety professionals to require joint EH&S/line management review and authorization.
- **Line Management Level Authorization.** Bench-level activities that do not require EH&S participation in hazard identification and mitigation are authorized by line management. Appropriate hazards and controls must be established for activities, even though they fall below the threshold of EH&S Division review level. Guidelines for hazards and controls are indicated in PUB-3000. The hazard review and establishment of controls are the responsibility of line management. EH&S Division safety professionals will assist if requested. An example of hazards at the line management authorization level is health-hazard compressed gases with a NFPA Class 1 hazard classification.
- **EH&S Level Authorization.** Activities requiring EH&S participation in the hazard identification and mitigation process are identified in the technical chapters of PUB-3000. Hazard identification, establishment of controls, and authorization are the joint responsibility of line management and appropriate EH&S safety professionals. An example of hazards at the joint EH&S/line management authorization level is health-hazard compressed gases with a NFPA Class 3 or 4 hazard classification. Applicable documents would include AHDs and/or RWAs.

1.4 IMPLEMENTING ISM USING FIVE CORE FUNCTIONS

The seven guideline principles are achieved through implementing the five core integrated safety management system functions, which must become part of every aspect of work at Berkeley Lab.

1.4.1 DEFINE SCOPE OF WORK (WORK PLANNING)

Missions are translated to work, expectations are set, tasks are identified and prioritized, and resources are allocated. A comprehensive hazard analysis was part of the 1996 Integrated Hazard Assessment (IHA) for each division or department. Each of the work activities identified was evaluated with respect to hazard and categorized with either a low, medium, or high level of concern. The determination was based on both the underlying risk and on the likelihood of occurrence in the light of controls present.

1.4.2 ANALYZE THE HAZARDS

Hazards and risks associated with the work to be performed are identified, analyzed, and categorized as to impact on employees, public, and the environment.

All LBNL buildings must be inspected annually for fire safety; other inspections may include electrical, industrial, and general environmental safety. The LBNL Fire Department is responsible for conducting fire safety inspections. Other inspections are met through the LBNL Self-Assessment Program or other assessments.

EH&S teams make inspections for safety deficiencies. A division representative, and/or the Building Manager, accompanies EH&S on their inspections. The division representative identifies, reviews, and ranks safety deficiencies.

Fire Safety Inspection Reports are sent to building managers and Division Safety Coordinators to track corrective actions to completion. Each division completes an annual self-assessment report, which is sent to the Division Director, EH&S Division. Corrective actions are tracked by each division.

1.4.3 DEVELOP AND IMPLEMENT CONTROLS

Controls are established based on identified applicable standards and requirements to reduce the risks to acceptable levels. Acceptable levels are determined by responsible line management, but are always in conformance with all applicable laws and WSS.

1.4.4 PERFORM WORK WITHIN CONTROLS

Activities are conducted in accordance with controls, procedures, requirements, and authorizations.

1.4.5 FEEDBACK AND CONTINUOUS IMPROVEMENT

Information is gathered from employee suggestions, assessments, lessons learned, operational awareness, and worker/customer/regulator and stakeholder feedback, as appropriate, to improve the work activity.

Supervisors should regularly review work practices and operations in light of any new hazard information available or due to changes in actual work practices. Occurrence reporting, self assessment, peer reviews, and lessons learned can be used as ways of improving the cost-effectiveness and reliability of hazard controls (engineering and administrative). Based on findings from occurrence reporting and other assessments, improvements should be made to work planning, and in rare instances, be used as a basis for changing line management responsibility, roles and responsibilities, worker competence, or other appropriate parts of the work cycle.

To ensure continued effectiveness, periodic reviews of LBNL procedures and operations are conducted by EH&S, the Internal Audits (IA), the Safety Review Committee (SRC), DOE, specialized consultants, state and local regulatory agencies, and prominent non-LBNL experts in various fields. Reviews include the Integrated Functional Appraisal (IFA), Integrated Hazard Assessment (IHA), Management of Environment, Safety and Health (MESH), and Self-Assessment.

1.5 STOPPING UNSAFE WORK

All LBNL employees, contractors, guests, and visitors are to stop work **IMMEDIATELY** if they encounter or discover any work-related activities that constitute an imminent danger. Stopping unsafe work applies to all activities conducted at LBNL and all off-site facilities and locations.

An **imminent danger** is any condition or practice that could reasonably be expected to cause death or serious physical harm (e.g., permanent or prolonged impairment or temporary disablement requiring hospitalization) unless immediate actions are taken, including removing the employee, to mitigate the effects of the hazard.

When employees discover conditions or practices that appear to constitute an imminent danger, employees must:

- Stop work immediately, if it is related to the danger.
- Call the danger to the attention of the responsible employee and the employee's supervisor.
- Notify the EH&S Division office.

Upon being notified of a situation involving imminent danger, the supervisor or, in his or her absence, the technical EH&S staff must:

- Stop the work immediately or ascertain that no danger exists.
- Notify the responsible division office.
- Ensure that the EH&S Division office is kept informed.

Upon being notified of a situation involving imminent danger, the responsible division office must:

- Investigate the situation and arrange for any required remediation.
- Prepare an investigation and remedial action report for immediate submittal to the Director of EH&S.

LBNL employees who observe conditions or practices that appear to constitute an imminent danger in areas under the control of construction subcontractors must:

- Call the danger to the attention of the responsible subcontractor or subcontractor's employee.
- Call the Facilities Department, ext. 5495, to notify the Construction Supervisor and the Construction Manager.

ALL LBNL EMPLOYEES, CONTRACTORS, GUESTS, AND VISITORS ARE RESPONSIBLE FOR STOPPING WORK ACTIVITIES CONSIDERED TO BE AN IMMINENT DANGER.

This stop-work policy applies to all LBNL employees regardless of job classification. There is no variance from the responsibility for stopping unsafe work.

1.6 REPORTING EMPLOYEE CONCERNS

Employees or former employees may file a concern with their immediate supervisor, higher level managers, Internal Audit Services and Assessments (IASA), or with the local DOE office. Concerns may be submitted in confidence, either verbally by calling the local DOE office Employee Concerns hotline, (510) 637-1601, or the Berkeley Lab Employee Concerns "Ethics Line," (800) 999-9057. This toll free number is available 24 hours every day and is operated by a third-party vendor retained by the Lab for confidentiality and anonymity if so desired by the caller. Persons reporting improper activities are fully protected by the law and Lab policy against retaliation.

1.7 REQUESTING A VARIANCE FROM BERKELEY LAB SAFETY POLICY

Occasionally circumstances may arise where application of this policy and/or other chapters in this manual prevent work from being conducted without compromising safety. If it is necessary to perform this work, each circumstance will be bought to the attention of the EH&S Division in the form of a request for variance, identified below. Each request will be reviewed on a case by case basis.

Principal Investigators and/or other LBNL employees who have the concurrence from his/her cognizant division director may request in writing a variance from LBNL safety policy. Requests for variances go to the EH&S Division Director and must include:

- An explanation of the specific criteria, rules, or procedures for which the variance is being requested.
- An explanation of the need to perform the experiment in the proposed manner.
- A description of the experimental apparatus.
- A description of the measures to be taken to ensure that the variance will not compromise safety.
- A statement defining the period during which the variance is to be in effect.

For more information on variances, see Section 1.3.2, *Clear Roles and Responsibilities for ES&H.* If operations are suspended, the work stoppage must be investigated and reported in accordance with the relevant procedure specified in the Chapter 5, Part 1, of PUB-3000 *Accident Investigation & Reporting, Occurrence Reporting Program,* or Chapter 10 of PUB-3000, *Construction Safety.* Operations can resume when authorization has been granted by the EH&S Division Director or designee.

1.8 GLOSSARY

ISM. Integrated Safety Management System. The Berkeley Lab has adopted this system as a means assuring that work is performed safely. It is built around seven principals and five core work functions. The Integrated Environment, Health and Safety Management Plan documents how the Berkeley Lab will implement ISM throughout all its work functions.

Line Management. "Line management" applies to all Berkeley Lab employees with the responsibility and authority for assuring that work is performed safely.

Safety. The term "safety" applies to environmental concerns, including waste management and health or industrial hygiene.

1.9 STANDARDS

Applicable standards are listed in Appendix G of the contract between DOE and the University of California. Copies of these standards are available from EH&S.

1.10 REFERENCES

- *Operating and Assurance Program Plan,* PUB-3111, Lawrence Berkeley Laboratory, (http://www.lbl.gov/~connie/OAP/)
- *Regulations and Procedures Manual* (RPM), PUB-201, Lawrence Berkeley Laboratory, (http://www.lbl.gov/Workplace/RPM/)
- *Integrated Environment, Health & Safety Management Plan* Lawrence Berkeley Laboratory, (publication pending).

1.11 APPENDICES

- Appendix A. Process for Revising the LBNL *Health & Safety Manual* (PUB-3000)

APPENDIX A. PROCESS FOR REVISING THE LBNL HEALTH & SAFETY MANUAL (PUB-3000)

1. The change requester contacts the EH&S PUB-3000 Coordinator, ext. 4171 (MS 90-0026) with the following information:
   - Written description of change,
   - Reason for the change
   - Technical justification (if applicable).
2. The EH&S PUB-3000 Coordinator takes the following actions:
   (a) Coordinates the request with the responsible chapter author and technical reviewer to determine necessity and technical basis.
   (b) Coordinates the request with related information in other Chapters of PUB-3000.
   (c) Assesses the impact of the request on current activities.
3. If the EH&S PUB-3000 Coordinator determines that the revision is necessary and technically sound, the revision is recommended to the EH&S Division Director for signature. The recommendation includes the information established in Item 2 above (necessity, technical basis, coordination issues, and assessment of the impact).
4. If the EH&S PUB-3000 Coordinator determines that the revision is either not necessary or not technically sound, the revision is returned to the requester with the explanation. The requester can appeal directly to the EH&S Division Director for review.

Chapter 2

EH&S CHARTER

Revised December 1997

Reviewed by: Jeffrey Y. Chung 12/12/97
Date

Approved by: [signature] 12/15/97
EH&S Division Director Date

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Chapter 2

EH&S CHARTER

2.1 MISSION AND OBJECTIVES

Berkeley Lab is committed to perform all work safely and in a manner that strives for the highest degree of protection for employees, participating guests, visitors, subcontractors, the public, and the environment. In addition, Berkeley Lab seeks continuous improvement and sustained excellence in the quality of all safety (environment, health and safety) efforts.

To achieve these goals, Berkeley Lab has adopted the seven principles and five functional practices of the Integrated Safety Management System (ISMS), as prescribed in Department of Energy DEAR Clause 970.5204-2 (see Chapter 1).

The primary objective of the Environment, Health and Safety (EH&S) Division is to provide professional and technical expertise, *and follow-on services,* to support and enhance line management's active efforts toward implementation of integrated ES&H policies, procedures and activities into research and development programs and operations throughout their organizations.

In carrying out its primary mission, the Division is committed to six basic objectives:

- Provide employees with a safe workplace.
- Design and operate facilities and research activities to minimize adverse impact on public health and the environment.
- Produce and use only materials that can be disposed of safely and will minimize waste.
- Promptly communicate to affected persons the known hazards of our activities and the related methods necessary for safety and health protection.
- Use available technology, engineered safeguards, and responsible science to mitigate all significant risks arising from its research and related activities.
- Train and develop staff to meet the commitments to a safe workplace and minimal adverse impact on public health and the environment.

2.2 ORGANIZATION AND ADMINISTRATIVE RESPONSIBILITIES AND AUTHORITY

The EH&S Division is organized into six functional areas: one interdisciplinary support department and five specialty program groups. Two division deputies and four group leaders directly report to the Division Director. One division deputy also functions as the Field Support Department Head.

- The Field Support Department is aligned closely with the Laboratory organizational structure. The mission of the Field Support Department is to provide safety, health and emergency services in support of Berkeley Lab's mission and line management's commitment to a safe work environment. This includes providing technical consultation and responsive customer service, partnering with customers to implement cost-effective injury and illness prevention/loss control programs, assisting line management in the implementation of Division EH&S Plans, and facilitating compliance with Work Smart Standards in order to achieve ISMS:

To enhance service, EH&S Division Liaisons (primary and associate) have been designated for each Laboratory organization (see *Getting Help from the Environment, Health & Safety Division* at http://www-ehs.lbl.gov/html/ehshelp.htm). These individuals are considered points of contact between a customer division (typically via Division Safety Coordinator) and the EH&S Division. They function as troubleshooters and problem solvers. This relationship does not preclude any Laboratory employee from directly approaching an EH&S professional/subject matter expert (see *Getting Help from the Environment, Health and Safety Division*) to address a particular issue or need.

The five specialty program groups address core technical areas that impact institutional ES&H requirements: Environmental Protection (and Site Restoration), Waste Management, Radiation Protection, Health Services, and the Office of Assessment and Assurance (OAA).

The department head and group leaders are responsible for management of their organizations, including planning, staffing, and budgeting, and for the development and implementation of Laboratory policies and procedures in their functional areas. The division deputies and group leaders also represent the division in contact with internal and external organizations and individuals on matters of major significance to the success of Laboratory programs and activities.

Chapter 3

HEALTH SERVICES

Revised December 1997

Reviewed by: Henry Stauffer 12/9/97
Date

Approved by: D. C. McGraw 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 3

HEALTH SERVICES

3.1 POLICY

The LBNL Health Services policy ensures that employees are physically able to perform their assigned duties, ensures that employees with an occupational illness or injury receive medical care and rehabilitation, and provides for emergency treatment for serious illnesses or injuries. The policy also encourages all employees to maintain their physical and mental health and assists in maintaining a healthy and safe work environment.

3.2 LBNL HEALTH SERVICES PROGRAM

The Health Services Program manages medical surveillance, provides pre-placement, termination, and periodic health evaluations, first aid, initial assessment of injuries and illnesses and appropriate referrals, case management, contributes to health education through its Wellness Program, supports an ergonomic display area, and participates in research. The program staff works closely with other EH&S staff to ensure the existence of an effective Medical Surveillance Program and with staff from Human Resources to help implement the Laboratory's Return-to-Work Policy.

3.3 FACILITY

The Health Services facility, located primarily on the first floor of Building 26, houses the following:

- First aid room
- Examination rooms
- Clinical laboratory
- Two-bed holding ward
- Ergonomic display area
- Office for fitting and dispensing of safety glasses, examining laser users' eyes, and performing refractions
- Rooms for administrative functions and storage of medical records

3.4 STAFF

The Health Services Group is staffed by the Physician-in-Charge, LBNL health care professionals such as physicians and registered nurses, and licensed medical technologists.

3.5 PHYSICAL EXAMINATIONS

The Health Services Group establishes the frequency and content of physical examinations based on OSHA regulations, DOE guidelines, and the standards of medical practice. A physical examination may include:

- Family and personal medical history (see the section on *Privacy Notice*)
- Physical examination
- Vision tests
- Hearing tests
- Measurement of pulmonary function
- Electrocardiograms for employees in certain medical surveillance programs, and for other employees, if indicated
- Chest x-ray (available offsite) or tuberculin test (if requested by examining physician)
- Complete blood count
- Blood chemistries
- Urinalysis
- Special procedures

3.6 PREPLACEMENT EXAMINATIONS

A complete and confidential medical examination is required of new career employees and temporary employees hired for one year or longer. Appointments for examinations are scheduled by the Human Resources staff at the time of hire. Health Services attempts to schedule appointments at the employee's convenience. Employees may submit a written request to have their examination results forwarded to them or their personal physician.

Supervisors are required to complete and send to Health Services the "Supervisor's Survey of Work Environment and Activities" form (available from Human Resources Department) for new employees at the time of hire and whenever employees are transferred to new duties and/or changes occur in the potential hazards to which they may be exposed.

3.7 PERIODIC EXAMINATIONS

Medical examinations are also available periodically. Employees under age 40 are offered a complete physical examination every five years, between age 40 and 50 every three years, and above age 50 every two years.

3.8 TERMINATION EXAMINATIONS

Employees terminating employment at LBNL may be advised to have a termination examination, depending on how recently the employee has undergone a periodic examination. (See the section on *Employees Terminating Employment.*)

3.9 MEDICAL SURVEILLANCE PROGRAM

The Medical Surveillance Program provides medical examinations and laboratory evaluations to monitor and protect employees who may be at risk from health hazards at work. Employees who may require more frequent or additional medical examinations and laboratory evaluations include the following:

- Animal care staff
- Asbestos workers
- Bus drivers
- Carpenters
- Crane and forklift operators
- Fire Operations personnel
- Geotechnical support staff
- Hazardous Waste Operations staff
- HAZMAT Response Team
- Laser users
- Painters
- Staff exposed to excessive noise levels as defined by Chapter 4
- Staff who work with blood or blood products
- Staff who work with radioactive isotopes, x-ray devices, or accelerators
- Staff exposed to excessive levels of airborne dust gases and vapors
- Welders

In carrying out its medical surveillance activities, Health Services depends on the cooperation and collaboration of Industrial Hygiene, Analytical Services, and Radiation Assessment. (See the *Lawrence Berkeley Laboratory Medical Surveillance Program.*)

3.10 EXAMINATIONS FOR LASER USERS

Laser users must undergo an eye examination performed by an optometrist before they can begin working with lasers and after any accidental exposure to a laser.

3.11 RETURN-TO-WORK POLICY

The Return-to-Work Policy requires employees returning to work after one full day or more of lost time due to illness or injury that occurred at work report to Health Services for an evaluation of their condition and ability to resume customary work. Employees who have been absent for five or more consecutive workdays due to non-occupational illness or injury also are required to report to Health Services so that their ability to return to work can be determined.

3.12 MEDICAL RECORDS

Complete medical records are maintained for employees from the time of their first physical examination. These records are confidential and remain in the custody and control of Health Services.

Information from an employee's health records may be disclosed only as required by law or if an employee provides written consent for release of information. Records are retained indefinitely.

3.13 WORK RESTRICTIONS

Work restrictions may be placed on an employee's work based on the results of his or her physical examination, illness, or injury.

3.14 PREGNANCY

A health professional will discuss with a pregnant employee her work environment and determine whether any changes are required to protect the employee and her baby. See the section on *Declared Pregnant Worker Policy* (Radiation Protection Chapter).

3.15 MEDICAL EMERGENCIES AND FIRST AID

FOR EMERGENCIES, CALL:

FROM AN ICS PHONE:	**DIAL 7911**
FROM A 642 OR 643 PREFIX:	**DIAL 9-911**
FROM ANY OTHER PREFIX OR LOCATION:	**DIAL 911**

FROM 7:30 A.M. TO 4:30 P.M. FIRST AID IS AVAILABLE IN HEALTH SERVICES, BLDG. 26, EXT. 6266.

AT ALL OTHER TIMES EMERGENCY SERVICES ARE AVAILABLE FROM THE FIRE DEPARTMENT, BLDG. 48, EXT. 6015.

First aid is provided for occupational injuries and illnesses. Treatment is coordinated with outside specialists according to Workers' Compensation guidelines.

Employees are provided with primary aid at the site where the injury occurred if they cannot be moved from the site; treatment is provided by LBNL physicians, nurses, firefighters, and emergency medical technicians (EMTs) in charge of the LBNL ambulance.

REPORT EVERY INJURY SUSTAINED WHILE PERFORMING LBNL-ASSIGNED TASKS, NO MATTER HOW MINOR, TO YOUR SUPERVISOR AND HEALTH SERVICES.

3.16 TRANSPORTATION OF SICK OR INJURED PERSONNEL

Employees who are severely injured or become seriously ill at work will be transported by paramedics from the Berkeley Fire Department to nearby hospitals. This is in accord with the mutual aid agreement between LBNL and the City of Berkeley.

The LBNL Fire Department ambulance may be used to transport injured or ill employees to Health Services or to nearby hospitals and clinics if requested to do so by LBNL health care professionals. LBNL supervisors may be requested by Health Services staff to transport to hospitals and clinics employees with prior injuries or illnesses.

3.17 RADIOLOGICAL ACCIDENTS

EH&S notifies LBNL health care professionals of accidental exposures to radiation. In the event of contamination by radioactive isotopes or possible activation by high-energy beam, an employee may be given a whole-body count and have a radiochemical analysis of urine done by Analytical Services staff. The actions of the health care professionals include possible treatment and notification. The type and severity of the exposure or spill will determine the actions taken by the health care professionals.

LBNL has a mutual aid agreement with a local hospital to admit and care for LBNL employees who are either radioactively contaminated or both radioactively contaminated and injured.

3.18 SAFETY GLASSES

Safety glasses are supplied to employees free of charge. Employees can make an appointment with the optometrist, Ext. 7378, in Health Services to have safety glasses fitted. The optometrist can also perform refractions for a nominal fee for employees who require safety glasses but do not have a recent prescription.

3.19 THE EMPLOYEE ASSISTANCE PROGRAM (EAP)

The Employee Assistance program, an offsite program provided by the University of California Health Center (the Tang Center) on the Berkeley campus, offers confidential consultation, assessment, and referral for personal or work-related problems. Employees may seek help directly from the EAP or be referred by a supervisor.

3.20 IMMUNIZATIONS

Immunizations are available to employees who require such protection during the course of their work at the Laboratory or during work related travel. Yearly immunization against influenza may be offered all employees.

3.21 PRIVACY NOTICE

The State of California Information Practices Act of 1977 (effective July 1, 1978) requires LBNL to provide the information on the *Privacy Notice* form to individuals who are asked to complete medical history forms or otherwise supply personal information.

The information on the forms is requested by Health Services for purposes of maintaining a complete medical record for each LBNL employee. Furnishing the requested information is voluntary and is intended to help protect the health of LBNL employees.

All information in employees' medical records is available only to Health Services' staff. Information from medical records cannot be disseminated outside of Health Services without the written consent of the employee except as required by law. The information may be used as a basis for recommendations by Health Services to various LBNL and University departments in miscellaneous personnel matters (e.g., consideration for employment, transfer, work assignment, or eligibility of benefits).

Individuals have the right to review their records in accordance with LBNL and University policies. Information about these policies may be obtained from the Human Resources Department. (See the section on *The Physician-in-Charge.*)

3.22 RESPONSIBLE PARTIES

The following people and parties are responsible for implementing Health Services' policies:

3.22.1 PHYSICIAN-IN-CHARGE

- Is responsible for ensuring, with assistance from the Program Manager, that the LBNL Occupational Medical Program is available to all eligible employees and meets the highest professional standards.
- Is responsible for maintaining the information requested on the Privacy Notice form.

3.22.2 LBNL HEALTH CARE PROFESSIONALS

- Are on duty from 7:30 a.m. to 4:30 p.m. on workdays.
- Are available for medical emergencies.
- Follow standard initial treatment procedures for burns, eye injuries, severe allergies, heart attacks, and other emergencies.
- Assess and provide first aid for occupational injuries and illnesses.
- When clinically indicated, refer employees to private physicians or selected medical specialists, or provide transport by ambulance to a nearby hospital emergency room.
- Conduct physical examinations, including vision tests; hearing tests; spirometry; electrocardiograms; laboratory tests, including blood counts and chemistries and urinalysis; and, when medically advisable, refer for chest x-rays.
- Follow up on all positive findings in employees' physical examinations with letters, telephone calls, or revisits with employees.
- Coordinate return-to-work of employees who have been absent for medical reasons.
- Assist in decontamination of employees accidentally exposed to radioactive isotopes and treat contaminated wounds.

- Work with the Radiation Assessment Group to determine radiation doses for employees accidentally exposed to internal or external radiation.
- Notify Laboratory management and the family when employees are severely injured or become severely ill at work.

3.22.3 LBNL CONTRACT PHYSICIANS

- Conduct physical examinations.
- Review medical charts and interpret clinical findings

3.22.4 LASER SAFETY OFFICER

- Gives names of laser users to the Health Services Group.

3.22 5 ANALYTICAL SERVICES

- Uses radiochemical analyses and the whole-body counter system to measure internal radiation exposures. Forwards results to Health Services.

3.22.6 RADIATION PROTECTION PROGRAM

- Makes radiation dose estimates, with Health Services Group professionals, for employees accidentally exposed to internal or external radiation. Forwards results to Health Services.
- Coordinates Declared Pregnant Worker program.

3.22.7 CAREER AND TEMPORARY EMPLOYEES

- Must complete a confidential medical examination if hired for one year or longer.

3.22.8 EMPLOYEES WITH A NON-OCCUPATIONAL ILLNESS OR INJURY

- Must report to Health Services before returning to work after being ill or injured and absent from work for **five or more consecutive workdays.**

3.22.9 EMPLOYEES WITH AN OCCUPATIONAL ILLNESS OR INJURY

- Must inform the supervisor of the injury or illness.
- Must report to Health Services before returning to work if the employee has lost one full day or more of work due to occupational illness or injury.
- Must notify Health Services of the injury or illness and treatment received if the employee has seen a private physician off-site.

REPORT TO HEALTH SERVICES WHEN AN ILLNESS OR INJURY OCCURS.

NOTIFY AN LBNL HEALTH CARE PROFESSIONAL OF ANY SERIOUS ACCIDENT THAT OCCURS AT LBNL AT ANY TIME.

3.22.10 PREGNANT EMPLOYEES

- Must inform Health Services of the pregnancy as soon as the employee knows that she is pregnant.

3.22.11 EMPLOYEES WORKING WITH LASERS

- Must complete an eye examination with the LBNL optometrist before beginning to work with lasers and after accidental exposure to lasers.

3.22.12 EMPLOYEES TERMINATING EMPLOYMENT

- Are required to complete a termination questionnaire when employment is terminated at LBNL.

3.23 GLOSSARY

Confidentiality of medical records provides that medical information cannot be released outside Health Services without the written consent of the employee except as required by law.

Contract physicians include general practitioners and internists. Contract physicians are not LBNL employees.

Occupational illness or injury is an illness or injury arising out of or in the course of employment.

3.24 STANDARDS

- Americans with Disabilities Act (ADA)
- California Confidentiality of Medical Records Act (Civ. Code 56 *et seq.*)
- California Information Practices Act (Civ. Code 1798 *et seq.*)
- Federal Drug-Free Workplace Act
- OSHA 29 CFR 1910
- State of California Nurse Practice Act

- State of California, Department of Health Services, laws relating to Clinical Laboratories, California Business and Professions Code (Division 2, Chapter 3)
- DOE Order 440.1, *Worker Protection Management for DOE Federal and Contractor Employees*
- *Implementation Guide for Contractor Occupational Medical Program for Use with DOE Order 440.1*
- ANSI Z136.1-1986, Section K and Appendix E, *Medical Surveillance for the Safe Use of Lasers*

3.25 RELATED PUB-3000 CHAPTERS

- *Industrial Hygiene* (Chapter 4)
- *Lasers* (Chapter 16)
- *Personal Protective Equipment* (Chapter 19)
- *Radiation Protection* (Chapter 21)

3.26 REFERENCES

- American National Standards Institute (ANSI) N13.30-1987, *Draft Performance Criteria for Radiobioassay*
- ANSI Z80.1-1989 and Appendices A, B, and C, *Recommendations for Prescription Ophthalmic Lenses*
- ANSI Z87-1989, *Practice for Occupational and Educational Eye and Face Protection*
- *California Confidentiality of Medical Records Act* (Civ. Code 56 et seq.)
- *California Information Practices Act* (Civ. Code 1798 et seq.)
- *Lawrence Berkeley Laboratory Health Services Group Program Plan*
- *Lawrence Berkeley Laboratory Medical Surveillance Program*
- *Regulations and Procedures Manual* (RPM), PUB-201, Berkeley Lab

Chapter 4

INDUSTRIAL HYGIENE

Revised December 1997

Reviewed by: Bruce King 12/10/97
Date

Approved by: [illegible signature] 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 4

INDUSTRIAL HYGIENE

4.1 POLICY

Berkeley Lab industrial hygiene policy requires that all operations at the Laboratory be performed in a safe, responsible, and compliant manner. This includes maintaining personnel exposure to chemical, physical, and biological agents within acceptable exposure limits. This policy further requires that exposures be minimized by the use of hazard elimination, engineering controls, personal protective equipment, and administrative controls.

4.2 SCOPE

This chapter provides requirements and guidance related to select industrial hygiene concerns, hazards, and controls

Industrial Hygiene issues covered in this chapter include: drinking water, non-ionizing radiation, noise, ventilation, hoods, HEPA filters, biohazards, chemicals, asbestos, confined spaces, lead, respirators, procurement, and exposure assessment.

4.3 DRINKING WATER

Most drinking water hazards fall within a few common areas.

Some drinking-fountain units and copper-pipe dead legs (dead-end pipes) that are not flushed or used frequently can produce copper contamination in excess of allowable levels. Rust from iron piping is observed in some older facilities. Occasionally, other various off-colors and tastes are reported.

When designing/installing potable water systems that supply chemical-containing systems, it is important to install adequate back-flow devices that prevent back-siphoning of toxic materials into the potable water system. Although Berkeley Lab has completed a major project to upgrade all systems site-wide, we still require awareness on the part of system users to ensure that all new equipment is provided with adequate back-flow-prevention devices. Hoses extending into sinks are a common potential problem, if backflow devices are not installed.

For concerns regarding drinking water quality, call the Facilities Work Request Center, ext. 6274. EH&S follow-up may also be needed; the EH&S drinking water safety coordinator can be contacted at ext. 4942. Sampling of the water for contamination may be warranted, depending on the specific situation.

4.4 NON-IONIZING RADIATION

Non-Ionizing Radiation (NIR) refers to electromagnetic radiation with insufficient energy to release a bound electron from an atom. NIR includes the following categories of radiation: ultra violet (UV), visible light, infrared, radio frequency, microwave, magnetic fields, and lasers. Lasers are addressed in Chapter 16 of PUB-3000, *Lasers*. Exposures to NIR must be maintained below the limits specified in the following standards:

- Ultra violet and static magnetic fields: *Threshold Limit Values for Chemical and Physical Agents,* American Conference of Governmental Industrial Hygienists (ACGIH)
- Radiofrequency Radiation: IEEE Standard C95.1-1991, Safety Levels with Respect to Human Exposure to Radiofrequency Electromagnetic Fields

In addition, magnetic fields above 5 gauss require access control, usually through posting.

EH&S assistance on NIR may be obtained by contacting the EH&S NIR safety coordinator, ext. 7658.

4.5 NOISE

4.5.1 HEARING CONSERVATION PROGRAM

Generally, noise levels that can cause interference with verbal communication when people are only a few feet away from each other may be high enough to produce a risk to hearing. The Lab's Hearing Conservation Program requires employees' occupational exposure to noise be maintained below the Federal Occupational Safety & Health Administration Permissible Exposure Limit (PEL) through the use of engineering controls, administrative controls, and personal protective equipment. The EH&S Hearing Conservation Program coordinator may be contacted at ext. 4028.

The Lab's Hearing Conservation Program consists of the following elements:

- Noise exposure identification (e.g., noise level measurements, dosimetry, and employee tracking)
- Noise reduction controls (e.g., hearing protection and engineering controls)
- Hearing (i.e., audiometric) examinations
- Training

4.5.2 EXPOSURE LIMITS

Berkeley Lab uses the Federal Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for determining employee noise exposures and for complying with OSHA's Hearing Conservation Amendment to the Occupational Noise Exposure regulation. The OSHA PEL for an eight-hour Time Weighted Average (TWA) is 90 decibels (dBA). Generally, this is the maximum noise level that employees may be exposed to without hearing protection during an eight-hour workshift. The table below lists additional OSHA noise PELs that are based on the eight-hour, TWA PEL of 90 dBA. In addition, OSHA requires implementation of noise exposure controls at exposures at or above the OSHA eight-hour TWA action limit of 85 dBA. Exposure controls include participation in a Hearing Conservation Program, including audiometric testing and training. Furthermore, OSHA requires that the employee be offered hearing protection.

Table 4.1. OSHA Noise Permissible Exposure Limits

Duration Per Day (hours)*	Sound Level (dBA)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115

* Maximum allowable exposure time (without hearing protection) at given noise level.

4.5.3 HEARING LOSS AND AUDIOGRAMS

Exposure to high noise levels may cause hearing loss that can be temporary or permanent. Temporary hearing loss, or auditory fatigue, may occur after a few minutes of exposure to excessive noise levels, but normal hearing is recovered after a short period of time away from the noise. Permanent hearing loss may occur when exposure to high noise levels is repeated, and the time away from the noise is limited. Hearing loss typically occurs in the frequency range of 3,000 to 6,000 hertz, and the affected person is usually unaware that initial hearing loss has occurred. Audiograms are conducted on potentially exposed employees to determine if any hearing loss has occurred.

Employees who are exposed to noise at or above the OSHA action level of 85 dBA must have an initial baseline audiogram within six months of the start of the noise exposure, and must have annual audiograms for the duration of the exposure. The EH&S Field Support Department and Health Services track employees who may be exposed above the OSHA action level. Health Services provides audiometric examinations.

4.5.4 HIGH NOISE AREA IDENTIFICATION

EH&S identifies high noise areas and machinery by posting noise hazard warning signs such as the sign shown below. These signs identify the noise level and the total time allowed in the work area for personnel who are not wearing hearing protection. Employees who suspect they are working in an area or with machinery that may be generating high noise levels should contact the EH&S Hearing Conservation Program coordinator, ext. 4028. EH&S will evaluate the potential noise exposure, perform sound level measurements, and/or post the appropriate noise hazard signs, as needed.

WARNING
NOISE HAZARD

(Noise symbol shown on actual sign)

HEARING PROTECTION REQUIRED AFTER:

________ Hours, ________ Minutes

(Total time allowed during an 8 hour workshift without hearing protection)

NOISE LEVEL FOR: ______________________________

________________dBa at ______________________________

Name:____________________________ Date:__________

EH&S DIVISION, FIELD SUPPORT DEPARTMENT

Fig. 4-1. Example of Noise Hazard Warning Sign.

4.5.5 HEARING PROTECTION

Protector Noise Reduction

Hearing protectors must be designed and worn to control employee noise exposures to levels below the OSHA eight-hour TWA of 90 dBA.

Noise Reduction Ratings (NRRs) are assigned to all hearing protection devices and are usually displayed on the hearing protection package. The NRR is a method developed for estimating the adequacy of hearing protection attenuation. To calculate an employee's estimated noise exposure while wearing hearing protection, OSHA requires 7 dB to be deducted from the NRR as a safety margin. For example, if an employee is working in an area where the noise level is 95 dBA, and the selected hearing protection has a NRR of 22, then the estimated noise exposure would be calculated as follows:

- (manufacturer's NRR of 22) - (OSHA safety margin of 7 dB) = calculated noise protector attenuation of 15 dB
- (noise level of 95 dBA) - (calculated noise attenuation of 15 dB) = estimated employee exposure of 80 dBA

Protector Availability and Criteria

Hearing protection is available through Central Stores at Building 78. Stores offers a variety of ear plugs and ear muffs. EH&S establishes minimum acceptable purchasing criteria for hearing protection, periodically reviews the hearing protection selection available through the Central Stores, and provides recommendations to Purchasing. The following hearing protection purchasing criteria are established:

- Earplugs must provide protection by insertion into the ear canal and have a NRR of at least 30 dB that is printed on each earplug package. Earplugs may be attached to a cord or unattached, packaged in pairs or individually packaged for dispenser refilling, and reusable or disposable.
- Headband-type hearing protection must provide protection by insertion into the ear canal, allow wearing under the chin or behind the neck, and must have NRRs of at least 22 while worn under the chin. Ear canal caps are unacceptable.
- Earmuffs must cover the entire ear and have an NRR of at least 22. In addition, earmuff head bands must be adjustable and the inner acoustical material must be able to be removed for cleaning and sanitizing.

4.5.6 NUISANCE LEVEL NOISE

Nuisance noise levels are not intense enough to cause occupational hearing loss; however, they may disturb or interfere with activities such as speech communication and telephone use. The Facilities Work Request Center should be contacted to reduce this type of noise. EH&S can assist in determining if noise levels may cause hearing loss.

4.6 VENTILATION, HOODS, AND HEPA FILTERS

4.6.1 HOODS AND LOCAL EXHAUST POINTS

Local exhaust ventilation hoods and points are required for many operations to ensure sufficient reduction of airborne concentrations of contaminants that could pose risk to employees. Hoods include, for example, lab hoods, soldering bench hoods, extractor-arms, gloveboxes, and other exhausted equipment enclosures that perform a safety or health function.

To have the safety performance of local exhaust systems evaluated, call the EH&S ventilation safety coordinators, ext. 7625 or 5255. The EH&S Field Support Department performs air-flow measurements and other related investigations. A hood survey label that indicates performance testing must be present on all hoods. Hoods must be tested and their survey labels updated approximately every two years. Hoods that do not meet ventilation performance criteria are considered deficient. Ventilation performance criteria are specified in the EH&S Ventilation Survey Guidelines, or may be established by EH&S based on national recognized standards of performance. It is ultimately the responsibility of the area supervisor to ensure that a deficient hood is fixed and to use the hood within its safety limits until it is fixed.

New local exhaust ventilation systems and hoods must meet the requirements of the Building and Fire Codes, and each hood must have a monitor that quantitatively displays the hood's performance to the hood user.

4.6.2 HEPA FILTERS

High efficiency particulate air (HEPA) filters are used to filter hazardous chemical, biological, or radioactive particles from air streams with an efficiency of 99.97 percent. HEPA filters used for safety at Berkeley Lab can be found in vacuum cleaners used to clean up asbestos and lead containing dust and debris, biological safety cabinets in which biohazardous materials are handled, and in-place exhaust ventilation systems connected to lab hoods and glove boxes where radionuclides are used.

Since HEPA filters are used to protect both workers and the environment from hazardous agents, these filters must be tested periodically to ensure the integrity of the filtering system. HEPA filter vacuum cleaners and biological safety cabinets must be tested annually. In-place systems must be tested every two years.

For information regarding the safety of HEPA filtering systems (e.g., testing), contact the EH&S HEPA filter program coordinator, ext. 6218.

4.7 BIOHAZARDS AND SANITATION

Biohazardous material is defined as a material of biological origin capable of causing disease or infection in healthy humans. These materials include agents classified by The Center for Disease Control (CDC) and The National Institutes of Health (NIH) as bloodborne pathogens, recombinant DNA, and human tissue and cell cultures. Agents requiring Biosafety Containment Levels are listed in the Publication CDC/NIH *Biosafety in Microbiological and Biomedical Laboratories*. Risk Groups are listed in the NIH *Guidelines for Research Involving Recombinant DNA Molecules.*

Research involving biohazardous materials will be conducted in a safe manner incorporating the latest CDC and NIH recommendations in order to protect individual researchers and the community at large.

The following groups of agents must receive authorization from the Berkeley Lab Institutional Biosafety Committee prior to commencing research:

- Risk Group 2 agents, or agents requiring implementation of Biosafety Level 2 containment, and
- Attenuated Risk Group 3 agents

Agents requiring implementation of Biosafety Level 4 containment, or Risk Group 4 agents, may not be used or stored at Berkeley Lab.

Guidance for the disposal of biohazardous material is provided in Chapter 20 of this manual, *Hazardous Waste Disposal*. When biohazardous waste is to be rendered noninfectious, the process must be accomplished either by addition of bleach (sodium hypochlorite) or treatment by the biohazardous waste subcontractor. Autoclaving a biohazardous material may not render the material noninfectious or sterile, because autoclaves do not operate under a formal permit that ensures inactivation of all biohazards.

Anyone working with biohazardous material must attend the EH&S training class EHS 737, *Blood Biosafety and Medical Waste*.

For concerns regarding the handling and use of biohazardous materials or sanitation, contact the EH&S Biosafety Officer, ext. 6218. Questions regarding biohazardous or medical waste may be directed to the Generator Assistance Group, ext. 4843. For related medical information, call the Health Services Group, ext. 6266.

4.8 CHEMICALS

4.8.1 CHEMICAL HYGIENE AND SAFETY PLAN

Berkeley Lab's chemical hygiene and safety guidelines and requirements are primarily contained in PUB-5341, *Chemical Hygiene and Safety Plan* (CHSP), August 1992. A primary focus of the CHSP is worker protection from hazards related to chemicals in conformance with the Federal Occupational Safety and Health (OSHA) Hazard Communication and "Laboratory" Standards.

Copies of the CHSP have been distributed extensively at Berkeley Lab. Additional copies may be obtained from Information and Computing Sciences, ext. 6504.

4.8.2 CHEMICAL INVENTORY

Contact the EH&S chemical inventory coordinator, ext. 4171, for information on Berkeley Lab's site-wide computerized chemical inventory. The database is used to prepare an annual report for the City of Berkeley to identify hazards for emergency responders. It is the responsibility of all groups using chemicals at Berkeley Lab to keep an updated inventory of chemicals.

4.9 ASBESTOS

Asbestos can be found in most common insulation and surfacing materials. Examples of construction materials in Berkeley Lab facilities that frequently contain asbestos include: pipe insulation, ceiling tiles or spray-on insulation, taping compound on gypsum wallboard, floor tiles and mastic, roofing material, and transite wallboard.

Consequently, walls, floors, ceilings or other suspect asbestos containing material (ACM) should not be cut into or damaged without determining whether ACM is present. If ACM is found, special procedures will be needed to ensure proper control of potential airborne fibers, surface contamination, and waste disposal. Requirements and guidelines for managing asbestos are described in the Berkeley Lab Asbestos Management Plan.

For identification of asbestos content in materials, contact the Facilities Carpentry Shop. ext. 6022. For concerns regarding the safety of potential asbestos-containing materials, or a copy of the Asbestos Management Plan, contact the EH&S asbestos program coordinator, ext. 4942.

4.10 CONFINED SPACES

Confined space areas pose special hazards because of the difficulties related to egress and the potential to create oxygen deficiency or air-contaminant build-up inside the space. Requirements and guidelines for confined spaces are described in the Confined Spaces Program document.

For a copy of the Confined Spaces Program document, or concerns regarding hazards involving labeled confined spaces or spaces that may involve these hazards, contact the confined-space safety coordinator, ext. 4942.

4.11 LEAD

Most painted surfaces at Berkeley Lab have lead in some layer of paint at or beneath the surface. Though not currently used for painting at Berkeley Lab, lead was commonly used in the past as an ingredient in paints. Most of these painted surfaces do not pose a significant risk to LBNL employees unless dust is produced by sanding, grinding, or welding wall material or painted metal surfaces.

Another common form of lead at Berkeley Lab is lead bricks used for shielding. Moisture can react with unprotected lead to produce lead derivatives (white dusty appearance) on the surface. Because it can easily become airborne, this powdery material can become a hazard when these bricks are disturbed. Even when lead oxide and carbonate have not been produced, loose lead particulate can be spread when the brick surface is handled. Ingestion or inhalation of this dust can be hazardous. Consequently, bricks not permanently set in place as shielding or in a designated storage area must be painted or wrapped with tape to control this hazard.

For concerns regarding lead safety, contact the EH&S lead safety coordinator, ext. 4942.

4.12 RESPIRATORY PROTECTION

Respirators may be used at Berkeley Lab only after medical evaluation, training, fit-testing, and specific approval of the operation by an EH&S industrial hygienist. Respirators are the last resort for control of exposures and are only to be used when engineering controls, process modification, and other measures are not practical or have proved inadequate. Respirator users must:

- Renew fit testing and training annually for general use, and every six months for asbestos and lead use.
- Obtain respirator-use medical approval annually for users over 40 years of age and asbestos workers, and every two years for users under 40.
- Maintain a clean-shaven face where the respirator facepiece seals against the skin.
- Maintain the respirator in good condition and return it when it is no longer required.
- Use respirators for process and operations that have been reviewed and approved by EH&S.

Contact the respirator program coordinator, ext. 7625, for assistance or a copy of the Berkeley Lab Respirator Program.

4.13 PROCUREMENT

The EH&S related items noted below are included on the Berkeley Lab ProCard purchasing "Restricted Items" list. These items are required to be purchased through other Lab purchasing systems that include additional EH&S control:

- Hazardous Materials *
- All gases *
- Ozone-depleting substances *
- Biohazard Level 3 or 4 Infectious Agents
- Radioactive materials
- Drug Precursors *
- Respirators and breathing apparatuses
- Chemical storage cabinets
- Hoods and gloveboxes
- Filtering equipment, emissions collection equipment
- Fire extinguishers

- Lasers
- Safety shoes
- Slings

The general items noted by an asterisk (*) on the above "Restricted Items" list are further defined in the ProCard procedures by sub-lists that provide the specific names of materials that need to be reviewed at the time of purchase. The following material-specific sub-lists are provided in the ProCard procedures:

- Health hazard and pyrophoric gases
- Air-reactive and unique-hazard chemicals
- Ozone-depleting substances
- Drug precursors

Various Berkeley Lab groups review and/or approve such substances before delivery.

4.14 EXPOSURE ASSESSMENT AND MEDICAL SURVEILLANCE

Exposure assessment is an evaluation process performed by EH&S industrial hygienists and other experts to determine the risk of personnel exposure to hazardous chemical, biological, or physical agents and the adequacy of hazard controls. Results of exposure assessments may be used to validate or improve hazard controls, extend the same controls to employees in similar exposure groups (SEGs), provide employees with appropriate medical tests and examinations (i.e., medical surveillance) to monitor employee health, and demonstrate compliance with regulations.

Exposure assessment may include qualitative or quantitative evaluations of risk. Qualitative exposure assessments involve a professional judgment of risk. These assessments may be conducted when the hazardous agent cannot be practically measured or when current information is inadequate to evaluate the risk. Quantitative exposure assessments involve measurement (i.e., sampling, surveying, or monitoring) of exposure levels. These assessments may be conducted when there is insufficient information on the extent of potential exposure or measurement of the exposure level is required by regulation (e.g., OSHA).

Exposure assessments are conducted as one component of most EH&S programs presented in PUB-3000 that involve potential personnel exposure to hazardous agents.

Quantitative exposure assessment results are compared to occupational exposure limits such as OSHA Permissible Exposure Limits (PELs) and ACGIH Threshold Limit Values (TLVs). Employee exposures should be minimized, exposures must be maintained below required exposure limits, and appropriate controls must be implemented when required action limits are reached. Exposure and action limits are contained in the Berkeley Lab Work Smart Standards set.

When personal exposure monitoring is conducted on individuals, the monitored employees and their supervisors receive a copy of the exposure assessment from EH&S. Health Services (i.e., medical) also receives exposure assessments so that they can assign employees to medical surveillance groups and provide consultation to employees with respect to work-related medical problems.

For additional information on exposure assessment, refer to Section I of the Chemical Hygiene and Safety Plan (PUB-5341).

4.15 STANDARDS

- 29 CFR 1910 and 1926, *Occupational Safety and Health Standards (OSHA) for General Industry (29 CFR 1910) and Construction (29 CFR 1926), including the following sections:*
- 29 CFR 1910. 94 *Ventilation*, 1910.107 *Spray Finishing Using Flammable and Combustible Liquids*, 1910.108 *Dip Tanks Containing Flammable or Combustible Liquids*, 1926.57 *Ventilation*, 1926.353 *Ventilation and Protection in Welding, Cutting, and Heating*
- 29 CFR 1910.95 and 1926.52, *Occupational Noise Exposure*
- 29 CFR 1910.132-138, *Personal Protective Equipment*
- 29 CFR 1910.146, *Permit Required Confined Spaces*
- 29 CFR 1910.151, *Medical Services and First Aid*
- 29 CFR 1910.1000 - 1050, *Subpart Z, Toxic and Hazardous Substances*
- 29 CFR 1910.1030, *Bloodborne Pathogens*
- 29 CFR 1910.1200, *Hazard Communication*
- 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*
- 29 CFR 1926, Subpart D, *Occupational Health and Environmental Controls*
- 29 CFR 1926.21, 1926.352, 1926.353, *Confined Spaces*
- 29 CFR 1926.62, *Lead*
- 29 CFR 1926.1101, *Asbestos*
- 29 U.S.C. 668 et seq., Occupational Safety and Health Act (asbestos)
- 40 CFR 61, Subpart M, *National Emission Standard for Asbestos* and Subpart F, appendix A
- 40 CFR 141, 142, 143, *EPA Primary and Secondary Drinking Water Standards*
- 40 CFR 170, 171 Subpart E, *Pesticide Programs*
- BAAQMD, Bay Area Air Quality Management District, Regulation 11, Rule 2, *Asbestos*
- Center for Disease Control (CDC) and National Institutes of Health (NIH), *Biosafety in Microbiological and Biomedical Laboratories*, 3rd Edition.

- CAC, California Fire Code, including the following sections:
- Title 24, Part 9, Article 79, *Flammable and Combustible Liquids*
- Title 24, Part 9, Article 80, *Hazardous Materials*
- CCR, California Code of Regulations, including the following sections:
- CCR Title 22, Part 7 - *Retail Food Facilities*, Chapter 4 - *Retail Food Practices, California Uniform Retail Food Facilities Law (CURFFL)*
- CCR Title 22, Division 2, Part 12000 c, Chemicals Known to the State to Cause Reproductive Toxicity (consensus listing solely referenced to define reproductive toxins)
- IEEE Standard C95.1-1991, *Safety Levels with Respect to Human Exposure to Radiofrequency Electromagnetic Fields*, 1992
- *Guidelines for Research Involving Recombinant DNA Molecules*, National Institutes of Health (NIH), Federal Register, March 12, 1996 (61 FR 10004).
- *Flammable and Combustible Liquids Code,* National Fire Protection Association, NFPA 30
- *Threshold Limit Values for Chemical and Physical Agents,* American Conference of Governmental Industrial Hygienists (ACGIH): chemical substances, heat and cold stress, static magnetic fields, and ultra violet radiation

4.16 REFERENCES

The following Berkeley Lab documents provide additional requirements and guidance on specific industrial hygiene related areas. Copies of these documents can be obtained through the topic-area coordinators noted in each section of this chapter.

- *Asbestos Management Program*
- *Chemical Hygiene and Safety Plan* (CHSP), PUB-5341, Lawrence Berkeley Laboratory, August 1992
- *Chemical Inventory Instruction Manual*
- *Confined Spaces Program*
- *Drinking Water Program*
- *HEPA Filtered Vacuum Cleaner Acceptance Test Procedure*
- *Lead Program*
- *Medical Surveillance Program*
- *Respiratory Protection Program*
- *Ventilation Survey Guidelines*

Additional references that provide significant guidance include:

- American National Standards Institute (ANSI), ANSI/AIHA Z9.5-1992, *American National Standard for Laboratory Ventilation*
- American National Standards Institute (ANSI) Z88.2, *Practices for Respiratory Protection*
- *Industrial Ventilation, a Manual of Recommended Practice,* American Conference of Governmental Industrial Hygienists, 1995

Chapter 5

OCCUPATIONAL SAFETY

Revised December 1997

Reviewed by: Jeffrey Y. Chung 12/12/97
Date

Approved by: [signature] 12/15/97
EH&S Division Director
Date

CONTENTS

Chapter 5

OCCUPATIONAL SAFETY

PART I: ACCIDENT INVESTIGATION AND REPORTING

5.1.1 POLICY

The Accident Investigation and Reporting Program is an important element of the overall Laboratory safety program. Its purpose is to identify the causes of unplanned events in order to reduce the potential for recurrence.

Primary emphasis is placed on preventing accidents and incidents by:

- Developing sound operational procedures (e.g., Activity Hazard Documents).
- Providing training and protective equipment.
- Identifying causal factors and recommending corrective actions to reduce the potential for recurrence of similar accidents.

5.1.2 SCOPE

The policy applies to:

- All Laboratory employees
- All guest contractors
- All equipment and programs

5.1.3 LBNL SUPPORT ORGANIZATIONS

- Environment, Health & Safety (EH&S) Division
  - Field Support Department
  - Health Services
- The Director's Office
- DOE-Oakland, DOE-Berkeley Site Office

5.1.4 TRAINING

Supervisors and other lead employees who are responsible for the activities of other employees must know how to conduct an effective accident investigation. Commercial accident investigation training is frequently available in the Bay Area. The EH&S Division has also sponsored Accident Investigation training on site and will do so as needed. Contact your Division's EH&S Liaison for details.

5.1.5 EMERGENCIES

In case of fire, explosion, gas leak, chemical accident, radiological accident, or any other emergency:

- For emergencies, call:
  - From an ICS Phone: DIAL 7911
  - From a 642 or 643 PREFIX: DIAL 9911
  - From ANY OTHER PREFIX OR LOCATION: DIAL 911
- Give all information needed to dispatch appropriate aid to the scene. Identify who you are, where you are calling from, the phone number you are calling from, the nature of the emergency, and the extent of the injury or spill.
- Assign someone to meet the emergency crew and direct it to the accident, if possible.
- Do not move any injured individuals unless such action is necessary to prevent further injury.
- Apply first aid to stop severe bleeding and/or restore breathing immediately.

FIRST AID SHOULD BE ADMINISTERED BY TRAINED PERSONNEL ONLY (E.G., PARAMEDICS, FIREFIGHTERS, NURSES, OR CERTIFIED FIRST-AID CARDHOLDERS).

5.1.6 PRESERVATION OF THE ACCIDENT SCENE

DOE requires that the scene of an accident that has the potential to meet any of the criteria listed in DOE Order 225.1 be kept intact until a DOE investigating team has released the area. Accidents that meet these criteria include:

- A fatality.
- Disabling injuries to or illness of five or more persons.

- Serious property damage.
- Serious radiation exposure.
- Serious environmental release.

Until the designated individuals arrive, the area supervisor or lead employee is in charge of the scene of any accident.

In the event of such an accident, take the following actions:

- Verify that emergency assistance is present or call ext. 7911 to request such assistance.
- Preserve the scene – do not permit any equipment or vehicles involved in the accident to be moved.
- Notify the Director's Office and EH&S, ext. 5251, immediately.
- Obtain photographs (color if possible), particularly of transient evidence such as liquid spills or scuff marks.

5.1.7 RADIOLOGICAL INCIDENTS

REPORT RADIATION EXPOSURE IMMEDIATELY TO EH&S, EXT. 7652 OR 5251, OR TO THE FIRE DEPARTMENT, EXT. 7911 (AFTER HOURS).

Appropriate monitoring assistance and equipment are available for immediate dispatch.

In the event of a radioactive spill, supervisors or designated employees (e.g., building managers) are responsible for taking the following emergency actions immediately:

- Evacuate all personnel from the immediate area.
- Keep all personnel in a safe area until they are checked for radioactive contamination by EH&S.
- Quarantine the contaminated area.
- Preserve the scene of the accident.
- Notify EH&S, ext. 7652 or 5251, and report the pertinent information.

Anyone receiving a dose above the limits stated in 10CFR835, "Occupational Radiation Protection" may be restricted from further radiological work. That decision is the responsibility of the Director's Office or DOE-Oakland. The DOE-Oakland Manager is responsible for approving the employee's return to radiological work.

5.1.8 DOE-OAKLAND OR DOE-BERKELEY SITE OFFICE

The DOE-Oakland or DOE-Berkeley Site Office is responsible for:

- Releasing an accident scene.
- Restricting an employee after exposure to radiation. (This can also be done by the LBNL Director's Office.)
- Approving an employee's return to work in radiation areas after exposure.

5.1.9 ACCIDENT INVESTIGATION PROCEDURES

Accident investigation is the systematic collection and analysis of information about suspected causes of an occurrence. The depth of the investigation required depends on the actual and potential injuries or damages and the complexity of the relevant physical, psychological, and environmental conditions.

Every accident needs to be investigated. While serious accidents will be investigated by DOE or by the EH&S Division, most accidents are investigated by the supervisor. Regardless of who investigates, the following questions need to be answered:

- Who was involved.
- When, where, how, and why the accident happened.
- What action is necessary to prevent similar accidents.

5.1.9.1 PERSONNEL INTERVIEWING

As soon as reasonably possible, the accident investigator or investigation team will:

- Discuss the accident privately with the personnel involved.
- Request support, as needed.
- Explain that the purpose of the investigation is to identify the causes of the accident so that corrective action can be taken to prevent similar incidents.
- Determine the factors that caused or contributed to the accident.
- Determine what could be done to prevent similar incidents.
- Ensure that all relevant information has been obtained.

5.1.9.2 INFORMATION ANALYSIS

The accident investigator or investigation team will:

- Review the information gathered.
- Identify the root causes.
- Analyze the information.
- Establish that all factors pertaining to the accident and all appropriate corrective actions needed to prevent similar accidents have been determined.

5.1.9.3 CORRECTIVE ACTION

Corrective action is essential to the Laboratory's accident prevention program. Corrective action:

- Is the final result of an accident investigation.
- Eliminates or reduces the conditions that caused or contributed to the accident.
- Must be both effective and economically feasible.
- Must be taken as soon as possible to be effective.

After the investigation is completed and the corrective action has been identified, the supervisors are responsible for:

- Informing affected employees of the corrective action selected.
- Initiating a dialog with employees about the corrective action.
- Conducting a follow-up investigation to determine the effectiveness of the corrective action, after a reasonable amount of time.

5.1.9.4 DOCUMENTATION

Every accident investigation must be documented to provide a record of the accident's causes and corrective actions. Some investigation reports will be forwarded to DOE by EH&S. These include recordable injuries or illnesses, vehicle accidents with damage of more than $1,000 and property damage of more than $5,000.

5.1.10 OCCUPATIONAL INJURIES AND ILLNESSES

Occupational injuries and illnesses are routinely documented on the Supervisor's Accident Analysis Report (SAAR) and on DOE Form 5484.3.

Health Services is responsible for initiating the SAAR. This report is used to provide EH&S, Risk Management, and the employee's supervisor with information about:

- The nature of the injury or illness.
- The employee's brief statement on how the injury or illness occurred.
- The required medical treatment.
- Additional Health Services comments.

Health Services forwards the report to the supervisor for completion and enters the supervisor's response into the SAAR database.

The supervisor and subject employee are responsible for:

- Verifying the information on the SAAR.
- Describing factors that contributed to the accident.
- Documenting corrective action taken to prevent recurrence.
- Returning the completed SAAR to EH&S within two (2) days.

The Field Support Department is responsible for:

- Reviewing the supervisor's accident investigation.
- Completing the DOE 5484.3 form for DOE-reportable cases.

5.1.11 MOTOR VEHICLE ACCIDENTS

Laboratory motor vehicle accidents must be documented by the driver involved in the accident on Form RL-3617. Drivers must complete Sections I through X on the day of the accident and must submit the form to their supervisor.

Supervisors are responsible for:

- Reviewing the accident report for completeness.
- Verifying its accuracy by interviewing the driver.
- Completing Section XI of the report.

The vehicle and the completed report must be taken to the Motor Pool. The Motor Pool is responsible for:

- Documenting the damage to the vehicle.
- Completing Section XII of the report.
- Forwarding the report to the EH&S Field Support Department.
- The Field Support Department reports to DOE when the damage estimate exceeds $1,000.

5.1.12 PROPERTY DAMAGE

The supervisor is responsible for documenting accidents involving property damage in excess of $5,000 on the Property Loss form, DOE 5484.3. The completed report must be submitted to the Field Support Department, which will investigate further and which will forward it to DOE.

5.1.13 INVESTIGATION TYPES

If an accident meets the criteria for a Type A or Type B accident, DOE will appoint a formal Accident Investigation Board to investigate the accident and recommend corrective action. The DOE criteria for Type A and B incidents are described in DOE Order 225.1.

5.1.13.1 TYPE A

Type A accidents include:

- Fatalities.
- Severe environmental spills, greater than 5 times reporting limits.
- Disabling injuries to five or more individuals from one accident.
- Hospitalization of three or more individuals from one accident.
- Property loss or damage of $2,500,000 or more.
- Radiation exposure of 25 rems or more.

DOE-Oakland must be notified immediately in the event of a Type A accident. Type A accidents are reported by using the Occurrence Reporting Program procedures.

5.1.13.2 TYPE B

Type B accidents include:

- Property loss or damage of $1,000,000 or more.
- Illness of five or more people with at least one lost work day.
- Hospitalization of one individual for five or more days.
- Internal or external radiation exposure that exceeds allowable limits.
- Severe environmental spills, greater than twice reporting limits

DOE-Oakland must be notified within 72 hours in the event of a Type B accident. Type B accidents are reported by using the Occurrence Reporting Program procedures.

5.1.13.3 TYPE C

Type C accidents include:

- Reportable occupational injuries and illnesses.
- Accidents involving government-owned, -rented, or -leased vehicles or privately owned vehicles being used for official business, in which property damage exceeds $1,000.
- Property damage that exceeds $5,000.

In the event of a Type C accident, DOE must be notified by the Berkeley Lab Field Support Department, no later than the 25th day of the month after the end of the quarter in which the accident occurred. A Type C investigation may be conducted by individual Laboratory employees or by a board consisting only of Laboratory employees.

5.1.14 APPOINTMENT OF INVESTIGATION BOARDS

A board of investigation must consist of three to five members, one of whom is appointed as chair. Laboratory employees appointed to a Type C investigation board report to the chair during the investigation.

Managerial, scientific, professional, and investigative qualifications must be considered in appointing a board. If necessary, consultants or advisors who are experts in certain areas or who are familiar with the operations or management of the program involved in the occurrence should be named. These persons may be contract personnel. At least one of the members of any board must be a trained accident investigator.

5.1.15 REPORTS

Reports may follow any format, as long as the pertinent information is provided.

5.1.16 RESPONSIBLE PARTIES

The accident investigation and reporting program is the responsibility of:

5.1.16.1 EH&S DIVISION

The EH&S Division manages the Accident Investigation and Reporting program.

5.1.16.2 FIELD SUPPORT DEPARTMENT

The head of the Field Support Department or designee is responsible for:

- Discussing the accident with the Division Director responsible for the program in which the incident occurred (the cognizant Division Director).
- Determining whether the accident requires reporting based on what constitutes an occurrence and, if so, whether it requires an Occurrence Report.

5.1.16.3 DEPUTY LABORATORY DIRECTORS AND DIVISION DIRECTORS

Deputy Laboratory Directors and Division Directors are responsible for:

- Informing supervisors of the accident investigation and reporting requirements.

The cognizant Division Director is responsible for:

- Notifying program managers at DOE Headquarters, as needed.

5.1.16.4 SUPERVISORS

Supervisors are responsible for:

- Preserving the scene of serious accidents or spills to permit a thorough investigation.
- Identifying and correcting accident causes to prevent recurrence.
- Taking immediate action in the event of a radioactive spill.
- Instructing their employees to report all accidents to them as soon as possible, no matter how minor.
- Assisting EH&S in preparation and completion of the accident investigation DOE narrative report.

5.1.16.5 EMPLOYEES

Employees are responsible for:

- Reporting to their supervisor all accidents involving personal injury, safety, property damage, fires, or environmental pollution.
- Reporting promptly to Health Services if treatment is necessary.
- Notifying the supervisor and Health Services when a work-related injury or illness requires absence from work.
- Reporting to Health Services before returning to work.
- Reporting all accidents involving any vehicle used on Laboratory business to Protective Services as soon as possible.
- Submitting an LBNL Motor Vehicle Accident Report to their supervisor within one work day of any accident.
- Submitting the required reports on behalf of any driver who is unable to do so.

- Informing their supervisor and EH&S about accidents involving property damage.
- Preserving an accident scene.
- Reporting radiation exposure immediately.

5.1.17 STANDARDS

DOE Order 225.1, Change 1 and 2, *Accident Investigation*

DOE Order 231.1, Change 1, *Environment, Safety & Health Reporting*

DOE Manual 231.1-1, *Environment, Safety & Health Reporting Manual*

5.1.18 RELATED PUB-3000 CHAPTERS

- *Lessons Learned* (Chapter 14)

5.1.19 REFERENCES

- *Lawrence Berkeley Laboratory Master Emergency Plan*, PUB-533, Lawrence Berkeley Laboratory, July 1993

PART II: ELEVATED WORK LOCATIONS

5.2.1 POLICY

It is Berkeley Lab's policy to ensure that the equipment and structural provisions for accessing and working at elevated levels and for overhead movement of materials meet the best industry safety standards and comply with DOE, general industry safety orders (OSHA), and (for construction applications) Cal/OSHA regulations.

5.2.2 SCOPE

This policy applies to:

- All Laboratory employees
- Guests
- Contractors

5.2.3 LBNL SUPPORT ORGANIZATIONS

- Environment, Health and Safety Division
- Facilities (M&O)
- Engineering

5.2.4 LADDERS

Safety hazards in the use of ladders can be substantially reduced by observing certain basic safety precautions as noted below:

- Painters' stepladders longer than 3.7 m (12 ft) must not be used.
- Wood ladders must not be painted.
- Ladders must be stored to prevent weathering, blistering, or cracking.
- All metal ladders must be legibly marked with signs reading "Caution – Do not use around electrical equipment."
- Portable straight and extension ladders must be equipped with slip-resistant shoes.
- Straight or extension ladders must be placed against a support at an angle such that the distance from the ladder base to the base of the support is one-fourth the working length of the ladder.
- Lash straight or extension ladders when used for access to high places.

- Face ladders when ascending or descending.
- Do not use a ladder as a scaffold.
- Do not place a ladder in front of doorway, unless the door is blocked open, locked, or guarded.
- Ladders shall not be placed on boxes or unstable bases to obtain additional height.
- Do not climb higher than the second step from the top of a ladder.
- Ladders with broken rungs or missing steps must not be used.
- Inspect all ladders before use.
- Report any defective ladders to your supervisor.
- Supervisors must ensure that any ladder reported as defective or unsafe is removed from service.

5.2.5 ELEVATING WORK PLATFORMS

Elevating work platforms can be vertically adjusted by manual or powered means and may be self-propelled, towed, or manually moved. These include such equipment as scissor lifts, E-Z lifts, and others.

5.2.5.1 OPERATING CONDITIONS

Elevating work platforms are operated only under the following conditions:

- Employees using any elevating work platform must be certified in the proper and safe use of the equipment. One certified operator must be stationed on the ground to perform any emergency duties.
- All units must be inspected prior to each shift's use and must not be operated if found to be unsafe.
- Unless recommended for such use by the manufacturer, no elevating work platform is used on an inclined surface. In general, no elevating work platform is used on an incline over 5% or in winds that exceed 25 mph.
- All personnel on the work platform must be provided and wear an approved safety harness and lanyard properly attached to the equipment.
- All powered elevating work platforms must have working upper and lower control devices.
- Outriggers, if provided, must be used as recommended by the manufacturer.

5.2.5.2 IDENTIFICATION

The following must be displayed on all work platforms in a permanent manner:

- Special warnings, cautions, or restrictions necessary for safe operations.
- Make, model, and manufacturer's name and address.
- Rated work load capacity.
- Maximum platform height.
- Statement that device is in accordance with ANSI standards.
- Instructions to study operating manual.

5.2.5.3 SPECIAL INSTRUCTIONS

Travel of units while employees, materials, tools, or equipment occupy the platform in an elevated position is permitted only if the following information is permanently attached to the unit:

- Maximum rated load capacity at maximum height.
- Maximum travel height.
- Statement that the model has successfully passed the static stability test.

5.2.5.4 INSPECTIONS

- Daily Inspections – All elevating work platforms must be inspected prior to each shift's use. The inspector must sign and date the logbook and note any discrepancies. Inspections must include recommended items in the manufacturer's manual.
- Preventive Maintenance – All units must receive preventive maintenance at intervals no longer than recommended in manufacturer's manual.
- Copies of all inspections, preventive maintenance, and work reports must be retained for at least 5 years.

5.2.6 EXTENSIBLE BOOM WORK PLATFORMS

An extensible boom work platform has a telescoping or extensible boom with a personnel platform attached. Examples include the Condor, Hotstick, Pittman, and similar units.

5.2.6.1 OPERATING CONDITIONS

Extensible boom work platforms must be operated under the following conditions:

- Two certified operators must be present at all times. One certified operator must be present on the work platform and the other stationed on the ground to assist in the operation and perform any emergency duties.

- All units must be inspected prior to each shift's use and must not be operated if found to be unsafe.
- All personnel occupying the work platform must wear an approved safety harness and lanyard properly attached to the equipment.
- Outriggers, if provided, must be used as recommended by the manufacturer.
- Unless recommended for such use by the manufacturer, no extensible boom work platforms are to be used on an inclined surface. No unit is used on an incline over 5% or in winds over 25 mph.
- All units must have upper and lower control devices.
- Units equipped with outriggers must not be relocated while personnel are on the work platform in an elevated position and must not elevate personnel without the stability of outriggers.

5.2.6.2 IDENTIFICATION

The following must be displayed on all work platforms in a permanent manner:

- Special warnings, cautions, or restrictions necessary for safe operation.
- Make, model and manufacturer's name and address.
- Rated work load capacity.
- Maximum platform height.
- Instructions to study operating manual.
- Chart, schematic, or scale showing capacities of all combinations in their operating positions and cautions or restrictions, or both, regarding operation of all alternate configurations or combinations of alternate configurations.

5.2.6.3 INSPECTIONS

- Daily Inspection – All units must be inspected prior to each shift's use. The inspector must sign and date the logbook and note any discrepancies. Inspections must include all items recommended by the manufacturer's manual.
- Preventive Maintenance – All units must receive preventive maintenance at intervals no longer than recommended in the manufacturer's manual.
- Copies of all inspections, preventive maintenance, and work reports must be retained for at least 5 years.

5.2.7 RESPONSIBLE PARTIES

The responsibility for ensuring that the equipment described herein is properly used and maintained rests with the managers, supervisors, and employees of the using organizations.

Improper use or handling thereof constitutes a serious violation of LBNL policies and procedures, DOE orders, and federal and state OSHA regulations.

5.2.8 STANDARDS

- 29 CFR 1910, *Occupational Safety and Health Standards for General Industry* and *General Duty Clause*
- 29 CFR 1910.25 (b), 29 CFR 1910.25 (c)(3)(ii)
- 29 CFR 1910.66 (i), Appendix C, Section I, *Personnel Fall Protection*
- 29 CFR 1910.67, *Vehicle-Mounted Elevating and Rotating Work Platforms*
- 29 CFR 1926.500-502, *Safety Belts, Lifelines and Lanyards*

5.2.9 RELATED PUB-3000 CHAPTERS

- *Electrical Safety* (Chapter 8)
- *Occupational Safety* (Chapter 5)–Part VI, *OSHA Compliance*

5.2.10 REFERENCES

- (GPO 017-033-00124-3) *Criteria for a Recommended Standard Emergency Egress from Elevated Workstations*

PART III: MACHINE SAFEGUARDING

5.3.1 POLICY

The machine safeguarding program at Berkeley Lab is an important element of the overall Laboratory safety program. Its purpose is to provide employees with a safe and healthful work environment. Guards must be designed to conform with OSHA requirements and are recommended to be designed in conformance with ANSI B15.1, *Safety Standard for Mechanical Power Transmission Apparatus*. Guards must be provided where rotational motion; nip points; and cutting, shearing, punching, and forming mechanisms can cause injury to personnel or damage to tools and equipment.

5.3.2 SCOPE

This policy applies to :

- All Laboratory employees
- Guests
- Contractors

5.3.3 LBNL SUPPORT ORGANIZATIONS

- Environment, Health & Safety (EH&S) Division
- Facilities Department
- Mechanical Engineering

5.3.4 INTRODUCTION

The Laboratory requires safety planning and practices for commonplace tasks to be as thorough as those for operations with unusual hazards. Commonplace tasks make up the greater part of the daily activities of most employees and, not unexpectedly, offer more potential sources of accidents resulting in injuries and property damage.

Every machine tool operation or work assignment begins and ends with the operator interacting with the piece of equipment. Accident risks can be reduced with adequate machine safeguarding. Identifying obvious and hidden hazards should be the first step in planning and reviewing the need for machine tool safeguarding. The information presented in this chapter should be considered from a safety standpoint.

Most incidents leading to injury are the result of inadvertent or unwise contact with moving machine parts. Because of the great diversity of machine designs and functions, appropriate guarding to protect workers from such hazards may also have numerous forms. Certain principles, however, are basic to any effective safeguarding design.

The object of this chapter is to discuss these principles. More detailed design guidance for specific machine types may be found in Federal OSHA (1983), and the publications of the American National Standards Institute (ANSI).

5.3.5 MACHINE SHOP USAGE

A machine shop is any area in which one or more machine tools (lathes, grinders, milling machines, drill presses, etc.) are used.

All machine shop usage must be monitored by an individual who is deemed qualified. This person determines who may use the equipment and how and when they may do so. The supervisor of the shop must ensure that only "qualified people" operate machine tools. A qualified person is one who can, through experience, sufficient knowledge, or training, mitigate hazards associated with such work. The Field Support Department can assist supervisors in verifying qualifications.

5.3.6 REQUIREMENTS

To protect workers against mechanical hazards, machine guards must meet these minimum general requirements:

- They must prevent contact. The machine guard must prevent hands, arms, or any other part of a worker's body from making contact with dangerous moving parts. A good machine guarding system reduces the possibility of the operator or another worker placing his or her hands or other body parts near hazardous moving parts.
- They must be secure. Workers should not be able to easily remove or tamper with the machine guard. Machine guards and safety devices should be made of durable material (e.g., sheet metal of at least 20 gauge thickness, acrylic sheeting at least 0.3 cm [1/8 in.] thick) that will withstand the conditions of normal use. They must be firmly secured to the machine.
- They must protect the user from falling objects. The machine guard should ensure that no objects can fall into moving parts. A small tool or part dropped into a cycling machine could easily become a projectile that could strike and injure someone.
- They must create no new hazards. A safeguard defeats its purpose if it creates a hazard. A shear point, a jagged edge, or an unfinished surface can cause a laceration. The edges of machine guards, for instance, should be rolled or bolted in such a way that they eliminate sharp edges.
- They must have the proper design. Any safeguard that impedes a worker from performing the job quickly and comfortably might be soon overridden or disregarded. Proper

safeguarding can actually enhance efficiency since it can relieve the worker's apprehensions about injury.

- They must allow safe lubrication. If possible, one should be able to lubricate the machine without removing the safeguards. Locating oil reservoirs outside the guard, with a line leading to the lubrication point, will reduce the need for the operator or maintenance worker to enter the hazardous area.

5.3.7 TRAINING

Even the most elaborate safeguarding system cannot offer effective protection unless the worker knows how to use it and why. Specific and detailed training is therefore a crucial part of any effort to provide safeguarding against machine-related hazards. Thorough operator training should involve instruction or hands-on training in the following:

- A description and identification of the hazards associated with particular machines.
- The safeguards themselves, how they provide protection, and the hazards for which they are intended.
- How and why to use the safeguards.
- How and under what circumstances safeguards can be removed and who may remove them (in most cases, repair or maintenance personnel only).
- What to do (e.g., contact the supervisor) if a safeguard is damaged, missing, or unable to provide adequate protection.

This kind of safety training is necessary for new operators and maintenance or setup personnel. It is also needed when any new or altered safeguards are put in service and when workers are assigned to a new machine or operation.

5.3.8 MACHINE SHOP SAFETY

Machine shop safety is included in the Machine Safeguarding Program in order to promote safety awareness in the shop. Machine shop safety, along with machine safeguarding, ensures the safety of both the employee and the machine tool.

The following rules apply to machine shop safety. (Rules more specific to each machine shop based upon type of user and work may be added.)

- Approved eye protection must be worn at all times while in the shop. This rule applies to visitors as well as to those working on the machinery.
- No bare feet or open-toed sandals are allowed in the shop. Long hair must be tied back, long sleeves cuffed or rolled up, and loose jewelry secured when working on the machinery.
- No food or drink is allowed in the machine shops. Use only designated areas for eating and drinking.

- Do not work alone in the shop. Use the buddy or two-person system in order to have someone present in the shop to summon help in case of an accident.
- Secure and clamp down all work pieces in drill presses and milling machines. This will prevent work from being lifted up or spun around with the cutters. Use all available machine guards and be wary of points of contact with rotating cutters and chucks.
- Use push sticks or some other approved method for keeping fingers away from moving blades on bandsaws.
- Use a vacuum cleaner and the "Blazo-Cut" water-soluble lubricant when machining nonmetallic substances (macor, micarta, phenolics, etc.). This will help control airborne dust.
- Do not machine-grind or cut any radioactive or other solid toxics (beryllium, asbestos, etc.) in the shop. When machining lead, follow the posted or prescribed rules for handling hazardous materials.
- Do not leave keys in chucks of lathes, drill presses, and milling machines. The key can be thrown out with great force when machinery is turned on. This also applies to wrenches used to tighten the cutting tools into the spindles of milling machines.
- Use a brush or wooden dowel to remove chips from the machining area. Chips can be very sharp and are often very hot.
- Clean up the work area with a brush and dustpan. Do not use compressed air to blow chips off machinery. Vacuum the machine and sweep the floor area of any remaining chips.
- Do not attempt any unfamiliar operations. When in doubt, seek advice and help from your supervisor.
- Follow the guidelines posted on the walls of the shop and, in some cases, on the individual piece of equipment.
- In order to prevent injuries to you and damage to the equipment, do not attempt to overload the capabilities of the machinery.
- Remember: when in doubt, see your supervisor.

5.3.9 METHODS OF MACHINE SAFEGUARDING

5.3.9.1 GUARDS

- A **fixed guard** is a permanent part of the machine. It is not dependent upon moving parts to perform its function. This guard is usually preferable to all other types because of its relative simplicity and permanence. (See Fig. 5.1.)

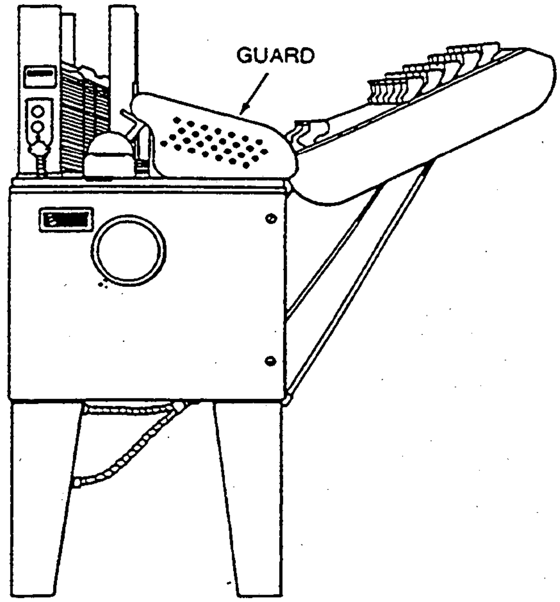


Fig. 5.1. A fixed guard.

- When an **interlocked guard** is opened or removed, the tripping mechanism or power automatically shuts off or disengages. The machine cannot cycle or be started until the guard is back in place. (See Fig. 5.2.)

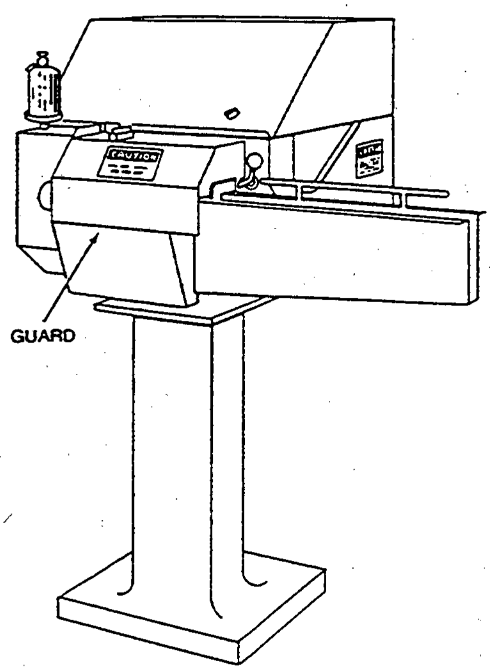


Fig. 5.2. An interlocked guard.

- **Adjustable guards** are useful because they allow flexibility in accommodating various sizes of stock. (See Fig. 5.3.)

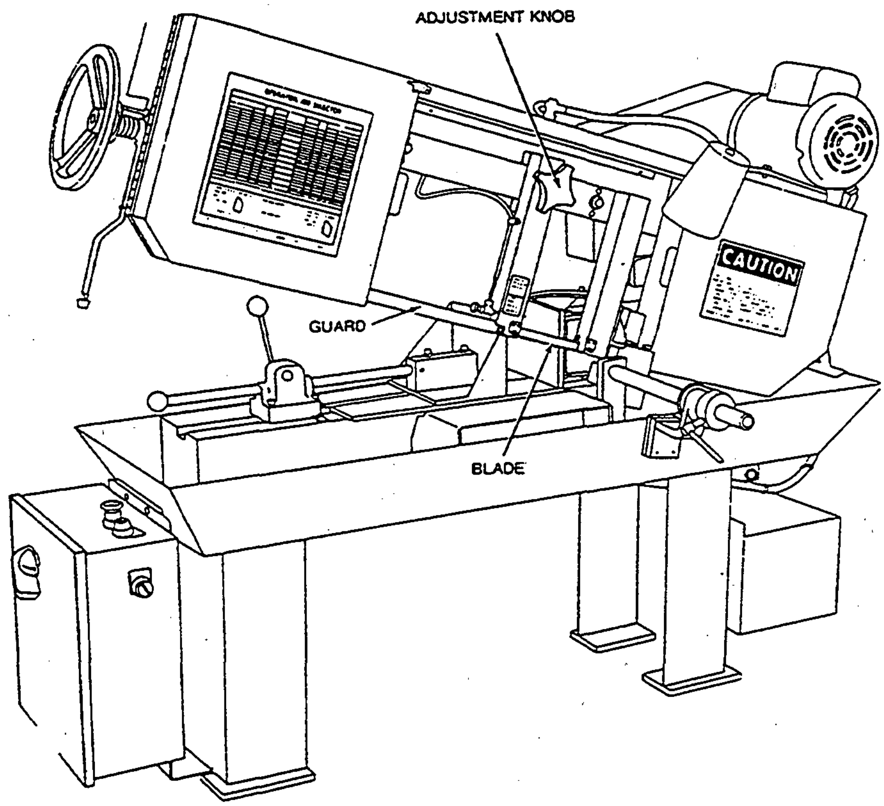


Fig. 5.3. An adjustable guard.

- The openings of **self-adjustable guards** are determined by the movement of the stock. As the operator moves the stock into the danger area, the guard is pushed away, providing an opening that is only large enough to admit the stock. After the stock is removed, the guard returns to the rest position. (See Fig. 5.4.)

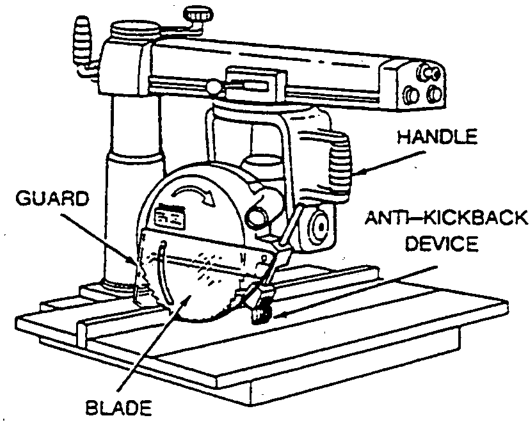


Fig. 5.4. A self-adjustable guard.

5.3.9.2 DEVICES

A safety device may perform one of several functions:

- It may stop the machine if a hand or any part of the body is inadvertently placed in the danger area.
- It may restrain or withdraw the operator's hands from the danger area during operation.
- It may require the operator to use both hands on machine controls, thus keeping both hands and body out of danger.
- It may provide a barrier that is synchronized with the operating cycle of the machine in order to prevent entry to the danger area during the hazardous part of the cycle.

5.3.9.3 PRESENCE SENSING

- A **photoelectrical (optical) sensing device** uses a system of light sources and control that can interrupt the machine's operating cycle. If the field of light is broken, the machine stops and will not cycle. This device must be used only on machines that can be stopped before the worker can reach the danger area. (See Fig. 5.5.)

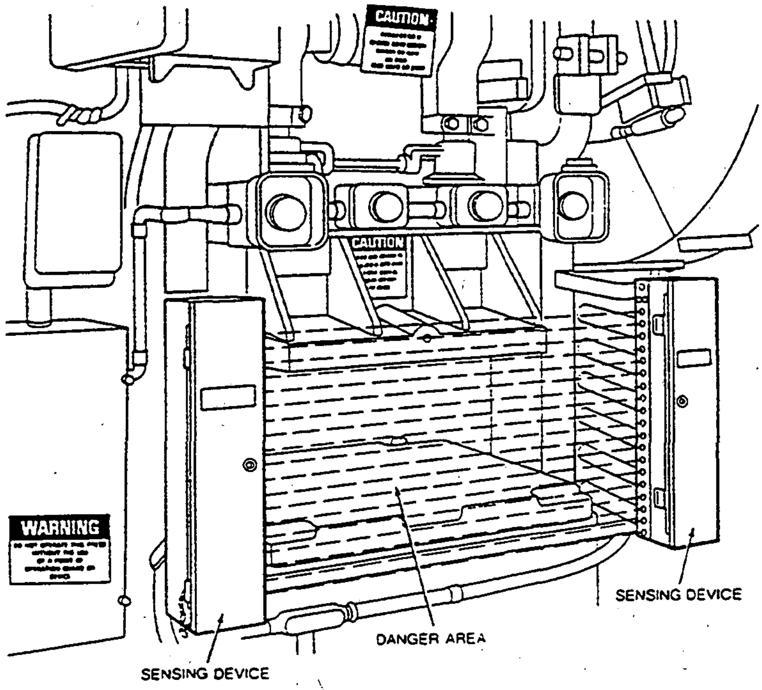


Fig. 5.5. A photoelectrical (optical) presence-sensing device.

- A **radio frequency (capacitance) sensing device** uses a radio beam that is part of the machine control circuit. When the capacitance field is broken, the machine will stop or will not activate. Like the photoelectric device, this device must only be used on machines that can be stopped before the worker can reach the danger area. This requires a friction clutch or other reliable means for stopping. (See Fig. 5.6.)

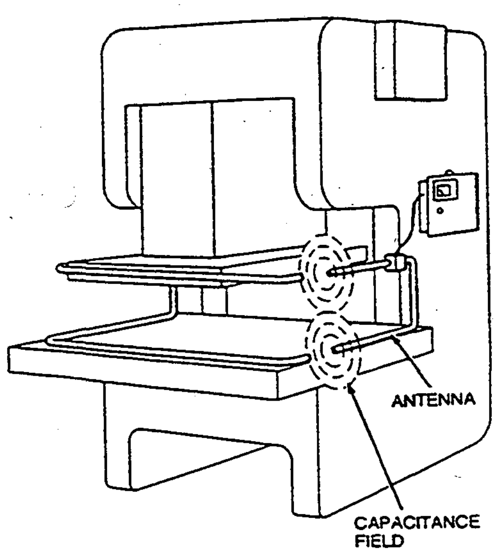


Fig. 5.6. A radio frequency (capacitance) presence-sensing device.

- An **electromechanical sensing device** has a probe or contact bar that descends to a predetermined distance when the operator initiates the machine cycle. If there is an obstruction preventing it from descending its full predetermined distance, the control unit does not actuate the machine cycle. (See Fig. 5.7.)

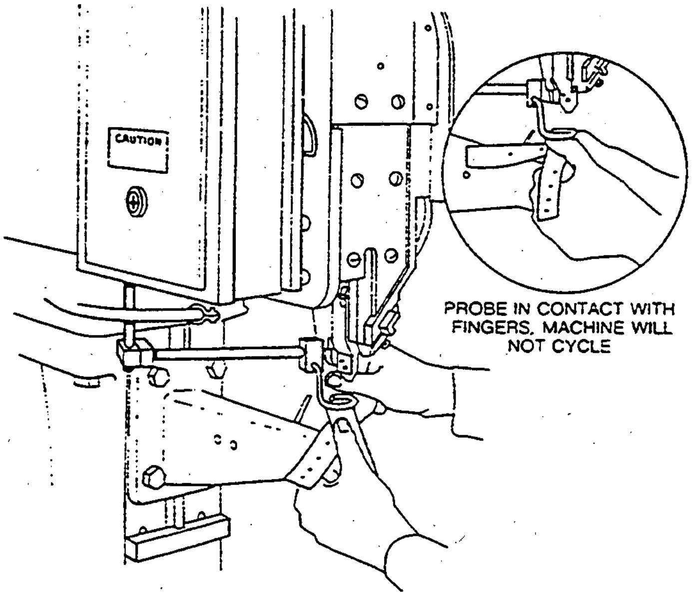


Fig. 5.7. An electromechanical position-sensing device.

- **Pullback devices** utilize a series of cables attached to the operator's hands, wrists, and/or arms. This type of device is primarily used on machines with a stroking action. When the slide or ram is up, the operator is allowed access to the point of operation. When the slide or ram begins to descend, a mechanical linkage automatically ensures withdrawal of the hands from the point of operation. (See Fig. 5.8.)

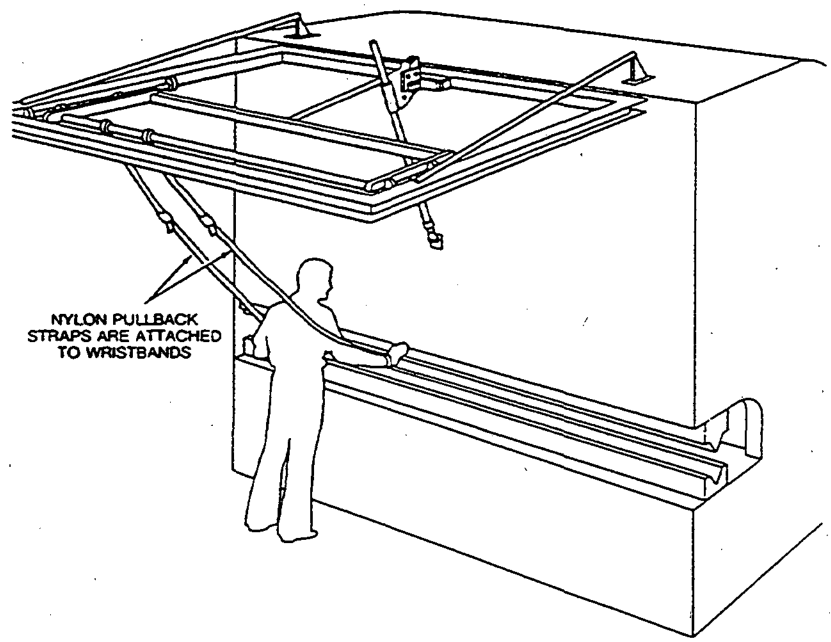


Fig. 5.8. A pullback device.

- A **restraint device** utilizes cables or straps that are attached to the operator's hands and to a fixed point. The cables or straps must be adjusted to let the operator's hands travel within a predetermined safe area. (See Fig. 5.9.)

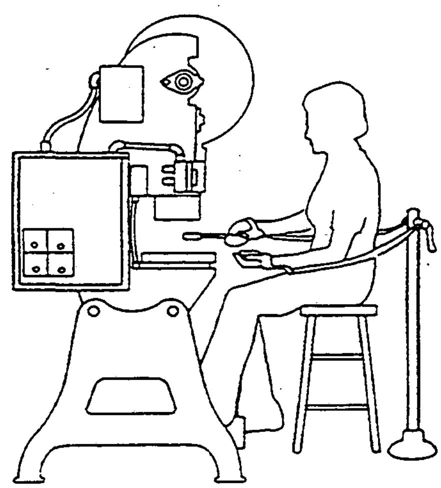


Fig. 5.9. A restraint device.

5.3.9.4 SAFETY CONTROLS

Safety Trip Controls

Safety trip controls provide a quick means for deactivating the machine in an emergency situation.

- A pressure-sensitive **body bar**, when depressed, will deactivate the machine. If the operator or anyone trips, loses balance, or is drawn into the machine, applying pressure to the bar will stop the operation. (See Fig. 5.10.)

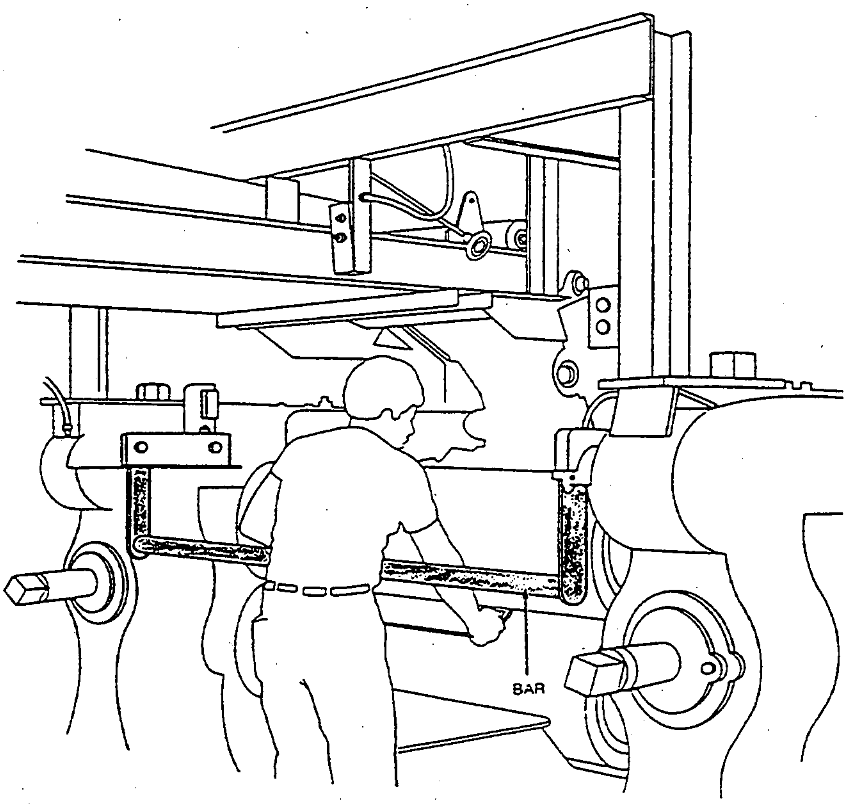


Fig. 5.10. A pressure-sensitive body bar.

- A **safety triprod**, when pressed by the operator's hand, deactivates the machine. Because it has to be actuated by the operator during emergency situations, proper position is critical. (See Fig. 5.11.)

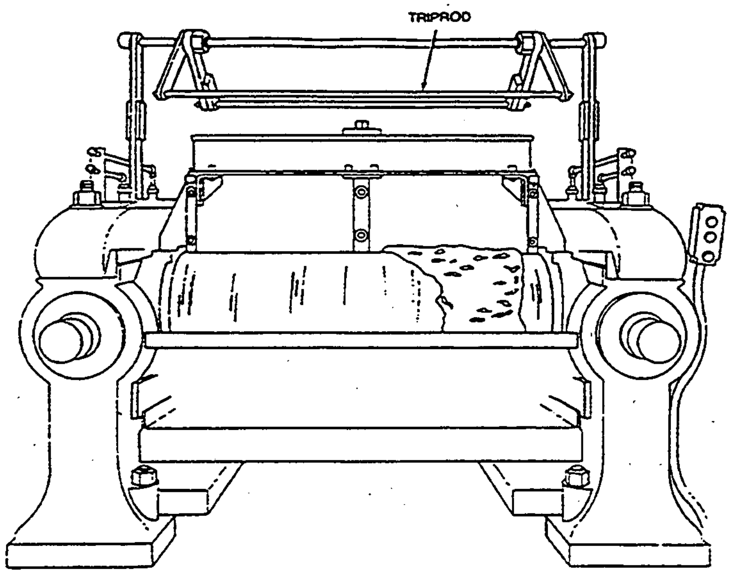


Fig. 5.11. A safety triprod.

- **Safety tripwire cables** are located around the perimeter of or near the danger area. The operator must be able to reach the cable with either hand to stop the machine. (See Fig. 5.12.)

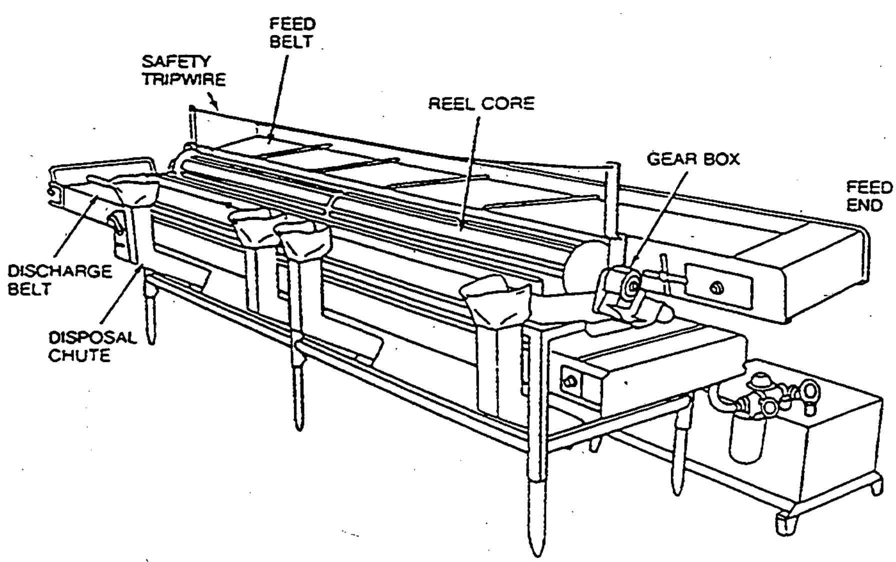


Fig. 5.12. Safety tripwire cables.

- **Two-hand control** requires constant, concurrent pressure by the operator to activate the machine. This kind of control requires a part-revolution clutch, brake, and a brake monitor if used on a power press. With this type of device, the operator's hands are required to remain at a safe location (on the control buttons) and at a safe distance from the danger area while the machine completes its closing cycle. (See Fig. 5.13.)

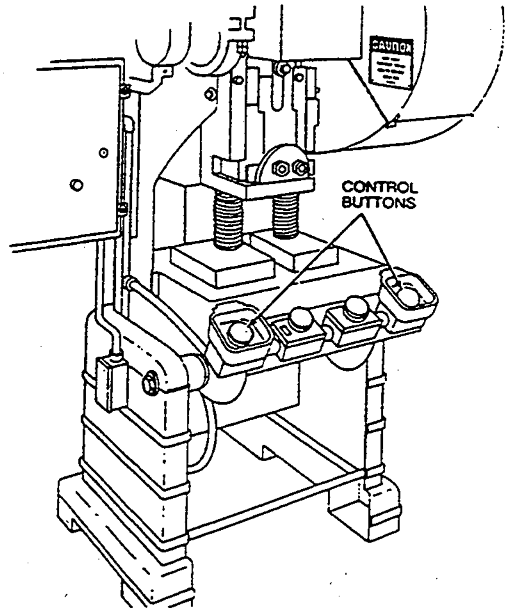


Fig. 5.13. A machine with two-hand control.

- A **two-hand trip** requires concurrent application of both of the operator's control buttons to activate the machine cycle, after which the hands are free. This device is usually used with machines equipped with full-revolution clutches. The trips must be placed far enough from the point of operation to make it impossible for the operator to move his or her hands from the trip buttons or handles into the point of operation before the first half of the cycle is completed. The operator's hands are kept far enough away to prevent them from being accidentally placed in the danger area before the slide, ram, or blade reaches the full "down" position. (See Fig. 5.14.)

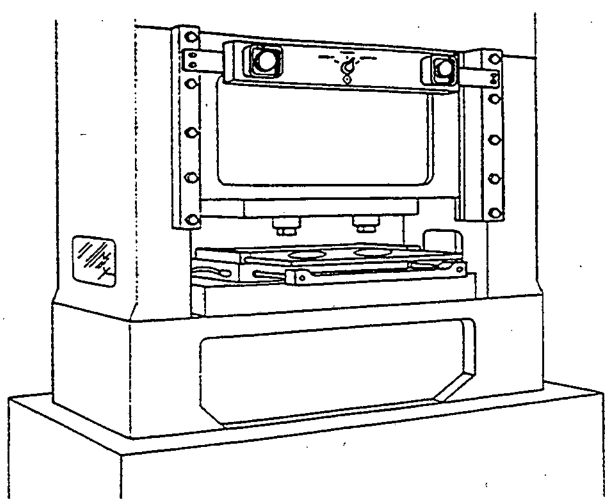


Fig. 5.14. A machine with a two-hand trip.

Gates

Gates are movable barriers that protect the operator at the point of operation before the machine cycle text can be started. Gates are, in many instances, designed to be operated with each machine cycle. (See Fig. 5.15.)

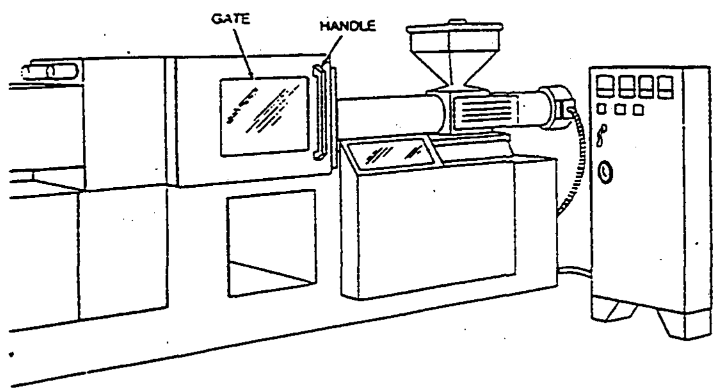


Fig. 5.15. A machine with a gate.

5.3.9.5 LOCATION/DISTANCE

A thorough hazard analysis of each machine and particular situation is essential before attempting this safeguarding method.

To safeguard a machine by location, the machine or its dangerous moving parts must be so positioned that hazardous areas are not accessible or do not present a hazard to a worker during the normal operation of the machine.

5.3.9.6 FEEDING AND EJECTION METHODS

Many feeding and ejection methods do not require the operator to place his or her hands in the danger area. In some cases, no operator involvement is necessary after the machine is set up.

Properly designed ejection methods do not require operator involvement after the machine starts to function. Some feeding and ejection methods may even create hazards themselves. For instance, a robot may eliminate the need for an operator to be near the machine but may create a new hazard itself by the movement of its arm. Using these feeding and ejection methods does not eliminate the need for guards and devices.

- **Automatic feeds** reduce the exposure of the operator doing the work process and sometimes do not require any effort by the operator after the machine is set up and running. (See Fig. 5.16.)

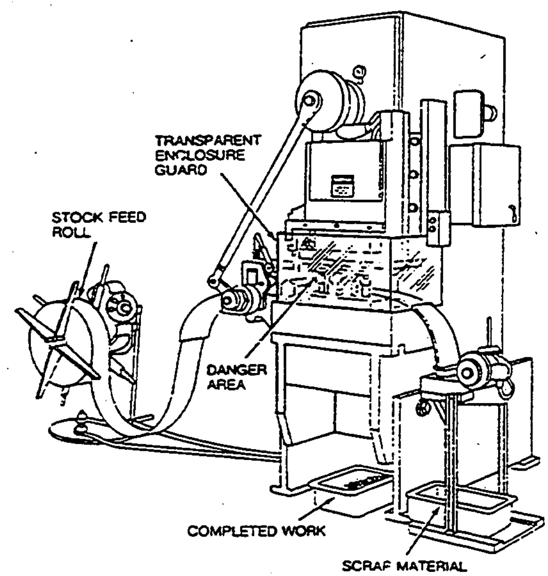


Fig. 5.16. A machine with automatic feed.

- With **semi-automatic feed,** as in the case of a power press, the operator uses a mechanism to place the piece being processed under the arm at each stroke. The operator does not need to reach into the danger area, and the danger area is completely enclosed. (See Fig. 5.17.)

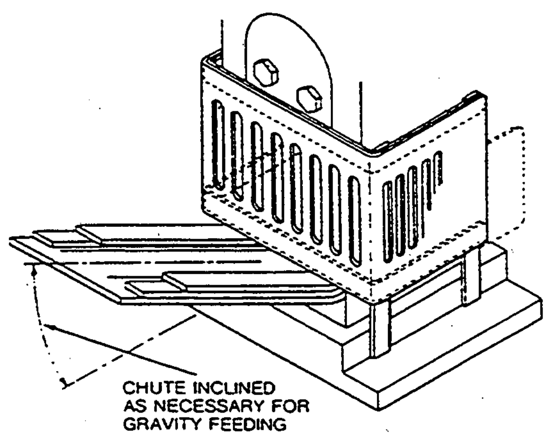


Fig. 5.17. A semi-automatic feed mechanism.

- **Automatic ejection** may employ either air pressure or a mechanical apparatus to remove the completed part from a press. It may be interlocked with the operating controls to prevent operation until part ejection is accomplished. This method requires additional safeguards for full protection of the operator. (See Fig. 5.18.) Note: Air ejection methods often present a noise hazard to operators.

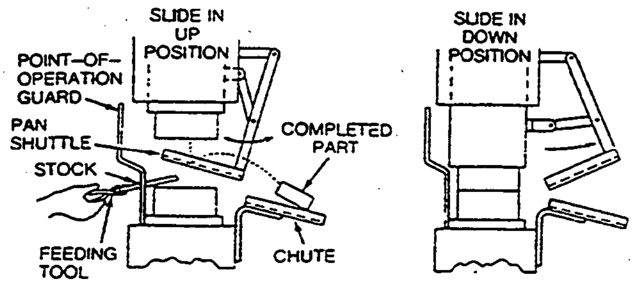


Fig. 5.18. An automatic ejection mechanism.

- **Semi-automatic ejection** is usually mechanically coupled with the machine to kick out the completed work. If the partially ejected product is not removed, the machine will not re-cycle or restart for the next task. (See Fig. 5.19.)

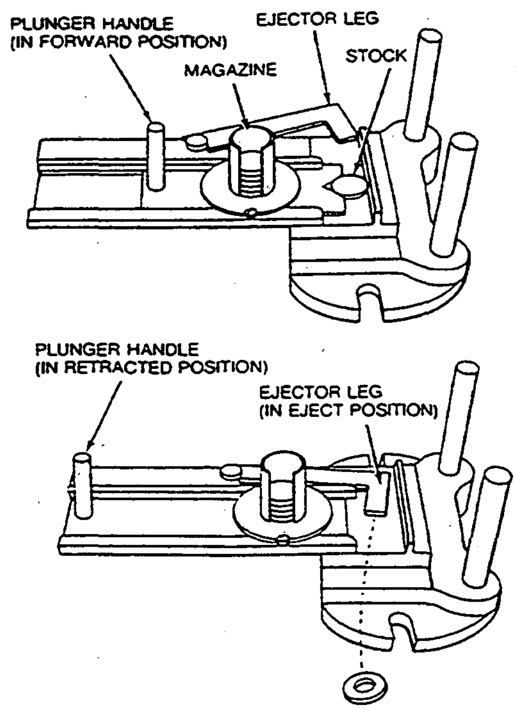


Fig. 5.19. A semi-automatic ejection mechanism.

5.3.9.7 MISCELLANEOUS AIDS

Although these aids do not give complete protection from machine hazards, they may provide the operator with an extra margin of safety. Sound judgment is needed in their use. These are examples of possible applications.

- **Awareness barriers** do not provide physical protection but serve only as reminders to a person that he or she is approaching the danger area. Generally, awareness barriers are not considered adequate where continual exposure to the hazard exists. (See Fig. 5.20.)

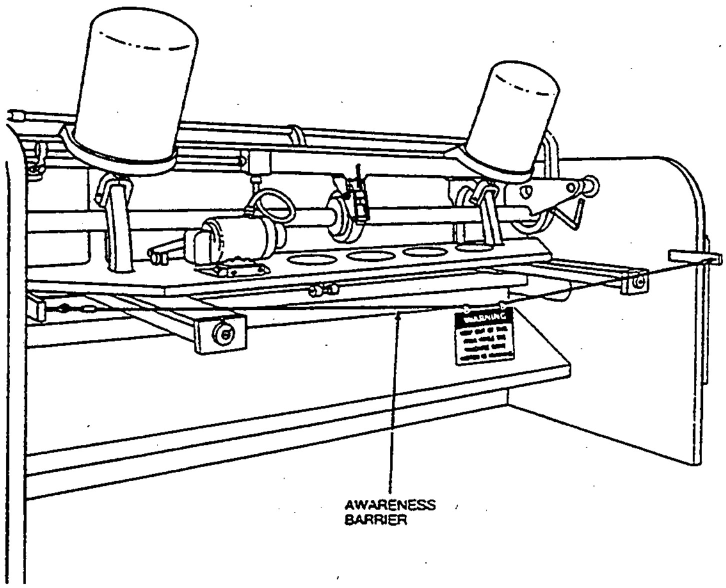


Fig. 5.20. An awareness barrier.

- Miscellaneous **protective shields** may be used to provide protection from flying particles, splashing cutting oils, or coolants. (See Fig. 5.21.)

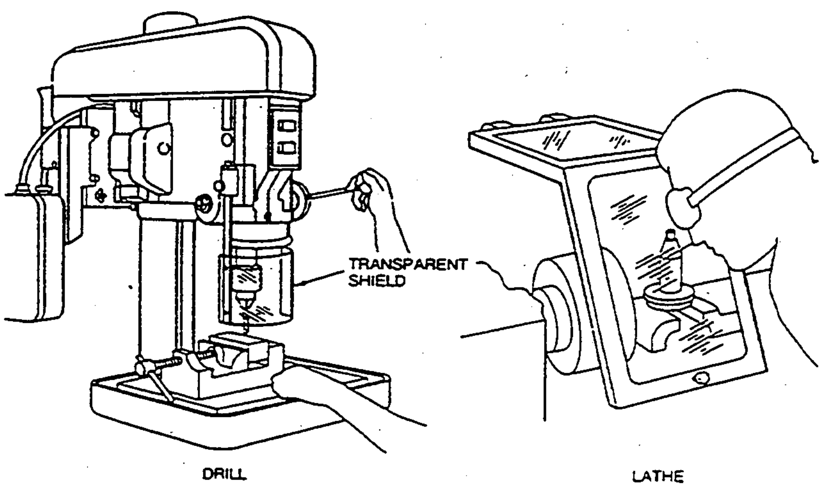


Fig. 5.21. Miscellaneous protective shields.

- **Hand-feeding tools** and **holding fixtures** can place or remove stock. A typical use would be for reaching in the danger area of a press or press brake. (See Fig. 5.22.)

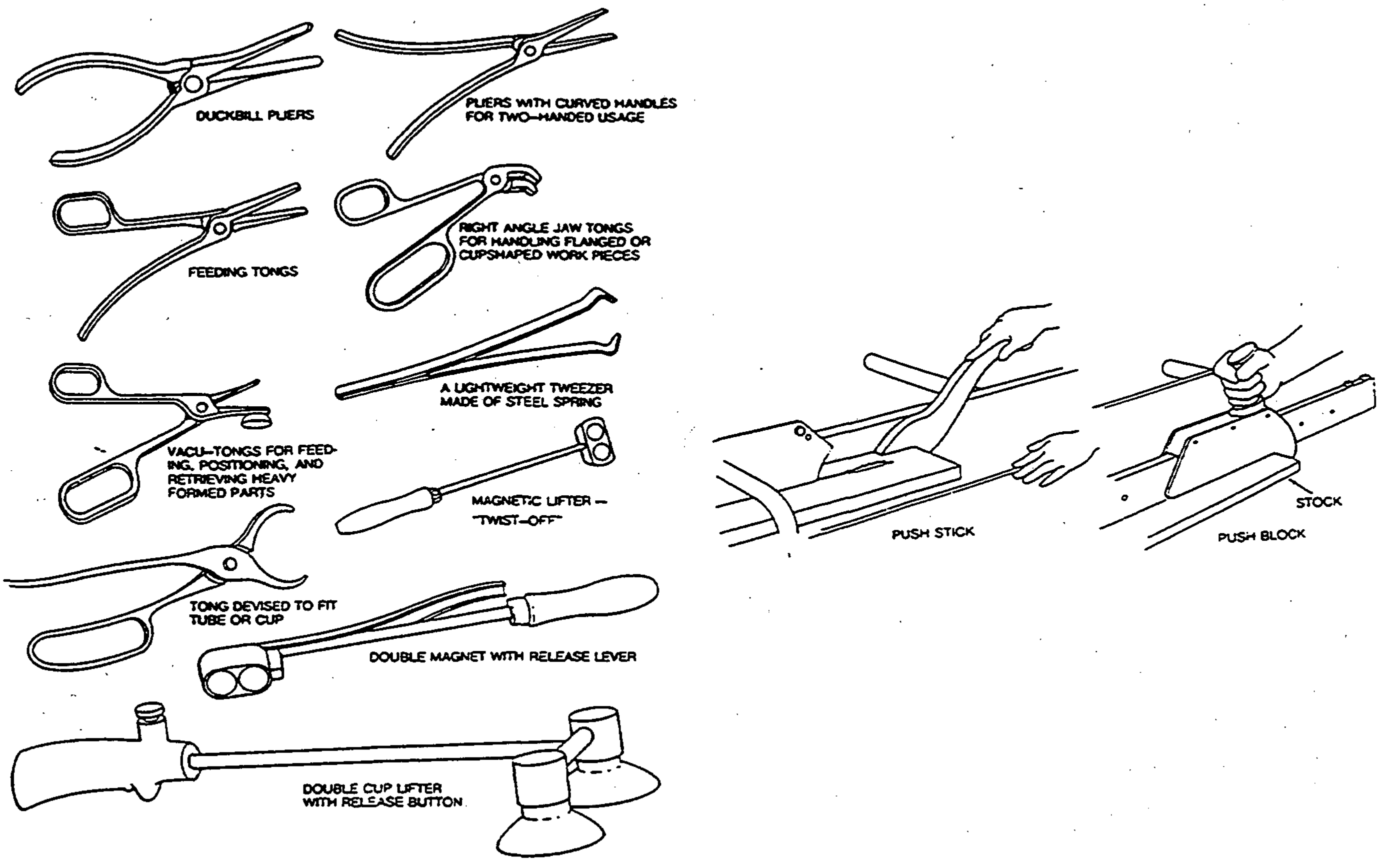


Fig. 5.22. Hand-feeding tools and holding fixtures.

5.3.10 GUARD CONSTRUCTION

Builders of many single-purpose machines provide point-of-operation and power-transmission safeguards as standard equipment. Unfortunately, not all machines in use have built-in safeguards provided by the manufacturer.

Guards designed and built by the manufacturer offer two main advantages:

- They usually conform to the design and function of the machine.
- They can be designed to strengthen the machine in some way or to serve some additional functional purposes.

Guards fabricated by the machine tool user are sometimes necessary for a variety of reasons. They have these advantages:

- Often, with older machinery, they are the only practical solution.
- In older plants, they may be the only choice for mechanical power transmission apparatus, where machinery is not powered by individual motor drives.

- They permit options for point-of-operation safeguards when skilled personnel and machinery are available to make them.
- They can be designed and built to fit unique and even changing situations.
- They can be installed on individual dies and feeding mechanisms.

They also have disadvantages:

- User-built guards may not conform well to the configuration and function of the machine.
- User-built guards may be poorly designed or built.

5.3.11 LOCKOUT/TAGOUT

Another aspect of machine safeguarding is the Lockout/Tagout (LOTO) Program. Lockout/tagout can be done electrically or mechanically. Specific instructions, guidelines, and procedures can be found in Chapter 18, *Lockout/Tagout*. Training for lockout/tagout is available through EH&S Training.

5.3.12 RESPONSIBLE PARTIES

5.3.12.1 SUPERVISORS

Supervisors must make certain that personnel know how to operate machine tools. Only those employees who are formally qualified by training and certification may operate machine tools.

Supervisors must enforce the use of safe machine tool use and maintain machine tools in good mechanical and operating condition.

5.3.12.2 EMPLOYEES

Employees are required to observe all established safety regulations relating to machine tool use and operation.

EH&S provides training programs for employees and individual authorization for those who have demonstrated the ability to operate machine tools.

Responsibility for all machine tool use is shared between the supervisor or person responsible for the shop and the actual machine tool user. Machine tool users are responsible for:

- Adhering to all machine shop safety requirements, rules and regulations.
- Upon request, providing the shop supervisor with information regarding the certification of user authorization.
- Providing suggestions on improving safeguarding that may already be in place.

- Reporting any machine that does not have a safeguard for all points of operation or rotational motion; nip points; and cutting, shearing, punching, and forming mechanisms.
- Wearing appropriate clothing to perform the job (i.e., no loose-fitting clothing or jewelry).
- Safe machine tool use and maintaining machine tools in good mechanical and operating condition.
- Reporting immediately any machine tools that exhibit signs of excessive wear or have damaged or misused parts (e.g., a lathe that is leaking an excessive amount of oil or a drill press that appears to have a faulty chuck).

5.3.13 STANDARDS

- OSHA 29 CFR 1910, *Occupational Safety and Health Standards for General Industry*
- OSHA 29 CFR 1910.211, *Definitions*
- OSHA 29 CFR 1910.212, *General Requirements for All Machines*
- OSHA 29 CFR 1910.213, *Woodworking Machinery Requirements*
- OSHA 29 CFR 1910.215, *Abrasive Wheel Machinery*

5.3.14 RELATED PUB-3000 CHAPTERS

- *Lockout/Tagout* (Chapter 18)

5.3.15 REFERENCES

- ANSI B11.1, *Safety Requirements for the Construction, Care, and Use of Mechanical Power Presses*
- ANSI B11.3, *Safety Requirements for the Construction, Care, and Use of Mechanical Power Press Brakes*
- ANSI B11.4, *Safety Requirements for the Construction, Care, and Use of Shears*
- ANSI B11.6, *Safety Requirements for the Construction, Care, and Use of Lathes*
- ANSI B11.7, *Safety Requirements for the Construction, Care, and Use of Cold Headers and Cold Formers*
- ANSI B11.8, *Safety Requirements for the Construction, Care, and Use of Drilling, Milling, and Boring Machines*
- ANSI B11.9, *Safety Requirements for the Construction, Care, and Use of Grinding Machines*
- ANSI B11.10, *Safety Requirements for the Construction, Care, and Use of Metal Sawing Machines*
- ANSI B11.13, *Safety Requirements for the Construction, Care, and Use of Single- and Multiple-Spindle Automatic Screw/Bar and Chucking Machines*
- ANSI B15.1, *Safety Standard for Mechanical Power Transmission Apparatus*

- *Concepts and Techniques of Machine Safeguarding,* U.S. Department of Labor Occupational Safety and Health Administration (1981)
- Wadden, Richard A. and Scheff, Peter A., *Engineering Design for the Control of Workplace Hazards,* 1987, Chapter 9
- *Guards, Safeguarding Concepts Illustrated,* 5th Edition, National Safety Council, 1987
- *Principles of Occupational Safety and Health, Training Course Participant Guide,* Section 11, Machine Safeguarding, National Safety Council, 1993

PART IV: MATERIAL HANDLING AND STORAGE

5.4.1 POLICY

The purpose of the Material Handling and Storage Program at Berkeley Lab is to provide employees with a safe and healthful work environment, protect personnel from injury and the environment from harm, and minimize damage to equipment and property. The Material Handling and Storage Program is an important element of the overall Laboratory safety program.

5.4.2 SCOPE

This policy applies to all Laboratory employees, casual and participating visitors, guests, and contractors.

5.4.3 LBNL SUPPORT ORGANIZATIONS

- Environment, Health & Safety (EH&S) Division
- Facilities Department
- Engineering Division

5.4.4 INTRODUCTION

The Laboratory requires safety planning and practices for commonplace tasks to be as thorough as those for operations with unusual hazards. Commonplace tasks make up the greater part of the daily activities of most employees and, not unexpectedly, offer more potential sources of accidents with injuries and property damage.

The information presented in this chapter should be considered from a safety and operational viewpoint. Most incidents leading to injury, occupational illness, and property damage stem from failure to observe the principles associated with safe materials handling and storage.

A less obvious hazard is the potential failure of used or obsolete handling or lifting equipment. EH&S must be notified before a crane, hoist, forklift truck, or other handling or lifting equipment is acquired from discarded sources. (See *LBNL Policy and Procedure Memo*, Vol. IX, No. 15, June 16, 1983.)

Before purchasing hoists or cranes, or lifting equipment such as shackles, clevices, wire rope slings, spreader bars (strong-backs), or lifting straps, obtain approval from the Facilities Department. After approval, send a copy to EH&S (Field Support Department, mailstop 48-102). The Engineering Division must also give prior approval for special equipment designed by or for the Laboratory. All equipment used at the Laboratory must have an LBNL proof load tag attached with a current inspection sticker. The user, supervisor, and operator are directly responsible for verifying proper tagging of equipment prior to use.

5.4.5 MATERIAL HANDLING

WHENEVER POSSIBLE, OBJECTS MUST BE LIFTED AND MOVED BY MECHANICAL DEVICES RATHER THAN BY MANUAL EFFORT.

ALTHOUGH THERE ARE NO LEGAL MAXIMUM WEIGHT LIMITS FOR OBJECTS LIFTED BY EMPLOYEES, THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY (NIOSH) RECOMMENDS A 23-KG (51-LB) MAXIMUM WEIGHT LIMIT FOR LIFTING COMPACT OBJECTS.

Employees must not be required to lift heavy or bulky objects that might overtax them physically (see Chapter 17, *Ergonomics*, "Manual Material Handling"). The mechanical devices must be appropriate for the lifting or moving task and must be operated only by personnel trained and authorized to operate them. All hoists, cranes, and secondary support equipment used at the Laboratory must be certified and approved by an appropriate engineer. A copy of the approval must be sent to EH&S (Field Support Department, mailstop 48-102).

5.4.5.1 PLANNING

Every operation or work assignment begins and ends with handling of material. Accident risks can be reduced with thorough preplanning. Identifying obvious and hidden hazards should be the first step in planning and in reviewing work methods and job practices. Thorough planning should include all the steps associated with good management, from job conception through crew and equipment decommissioning.

Planning for **safe-rigging** and **lifting** begins at the design stage, and lifting procedures must be developed for assembly and installation. Lifting procedures must be developed and discussed with EH&S and the rigging crew supervisor.

Responsibility for all rigging jobs is shared between the rigging crew and the customer. Customers are responsible for:

- Defining and requesting the move.
- Providing technical information on relevant characteristics of the apparatus, including special lifting fixtures when required.
- Providing suggestions on rigging and moving.

- Assigning someone to represent both the customer and the rigging crew during planning and coordination of all aspects of the job being performed.

Riggers are responsible for:

- Final rigging.
- Carrying out whatever moves have been designated.

Before any movement takes place, however, each representative must approve the rigging and other procedures associated with the intended move (e.g., filling out a Rigging Pre/Post Job Review form for high-consequence/high-value lifts, and noncritical/nonroutine lifts). Each representative must respect the responsibility and authority of the other to prevent or terminate any action judged to be unsafe or improper. In addition, final procedural review and approval for high-consequence/high-value hardware shall be obtained from the the Facilities Department and EH&S. Included are critical lifts and noncritical/nonroutine lifts.

5.4.5.2 MANUAL LIFTING AND HANDLING

Manual lifting and handling of material must be done by methods that ensure the safety of both the employee and the material. Laboratory policy requires employees whose work assignments involve heavy lifting to be properly trained and physically qualified by a medical examination.

Employees should apply the following rules to manual lifting:

- Inspect the route over which the load is to be carried. Make sure it is in plain view with adequate lighting and is free of obstructions or spillage that could cause tripping or slipping.
- Inspect the load to be lifted for sharp edges, slivers, and wet or greasy spots.
- Wear gloves when lifting or handling objects with sharp or splintered edges. Make sure the gloves are free from oil, grease, or other agents that may cause a poor grip.
- Consider the distance the load is to be carried. Recognize the fact that gripping power will weaken over long distances. DO NOT continue lifting when the load is too heavy.
- Size up the load and make a preliminary "heft" to be sure the load is easily within lifting capacity. If it is not, get help or use a mechanical lifting device.
- If team lifting is required, make sure that personnel are similar in size and physique. One person should act as leader and give the commands to lift, lower, etc.
- When two persons carry a long piece of pipe or lumber, carry it on the same shoulder and walk in step. Use shoulder pads to prevent cutting shoulders and to help reduce fatigue.

Use the following manual lifting guidelines to lift an object off the ground:

- Make sure of good footing and set your feet about 25 to 38 cm (10 to 15 in.) apart. It may help to set one foot in front of the other.

- Assume a knee-bend or squatting position, keeping your back straight and upright. Hold in your abdominal muscles to stabilize your back and to give you more lifting support.
- Get a firm grip on the load. Use a full-palm (palmer) grip to hold the load, not your fingertips.
- Lift the object by straightening your knees, while maintaining a straight back.
- Carry the load close to your body (not on extended arms). To turn or change your position, shift your feet—don't twist your torso.

The guidelines for setting an object on the ground are the same as above but in reverse.

5.4.5.3 MECHANICAL LIFTING

Mechanical devices must be used for lifting and moving objects that are too heavy or bulky for safe manual handling by employees. Employees who have not been trained must not operate power-driven mechanical devices to lift or move objects of any weight. Heavy objects that require special handling or rigging must be moved only by riggers or under the guidance of employees who have been specifically trained and certified to move such objects. The Facilities Department shall review all written procedures prior to lifting.

5.4.5.4 MECHANICAL LIFTING AND MOVING EQUIPMENT

All cranes, hoists, and accessory equipment shall be examined, certified, and proof-load-tested. Follow these rules when using mechanical lifting and moving devices:

- Inspect each device at least once a year. Verify that current quarterly inspection stickers and proof load tags are in place on **all** primary lifting equipment for hoists and cranes (see Fig. 5.23). Quarterly inspection stickers are located on the proof load tags.
- Inspect each device at least once a year. Verify that proper LBNL tags and inspection stickers are in place on **all** secondary lifting equipment for hoists and cranes (see Fig. 5.23).
- Make sure that defective equipment is repaired before it is used.
- Inspect each device before lifting a load near its rated capacity.
- **Do not exceed the rated load capacity** of lifting equipment.
- Drive material-moving equipment forward going up a ramp and backward going down a ramp. **Note:** ***Pallet jacks should not be used on ramps,*** unless the load is securely strapped to the pallet **and** the pallet is strapped to the pallet jack platform.
- Do not allow traffic or personnel to pass under a raised load.
- Check the floor loading limit before mobile lifting equipment enters an area.
- Do not allow passengers to be carried on lifting equipment unless it is specifically equipped to carry passengers.

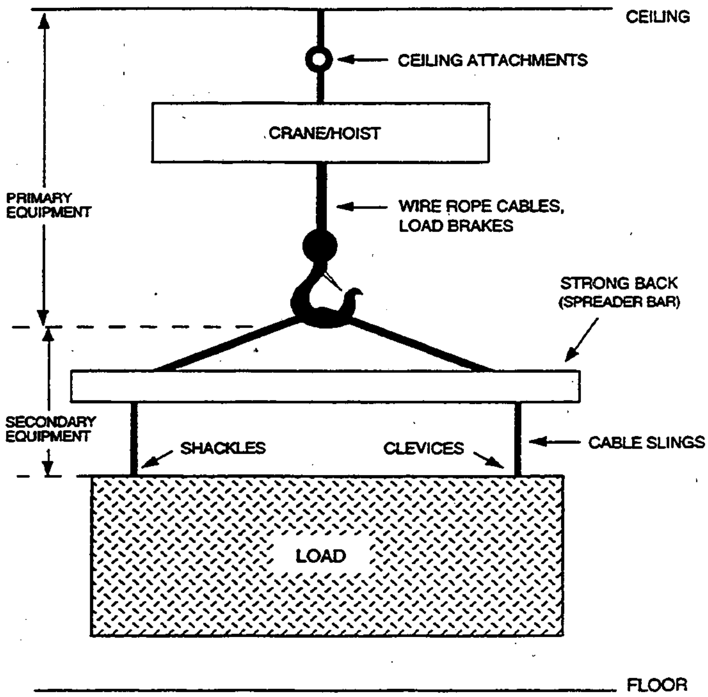


Fig. 5.23. Primary and secondary lifting equipment.

5.4.5.5 SUSPENDED LOADS

Follow these rules for suspended loads:

- Do not allow loads moved with any material-handling equipment to pass over any personnel.
- Select the load path to eliminate the possibility of injury to employees should the material-handling equipment fail.
- Ensure that equipment worked on while supported by material-handling equipment has a redundant supporting system capable of supporting all loads that could be imposed by failure of the material-handling equipment.
- Never leave a suspended load unattended. Lower it to the working surface and secure the material-handling equipment before leaving the load unattended. Any exceptions must be approved by the Facilities Department and EH&S.
- Wear protective equipment (e.g., hard hats, gloves, safety shoes, safety glasses) while working with suspended loads; this rule applies to LBNL personnel and contractors.

NEVER WORK UNDER SUSPENDED LOADS.

5.4.5.6 PACKING AND UNPACKING

Shipping is responsible for packing and crating material being shipped off-site. Send boxes, wooden crates, and other packing materials to waste or salvage as soon as possible following unpacking.

5.4.5.7 TRUCK LOADING

Follow these rules for loading trucks:

- Secure all objects to the truck to prevent any shifting of the load in transit.
- Block the wheels of trucks being loaded or unloaded to prevent movement.

5.4.5.8 ILLUMINATION

Every work location must be provided with **illumination** that meets OSHA requirements. Evaluation of illumination quality and requirements is made by Facilities, but the supervisor of an area is responsible for obtaining and maintaining suitable illumination.

Areas without natural lighting and areas where hazardous operations are conducted must be provided with enough automatically activated **emergency lighting** to permit exit or entry of personnel if the primary lighting fails.

5.4.5.9 INSTALLATION AND STORAGE OF TEMPORARY EQUIPMENT

Temporary equipment required for research projects or support activities must be installed or stored so that it will not constitute a hazard:

- Maintain a minimum clearance of 91 cm (36 inches) around electrical power panels.
- Install wiring and cables in a safe and orderly manner, preferably in cable trays.
- Use appropriate guarding for machinery and possible contact points with electrical power.
- Locate the controls for temporary equipment to prevent inadvertent actuation or awkward manipulation.
- When heat-producing equipment must be installed, avoid accidental ignition of combustible materials or touching of surfaces above 60 C (140 F).

5.4.6 STORAGE

Keep all Laboratory areas in a clean and orderly condition. Use areas only for activities or operations for which they have been approved.

Follow these rules for storage:

- Keep stairs, corridors, and aisles clear.
- Keep traffic lanes and loading areas clear and appropriately marked.
- Store materials in work rooms or designated storage areas only. Do not use hallways, fan lofts, or boiler and equipment rooms as storage areas.
- Do not allow exits, passageways, or access to equipment to become obstructed by either stored materials or materials and equipment in use.
- Arrange stored materials safely to prevent tipping, falling, collapsing, rolling, spreading, or any other unsafe motion.
- Do not exceed the rated floor capacity of stored material for the area. The load limit and the maximum height to which material may be stacked must be posted.
- Place materials such as cartons, boxes, drums, lumber, pipe, and bar stock in racks or in stable piles as appropriate for the type of material.
- Store materials that are radioactive, fissile, flammable, explosive, oxidizing, corrosive, or pyrophoric only under conditions approved for the specific use by EH&S.
- Segregate and store incompatible materials in separate locations.
- Remove items that will not be required for extended periods from work areas and put them in warehouse storage. Call Stores for assistance.

5.4.7 CRANES

5.4.7.1 OPERATORS AND TRAINING

There are several types of **heavy-duty cranes** at the Laboratory:

- **Bridge cranes, overhead cranes,** or **monorail cranes** that are cab-operated, pendant-operated, and/or radio-operated.
- **Mobile cranes** that consist of a boom with controls mounted on a truck chassis; included are all-terrain mobile cranes.

All Laboratory hoists and cranes must be operated only by trained and certified operators designated by the supervisor in charge of the facility. The supervisor is also responsible for:

- Ensuring that operators are trained.
- Carrying out daily inspections.
- Following the rules of the Operator/Rigger Training Program.

The LBNL Hoist, Crane and Forklift Program is a shared responsibility between the Facilities Department and the Environment, Health and Safety Division.

The Facilities Department conducts and ensures training courses and examinations to all codes and standards adopted by the Laboratory. The Facilities designated trainers teach all hoist, crane, and forklift classes that include a written examination on the safety aspects of operation and a satisfactory demonstration of operational skills. Health Services must determine that the applicant does not have any disqualifying medical or physical disabilities (e.g., high blood pressure).

To obtain an application form for attendance, contact the Division Training Coordinator (Engineering, ext. 7506, and all other divisions, ext. 5495).

DOE requires that the LBNL Hoist, Crane and Forklift Program complies with:

- Federal OSHA Standards 29 CFR 1910.179
- Cal-OSHA Standards, Title 8

The DOE Hoisting and Rigging Manual, ANSI/ASME B30.2 and ANSI/ASME B30.5 are recommended references. In addition, maintenance personnel must comply with LBNL PUB-3054, Electrical Overhead Traveling Cranes; and incidental crane operators must comply with PUB-3040, Incidental Crane Operator's and Incidental Rigger's Manual.

5.4.7.2 SIZING, ATTACHING, AND MOVING THE LOAD

The crane must not be loaded beyond its rated load except for test certification purposes. Hoist chain or hoist rope must be free of kinks or twists and must not be wrapped around the load. Crane operators and floor personnel must follow the OSHA requirements relating to moving the load. Refer to OSHA 1910.179.

For further information call EH&S, ext. 2976, or the Facilities Department, ext. 7796.

5.4.7.3 HIGH-CONSEQUENCE/HIGH-VALUE LIFTS

High-consequence/high-value lifts are parts, components, assemblies, or lifting operations designated as such by the customer or program organizations because the effect of dropping, upset, or collision of items could:

- Cause significant work delay.
- Cause undetectable damage resulting in future operational or safety problems.
- Result in significant release of radioactivity or other undesirable conditions.
- Present a potentially unacceptable risk of personnel injury or property damage.

High-Consequence/High-Value Lift Requirements

A detailed, step-by-step procedure must be prepared by the customer and/or the rigging supervisor for high-consequence/high-value lifts. For example, a Rigging Pre/Post Job Review form should be completed before any movement takes place. This form should be filed at the Facilities Department. While high-consequence/high-value lift procedures are customarily prepared for one-time use, general high-consequence/high-value lift procedures may be employed to accomplish routine recurrent high-consequence/high-value lift operations. For example, a general high-consequence/high-value lift may be used to lift cover blocks in a canyon or to lift a frequently lifted item in a shop. The procedure must contain the following:

- Identification of the item to be moved.
- Special precautions.
- Weight of the item.
- Total hook load (all component parts of the item plus tackle and load-measuring devices).
- Determination of the center of gravity.
- A list of each piece of equipment and each accessory (e.g., slings, spreader bars, yokes) to be used in the lift. Each must be identified by type and rated capacity. If a portable item to be used has no manufacturer's serial number, an LBNL identification number must be assigned by the person-in-charge (PIC) and affixed to the item.
- Surveillance procedures, checkpoints, and estimated instrument readings must be listed to enable confirmation that the lift is proceeding as planned.
- Checkpoint for the adequacy of the attachment point of the item to be lifted.
- A rigging sketch or sketches that include the following:
  - Lifting points
  - Load vectors
  - Sling angles
  - Accessories used
  - Method(s) of attachment
  - Other factors affecting the capacity of the equipment or accessories
  - Identification of the capacity (or limit) of equipment and load
  - Identification of the expected load in each item of equipment and each accessory.
- A load-path sketch of the load path with the expected height of the load at each point in the lift. Where appropriate, floor loading diagrams are to be included to provide for setting the load down at any point in the path if that should be necessary.
- A travel sketch as a part of the load-path sketch or a separate sketch indicating lifting and travel speeds.
- A sign-off for the PIC acknowledging the PIC's supervision of the lift. There must be a space for the PIC to initial the procedure at each step, as it is completed. The space should accommodate the date and time of item completion as well as the initials of the PIC.

- Load tests and practice lifts, if required, shall be included in the procedure.
- Verification that all primary and secondary hoisting equipment is within the current inspection and test time requirements in this manual (for example, yearly periodic inspections and certification).

When particular types of lifts are to be repeated many times (for example, lifts of items with special lifting features that do not allow variation of the parameters listed above, such as center of gravity, lift point, sling angle, and maximum weight) and set procedures are established for them, no new procedures are required. However, when the items to be lifted are different (for example, if they are unbalanced and do not have the same center of gravity), then separate procedures need to be written to specify the type of item to be lifted and the specific lifting equipment used. Where the design of the facility permits no significant variation in the travel path, the path does not have to be specified. The procedure must, however, clearly define the limits of the procedure. Also, when there is limited access to the crane operational view and control, the PIC's responsibility may be delegated to a specified operator.

High-Consequence/High-Value Lift Procedure Approval

The procedure must be approved by the Facilities Department and EH&S. Any change to the procedure must be reviewed and approved as if it were an original procedure.

High-Consequence/High-Value Lift Personnel

Each person involved in a high-consequence/high-value lift must be familiar with the procedure before beginning work.

A prelift meeting with all participating personnel must be held before the lift. The procedure must be thoroughly reviewed by the Facilities Department and EH&S.

5.4.7.4 SPECIFICATIONS OF NEW CRANES AND MODIFICATION OF EXISTING CRANES

The Facilities Department is responsible for:

- Establishing design parameters relating to general requirements, cabs, footwalks and ladders, stops, bumpers and rail sweeps, brakes, electric equipment, hoisting equipment, warning devices, and other appurtenances to cranes as required in 29 CFR 1910.179, *Occupational Safety and Health Standards for General Industry*.
- Establishing design parameters for all cranes and hoists.
- Incorporating provisions for maintenance workstations (platforms, railings, ladders, tie-off points, etc.) that permit maintenance personnel to safely perform their operations.

Hoists and cranes must have the load capacity marked on each side of the bridge or on the rail in the case of a monorail and jib crane. Mobile cranes must have the load capacity marked in a convenient location. EH&S must review specifications developed by the Engineering Division/Facilities Department.

5.4.7.5 INSPECTIONS

Frequent Inspections

All hoists, cranes, and accessory equipment must be inspected daily by the hoist/crane operator. Inspection tags must be attached daily to each hoist/crane and to all secondary equipment being used. Operator inspection is required only on days the equipment is used.

The **responsible user** or Building Manager must ensure that an annual inspection with a signed report is made.

Rope reeving must be inspected for compliance with the manufacturer's recommendations before first use and annually thereafter by the Facilities Department.

Periodic Inspections

The Facilities Department is responsible for complete inspection of the crane every three months. Additional inspections depend upon the severity of service and the use environment. LBNL and OSHA requirements must be followed.

Inspection of Cranes Not In Regular Use

A crane that has been idle for a period of over six months must be inspected according to LBNL and OSHA requirements before being placed back in service.

Crack Detection

All crane hooks and lifting fixtures must be submitted to a **nondestructive examination (NDE)** at least once every four years. Such NDEs will normally coincide with certification load testing and inspection.

The person in charge of a crane may request testing of hooks or lifting fixtures more frequently than every four years. The person in charge must give Facilities Department personnel a schedule of the desired frequency for testing the hook so they can include disassembly of the hook block in their schedule for preventive maintenance of a particular crane.

Rope Inspections

Running ropes must be thoroughly inspected at least once a year during the quarterly or annual inspection of the crane. A full written, dated, and signed report of rope conditions must be kept on file by the Facilities Department.

5.4.7.6 MAINTENANCE

Routine maintenance, adjustments, and repairs must be performed by the Facilities Department according to its established schedules and in accordance with LBNL and OSHA requirements.

5.4.7.7 USED EQUIPMENT

The Laboratory Hoist/Crane Engineer and EH&S must be notified whenever a crane is requested from excess sources. See *LBNL Policy and Procedure Memo,* Vol. IX, No. 15, June 16, 1983.

5.4.8 FORKLIFT TRUCKS

5.4.8.1 GENERAL SAFETY PRACTICES

Users must familiarize themselves with and comply with OSHA Standard 29 CFR 1910.178. This standard is summarized as follows:

- Modifications and additions must not be performed by the customer or user without the manufacturer's prior authorization or without a qualified engineering analysis. Where such authorization is granted, capacity, operation, and maintenance instruction plates, tags, or decals must be changed accordingly. **Note:** ***Prior to modifications or additions,*** the Facilities Department and EH&S shall be contacted for approval.
- If the forklift truck is equipped with front-end attachments other than factory-installed attachments, the user must ensure that the truck is marked with a card or plate that identifies the current attachments, shows the approximate weight of the truck with current attachments, and shows the lifting capacity of the truck with current attachments at maximum lift elevation with the load laterally centered.
- The user must see that all nameplates, caution markings, and instruction markings are in place and legible.
- The user must consider that changes in load dimension may affect truck capacities.

5.4.8.2 FIRE SAFETY

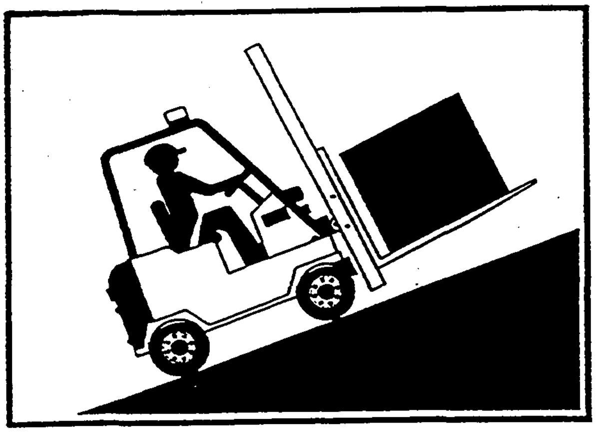
Users must familiarize themselves with and comply with NFPA No. 30-1969. NFPA standards specify certain hazardous locations, Class I through Class III, in which various types of trucks should not be used unless they comply with NFPA requirements.

- Precautions must be taken to prevent emissions and hazardous sparks when flammable materials are present.
- All forklift trucks must carry fire extinguishers, usually 1.1 kg (2-1/2 lb) ABC, regardless of their location classification.
- Repairs or refueling of gasoline and liquefied petroleum gas (LPG) trucks shall be done according to NFPA standards to avoid health hazards, burns, and explosions.
- Only authorized fuel and fuel tank equipment are to be used in gasoline and liquefied petroleum gas trucks.

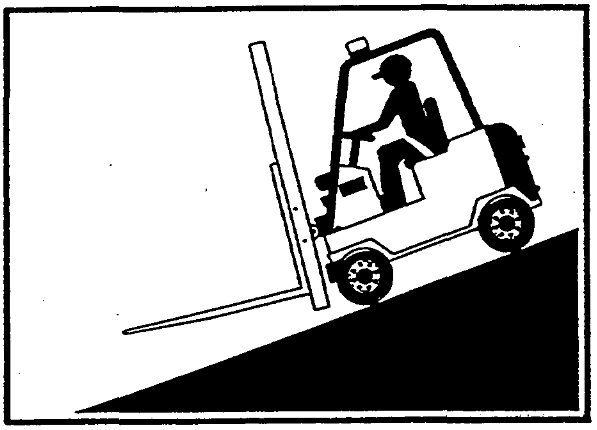
ONLY AUTHORIZED LBNL PERSONNEL SHALL REFILL LPG TANKS ON FORKLIFT TRUCKS.

5.4.8.3 SAFE OPERATION

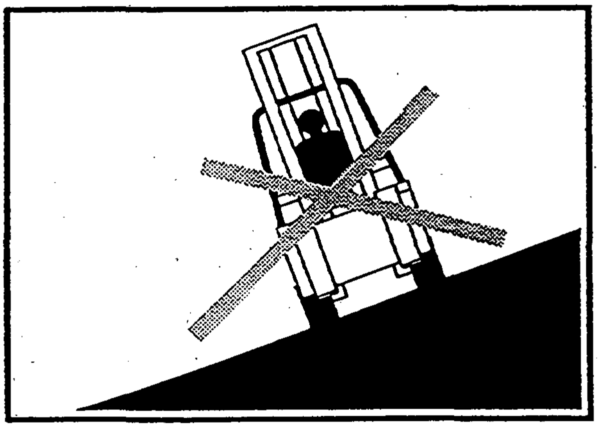
Operators must follow all safety rules regarding speed, parking, loading, unloading, and moving loads. Operators should use extreme caution when operating on ramps, grades, or inclines. (See Fig. 5.24.)



Always ensure the load is against the backrest. Drive a loaded forklift with the load on the uphill side. Back downhill.



Always drive an unloaded forklift with the forks on the downhill side. Drive down forward and back up.



Never turn a forklift sideways on a ramp.

Fig. 5.24. Forklift—safe operation.

5.4.8.4 LICENSING AND CERTIFICATION

All persons operating forklifts at the Laboratory require special Forklift Operator Certification issued by the Hoist, Crane and Forklift Program at LBNL. To be issued certification, applicants must:

- Possess a valid California driver's license.
- Attend and pass a forklift safety training class given by a designated forklift safety instructor.
- Be trained and qualified in forklift operation by an authorized, designated forklift trainer/examiner.
- Be free of any disqualifying medical or physical disabilities based on established requirements, as determined by Health Services.
- Be recertified every three years.

A current list of forklift operators with certification and recertification dates must be kept by each department.

5.4.8.5 MAINTENANCE

Because forklift trucks may become hazardous if maintenance is neglected or incomplete, procedures for maintenance must comply with ANSI B56.1, Section 7, and OSHA Standard 29 CFR 1919.178g.

Operators must follow all safety rules regarding changing and charging batteries in forklift trucks. Battery **changing** must be performed **only by trained and authorized** LBNL personnel. All operators are allowed to charge batteries, once they have been trained by the authorized forklift examiner or their supervisor.

5.4.8.6 CRACK DETECTION

Magnetic particle inspection for cracks must be made, primarily at the heel of the forks:

- Whenever components have been stressed beyond capacity.
- Upon request by the forklift supervisor.

Call Non-Destructive Testing (NDT)/Inspection, ext. 7667, for service.

5.4.8.7 FORK EXTENSIONS

Maximum efficiency, reliability, and safety require that **fork extensions** be used properly. The user must notify EH&S before purchasing extensions or having them fabricated.

Fork extensions are only appropriate for occasional use. When longer forks are needed on a regular basis, the truck should be equipped with standard forks of a longer length.

Routine on-the-job inspections of the fork extensions must be made by the fork lift operator before each use unless the supervisor permits less frequent inspections.

Extensions must be inspected for evidence of:

- Bending
- Overloading
- Excess corrosion
- Cracking
- Other deterioration

All fork extensions, whether they are supplied commercially or fabricated at the Laboratory, must be **proof load tested** to establish or verify their rated capacities. Proof load testing is required **every 2 years.**

A load equal to the rated capacity of the pair at a particular load center, multiplied by 1.15, must be placed on each fork extension pair and fork assembly and supported for a period of five minutes without any significant deformation. Rated capacity must be determined at significant load centers, including the midpoint of the extension and at the tip. Once determined, the rated capacity and load center information must be shown by stamping or tagging the extensions in a protected location of low stress. The proof load test must be witnessed by a mechanical engineer, or a designer from Mechanical Engineering, or EH&S, or by the Facilities Department.

Magnetic particle inspection must be performed whenever evidence of deterioration is detected or whenever the extensions have been overloaded. Call NDT/Inspection, ext. 5901, for service.

5.4.9 LIFTING FIXTURES

5.4.9.1 INSPECTION AND TESTING

Each division is responsible for the safety and inspection of its **lifting devices** (such as screw pin shackles, hoist rings, commercial equipment, etc.) and for its **lifting fixtures** (such as spreader bars, special slings, equipment designed at the Laboratory, etc.). **LBNL proof load tags and inspection stickers must be current.**

All lifting fixtures designed at the Laboratory must be proof-tested to twice their maximum rated loads before being placed in service. An **NDE** is required after the proof test. The rated capacity must be marked on the lifting fixture so that it is clearly visible to the equipment operator.

All **lifting device pins** of 5 cm (2 in.) in diameter or larger must have a magnetic particle inspection before they are placed in service.

Lifting devices and fixtures must be inspected by NDT/Inspection at least once every four years (or upon request), using magnetic particle detection or other appropriate methods. Make arrangements to send lifting fixtures for inspection with NDT/Inspection, ext. 5901, Building 77, Room 158. Records must be maintained current by the Hoist/Crane and NDE organizations.

The Responsible User must ensure that:

- Proof-testing is performed by the Facilities Department on all lifting fixtures designed at the Laboratory, before they are placed in service.
- Adequate test records are kept.
- Lifting devices and fixtures are used and maintained correctly.

The Responsible Designer must obtain design approval from the Facilities Department, then witness and document the proof test and the crack-detection inspection of the lifting device or fixture. For equipment designed at the Laboratory, the Responsible Designer must provide the user with the information required to operate the lifting device or fixture safely. The Facilities Department will provide a test report to the user upon request.

5.4.9.2 DESIGN

Mechanical Engineering is responsible for the design, fabrication, and testing of lifting fixtures.

The **design stress** for lifting fixtures or lifting attachment points must not exceed one-fifth the ultimate strength of the material at its operating temperature. If welded fabrication is used, the design stress must take into consideration any weakening effects of welding, such as those that occur in aluminum alloys.

If practical, avoid welding in the fabrication of lifting fixtures. If welding must be used, design and fabrication in conformance with the latest standards of the American Welding Society (AWS) are recommended. Careful, thoughtful design and follow-up are required. Follow these rules when designing welded units:

- Do not allow welds to be subjected to tearing loads. Stresses in welds must be substantially uniform.
- Where possible, design lifting fixtures so that the main loads are carried only by structural members, plates, or shear pins rather than by welds. Examine this possibility carefully.
- Proof-test welded fabrications to twice the maximum rated load. Follow by a NDE inspection. X-ray primary load-carrying welds and welds in tension.
- The screw-thread engagement required for conservative development of the full strength of a screw fastener depends upon the screw fastener material and the material of the threaded

member. If the fastener is made of the same material as the female threaded member—e.g., a low-carbon steel bolt and a hole threaded into low-carbon steel—an engagement of at least 1–1/2 diameters is required. A hardened steel screw (Allen screw) in mild steel requires at least 2 diameters of engagement. A low-carbon screw fastener, threaded into a tapped hole in aluminum alloy, copper, or cast iron must have a threaded engagement of 1–1/2 diameters. Other material combinations must be approved by Mechanical Engineering. Safety hoist rings may be used to make lifts up to their rated load when screwed 2 hoist-ring bolt diameters into materials such as aluminum alloy, copper, or cast iron.

- When special high-strength bolts are required, consider the use of nonstandard pitch threads to avoid the possibility of using the wrong bolt in the lifting device. Test any bolt used as part of Laboratory-designed lifting fixtures or pickup devices to two (2) times its rated load. A crack-detection inspection must be performed after the load test to ensure soundness. Try to maintain a supply of tested bolts in the event that one is lost, or better yet, to have the bolt on a permanent lanyard.

Once a lifting device or fixture has been delivered to the user, the user is responsible for ensuring that the proper bolt is inserted to the proper depth and correctly torqued.

5.4.9.3 SINGLE-BOLT PICKUP DEVICES

When equipment is designed to be crane-lifted at a single point with a **single-bolt pickup device**, the vertical lifting load through the screw thread of the bolt must be in line with the axis of the bolt so the load will remain level when it is lifted. With this bolt alignment, the lift will be through the center of gravity and will be safer, since the load will not tilt or kick out when it is lifted. A single-bolt pickup device must be used, such as a **safety hoist ring** or equivalent in-house device that is carefully designed and maintained. The threaded engagement must comply with the requirements in the *Design* section above.

When a load is to be crane lifted by slings from a crane hook through two, three, or four single-load pickup points located at the corners of the load, and without the use of a spreader bar, the forces at the lift points are nonvertical. Again, a single-bolt pickup device, such as a safety hoist ring or equivalent in-house device that is carefully designed and maintained, must be used at each pickup point.

Eyebolts with shoulders are permitted for lifting light incidental loads after receiving approval from the building-crane-certified operator or supervisor when the following conditions are met:

- The load is in line with the axis of the eyebolt, and side loads are minimal (a spreader bar may be required).
- The average stress at the root area of the thread does not exceed 3.5×10^7 Pa (5000 psi).
- The thread engagement is at least two bolt diameters.

5.4.10 RESPONSIBLE PARTIES

5.4.10.1 SUPERVISORS

Supervisors must make certain that personnel know how to move objects safely by hand or with mechanical devices. Only those employees who are formally qualified by training and certification may operate a fork truck, crane, or hoist. Supervisors must enforce the use of safe lifting techniques and maintain lifting equipment in good mechanical and operating condition.

5.4.10.2 EMPLOYEES

Employees are required to observe all established safety regulations relating to safe lifting and handling techniques.

5.4.11 STANDARDS

- 29 CFR 1910, *Occupational Safety and Health Standards for General Industry*
  - OSHA Standard 29 CFR 1910.178
  - OSHA Standard 29 CFR 1910.179
- 29 CFR 1926, *Occupational Safety and Health Standards for Construction*

5.4.12 RELATED PUB-3000 CHAPTERS

- *EH&S Training* (Chapter 24)
- *Ergonomics* (Chapter 17)–Section 17.2.1, *Manual Material Handling*

5.4.13 REFERENCES

- NFPA No. 30-1969, *National Fire Protection Association Flammable and Combustible Liquids Code*
- NFPA No. 58-1969, *National Fire Protection Association Storage and Handling of Liquefied Petroleum Gases*
- NFPA No. 505-1969, *National Fire Protection Association Powered Industrial Trucks*
- ANSI/ASME B30.2, *Overhead and Gantry Cranes (Top Running, Bridge, Multiple Girder)*
- ANSI/ASME B30.5, *Crawler, Locomotive, and Truck Cranes*
- ANSI B56.1, *Low Lift and High Lift Trucks*
- *DOE Hoisting and Rigging Manual*, April 1993
- *Electric Overhead Traveling Cranes*, PUB-3054, Lawrence Berkeley Laboratory, March 1986 (under revision)

- *Incidental Crane Operator's and Incidental Rigger's Manual,* PUB-3040, Lawrence Berkeley Laboratory, November 1992
- *LBL Policy and Procedure Memo*, Vol. IX, No. 15, June 16, 1983

PART V: OFF-SITE SAFETY

5.5.1 POLICY

It is LBNL's policy to prevent injuries and illnesses at all locations of responsibility, including off-site operations. Off-site operations include all sites on the UC Berkeley campus and all sites away from LBNL.

5.5.2 SCOPE

This policy applies to:

- All Laboratory employees away from LBNL
- All Laboratory employees on the UC Berkeley campus
- Guests away from LBNL or on the UC Berkeley campus
- Contractors away from LBNL or on the UC Berkeley campus

5.5.3 LBNL SUPPORT ORGANIZATIONS

- Environment, Health & Safety Division (EH&S)
  - EH&S Field Support Department
  - EH&S Radiation Protection Group

5.5.4 OFF-SITE OPERATIONS

Personnel contemplating off-site operations must give written notification to the EH&S Field Support Department of the nature and scope of the project. This notification must be made as soon as possible during the proposal stages of the project. The notification must include a completed Hazard Assessment Guide Table (see Chapter 6, *ES&H Documentation and Approvals*). Additional safety documentation required by LBNL (e.g., Activity Hazard Documents, Specific Safety Procedures, Radiation Work Permits) must be provided and approved by the appropriate LBNL safety professional prior to initiation of the project unless:

1. The work is performed in space identified in Appendix J of the Memorandum of Understanding (MOU).

or

2. The safety jurisdiction of the location where the work is to be performed (e.g., other National Laboratories) requires documentation equivalent to LBNL.

If the work is performed in an equivalent safety jurisdiction, then the appropriate safety professionals at that jurisdiction approve the documentation.

Safety representatives from the division and/or the Field Support Department of EH&S may visit off-site operations to:

- Observe local conditions
- Inspect facilities prior to operations
- Evaluate operating procedures

5.5.5 OFF-SITE INJURIES AND ILLNESSES

When LBNL employees are injured or become ill during off-site operations, the following procedure should be used:

1. Employees should obtain appropriate treatment by a local physician or hospital staff.
2. The Health Services Group, ext. 7192, should be informed so that the proper injury/illness report can be prepared.
3. The Health Services Group forwards this injury/illness report to the EH&S Field Support Department and the Risk Manager when applicable.
4. The EH&S Field Support Department determines whether the injury/illness is work related.

5.5.6 ACTIVITY HAZARD DOCUMENT

Divisions determine whether a written Activity Hazard Document (AHD) is needed. The determination is the responsibility of the Division Director. When reviewed and approved, the AHD becomes the principal safety document for the project or activity. For an example of an AHD, refer to PUB-3000, Chapter 6, *ES&H Documentation and Approvals*.

5.5.7 BOATING AND DIVING OPERATIONS

Supervisors of employees planning to engage in work-related boating or diving operations must contact the Field Support Department, ext. 7067, for guidelines and safety procedures relevant to their specific operation.

An Application for Vessel Use form from EH&S (see Appendix for example) must be filled out and reviewed by the Field Support Department for each vessel.

5.5.8 RESPONSIBLE PARTIES

Personnel contemplating off-site operations must give written notification of the nature and scope of the project, including an AHD (if necessary).

Safety representatives from the division and/or Field Support Department of EH&S may visit off-site operations.

The AHD is to be reviewed and approved by the operation's **Division Director** and by the EH&S Division.

5.5.9 STANDARDS

- 29 CFR 1910, Subpart T, *Commercial Diving Operations*

5.5.10 RELATED PUB-3000 CHAPTERS

- *ES&H Documentation and Approvals* (Chapter 6)

5.5.11 REFERENCES

- U.S. Department of Transportation, Coast Guard, Series 323, *Rules and Regulations for Small Passenger Vessels (under 100 gross tons)*
- U.S. Department of Transportation, Coast Guard, Series M6672.2, *Navigation Rules: International-Inland*

5.5.12 APPENDICES

- Appendix A. Application for Vessel Use

5.5.12 APPENDIX A

Lawrence Berkeley National Laboratory
Environmental Health and Safety

APPLICATION FOR VESSEL USE

Name of Vessel		Official or Award Number:	
Legal Owner		U.S. Coast Guard Certification #	
Mailing Address		City	State & Zip Code
Port of Call		Bodies of water used in	
Operator	License #	Residence Phone:	Business Phone:
Mailing Address:		City	State & Zip Code
Length	Beam	Draft	Light Displacement	Construction
Propulsion: Sail Only ( ) Power Only ( )	Single Screw ( ) Twin Screw ( )	Engine Mfgr. & Type	
Date Built:	Name Vessel Type or Class	Builder	
Date of Last Safety Inspection:		Inspected By:	
Date of Last Dry Dock Inspection:		Inspected By:	
Describe any Significant Modifications to the Vessel or Her Equipment Since Last Inspection(s):			
Registered Owner		Address	

Reviewed By (LBNL EH&S) ______________________ Date ______________________

General Comment:

PART VI: OSHA COMPLIANCE

5.6.1 POLICY

It is LBNL's policy to prevent injuries and illnesses. Compliance with laws, such as OSHA regulations, is very important. However, a truly effective program looks beyond the specific requirements of law to address all potential hazards.

5.6.2 SCOPE

This policy applies to:

- All Laboratory employees
- Guests
- Contractors

5.6.3 LBNL SUPPORT ORGANIZATIONS

- Environment, Health, and Safety Division
  - Field Support Department
  - Fire Services Group
  - Radiation Assessment Group
  - Health Services Group
  - Environmental Protection Group
  - Waste Management Group

5.6.4 CHEMICAL HYGIENE AND SAFETY PLAN

The Chemical Hygiene and Safety Plan (CHSP) is Berkeley Lab's plan for controlling exposures to hazardous chemicals. Exposures to airborne chemicals are to be kept below the permissible exposure levels set forth in the Code of Federal Regulations (29 CFR 1910.1000) and the Threshold Limit Values (TLV) set forth by the American Conference of Government Industrial Hygienists. These standards are met with the proper combination of engineering, administrative, and personal protective controls. See Chapter 4, Industrial Hygiene.

5.6.5 WALKING-WORKING SURFACES

5.6.5.1 GENERAL REQUIREMENTS

Each division is responsible for all laboratory space assigned to it. Therefore, it is incumbent upon the divisions' line management to ensure that the requirements of this section apply to all personnel and to all space for which the respective Division Directors are responsible.

5.6.5.2 HOUSEKEEPING

- All places of employment, passageways, storerooms, and service rooms must be kept clean, orderly, and in a sanitary condition.
- The floor of every workroom must be maintained in a clean and, so far as possible, dry condition. Where wet processes are used, drainage must be maintained, and false floors, platforms, mats, or other dry standing places should be provided where practicable.
- Floors, working places, and passageways must be kept free from protruding nails, splinters, holes, and loose boards.
- Solid or liquid wastes, refuse, and garbage must be removed to avoid creating a menace to health. Floors are to be swept as often as necessary or appropriate to maintain the workplace in a sanitary condition.

5.6.5.3 AISLES AND PASSAGEWAYS

- Where mechanical handling equipment is used, sufficient clearances must be allowed for aisles, at loading docks, though doorways, and wherever turns or passage must be made. Aisles and passageways must be kept clear and in good repair, with no obstruction across or in aisles that could create a hazard.
- Permanent aisles and passageways must be appropriately marked.

5.6.5.4 COVERS AND GUARDRAILS

- Covers and/or guardrails must be provided to protect personnel from the hazards of open pits, tanks, vats, ditches, etc.

5.6.5.5 FLOOR LOADING PROTECTION

In every building, other structure, or part thereof, the loads approved by the Facilities Department must be marked on plates of approved design. These plates must be securely affixed to the building in a conspicuous place. Such plates will not be removed or defaced.

It is unacceptable to place a load on any floor or roof of a building or other structure that is greater than the load approved by the building official.

5.6.5.6 LADDERS

Ladders must be in good condition, made of suitable material, of proper length, and of the correct type for the use intended. Damaged ladders must never be used; they should be tagged "Out of Service" and repaired or destroyed. Ladders used near electrical equipment must be made of a nonconducting material. Stored ladders must be easily accessible for inspection and service, kept out of the weather and away from excessive heat, and well supported when stored horizontally.

A portable ladder must not be used by more than one person at a time. Such ladders must not be placed in front of doors or placed on boxes, barrels, or other unstable bases. Ladders must not be used as guys, braces, or skids. The height of a stepladder should be sufficient to reach the work without using the top or next-to-the-top steps. Bracing on the back legs of stepladders must not be used for climbing.

All fixed ladders, along with their appurtenances and fastenings, shall be designed to meet the following load requirements:

- The minimum design live load shall be a single concentrated load of 90 kg (200 lb).
- The design must take into consideration the number and position of rated live load units of 90 kg (200 lb), as determined by the anticipated use of the ladder.
- For each structural member, the live loads imposed by persons occupying the ladder are considered to be concentrated at the points that cause the maximum stress in the member.
- The design of rails and fasteners must consider the weight of the ladder and attached appurtenances together with the live load.

Design stresses for wood components of ladders must not exceed those specified in 29 CFR 1910.25. All wood parts of fixed ladders must meet the requirements of 29 CFR 1910.25(b). As described in 29 CFR 1910.25 (c)(3)(ii), single, fixed ladders that consist of wood side rails and wood rungs or cleats are acceptable for pitches in the range 75–90°, if they are intended for use by no more than one person per section.

All ladders must be maintained in a safe condition and inspected regularly, with the intervals between inspections to be determined by use and exposure.

5.6.5.7 SCAFFOLDS

All scaffolds, whether fabricated on-site, purchased, or rented, shall conform with the specifications found 29 CFR 1910.28-29 and 29 CFR 1926.450-454.

The footing or anchorage for a scaffold must be sound, rigid, and capable of carrying the maximum intended load without settling or displacement. Unstable objects such as barrels, boxes, loose brick, or concrete blocks must not be used to support scaffolds or planks. No scaffold may be erected, moved, dismantled, or altered unless the operation is supervised by competent persons. Scaffolds and their components shall be capable of supporting at least four times the maximum intended load without failure.

Guard rails and toeboards must be installed on all open sides and ends of scaffolds and platforms more than 3 m (10 ft) above the ground or floor. Scaffolds 1.2–3 m (4–10 ft) in height having a minimum horizontal dimension in either direction of less than 1.1 m (45 in.) shall have standard railing installed on all open sides and ends of the platform.

5.6.5.8 WORK SURFACES

Workroom floors must be clean and dry as much as possible. Drainage mats, platforms, or false floors should be used where wet processes are performed. Floors must be free from protruding nails, splinters, holes, and loose boards or tiles. Permanent aisles or passageways must be marked. Floor holes must be protected by covers that leave no openings more than 2.54 cm (1 in.) wide. Floor openings into which persons can accidentally walk must be guarded by standard railings and toeboards. Open-sided floors, platforms, and runways higher than 1.2 m (4 ft) must be guarded by standard railings. Toeboards must be used wherever people can pass below or when hazardous equipment or materials are below.

5.6.5.9 ELEVATED WORK STATIONS

When workers are required to work from elevated surfaces that are unprotected by railings, the following procedures and guidelines are to be followed:

- Before selecting personnel for work at elevated work stations, supervisors must consider the workers' physical condition, such as medical problems, fear of heights, and coordination. The Health Services Group should be contacted for information in this regard.
- Approved fall-arrester systems are required for all work at heights of ≥ 1.8 m (6 ft). A recommended fall-arrester system consists of a full body-harness, a lanyard consisting of 1.27-cm (1/2-in.) nylon rope or equivalent with a breaking strength of 2450 kg (5,400 lb) and a maximum length to provide for a fall no greater than 1.8 m (6 ft), fall-arrester block (optional), and an anchored hook-up location. Alternate equipment must be approved by the EH&S Division (Reference 29 CFR 1926.500–502).
- Fall-arrester systems are not required when work is being done while standing on a ladder. Ladders should be tied off.
- Use of a controlled-descent device is not necessary unless it is impossible to reach a stranded person by another means.
- The EH&S Division will advise, on request, regarding usage and procedures.

5.6.5.10 EXIT CORRIDORS

Exit corridors must not be used for storage. The *Life Safety Code,* NFPA 101, requires that buildings designed for human occupancy must have continuous and unobstructed exits to permit prompt evacuation of the occupants and allow necessary access for responding emergency personnel. The intent of the code is to keep exits free from obstructions and clear of combustible materials. Therefore, attention to housekeeping is very important.

"Temporary" storage of furniture, equipment, supplies, or anything else is not permitted in exit ways. Combustibles, including recyclable waste paper, are not permitted in exit ways.

5.6.6 GENERAL VENTILATION

Refer to *Chemical Hygiene and Safety Plan: Paragraph F2, General Ventilation,* and PUB-3000, Chapter 4, *Industrial Hygiene.*

Local Exhaust Ventilation

Refer to *Chemical Hygiene and Safety Plan: Paragraph F2, Local Exhaust Ventilation (hoods),* and PUB-3000, Chapter 4, *Industrial Hygiene.*

5.6.7 NOISE

Refer to PUB-3000, Chapter 4, *Industrial Hygiene,* Noise.

5.6.8 RADIATION

Refer to PUB-3000, Chapter 21, *Radiation Protection.*

5.6.9 HAZARDOUS MATERIALS

Refer to PUB-3000, Chapter 4, *Industrial Hygiene.*

Refer to PUB-3000, Chapter 20, *Hazardous Waste Disposal.*

5.6.10 PERSONAL PROTECTIVE EQUIPMENT

Refer to PUB-3000, Chapter 19, *Personal Protective Equipment.*

5.6.11 HEALTH SERVICES

Refer to PUB-3000, Chapter 3, *Health Services.*

5.6.12 EMERGENCIES AND FIRST AID

Refer to PUB-3000, Chapter 3, *Health Services.*

5.6.13 FIRE PROTECTION

Policy and planning for fire safety at LBNL takes into account special fire hazards for specific operating areas, protection of high-value property, and the safety of employees. Listed below are the important aspects of the fire protection plan.

- Noncombustible or fire-rated materials and construction practices suitable to the assigned uses of buildings and facilities.
- Alarm systems and automatic extinguishing systems.
- Availability of suitable hand-held extinguishers and local hose lines for use before firefighters arrive.
- A professional fire department, always staffed and trained in the control of emergencies that could occur at the Laboratory. (The Fire Department makes the initial response to all requests for emergency aid received on the Laboratory emergency telephone number, ext. 7911.)

Refer to PUB-3000, Chapter 12, *Fire Prevention and Protection.*

5.6.14 COMPRESSED GAS

Refer to PUB-3000, Chapter 7, *Pressure Safety and Cryogenics.*

5.6.15 COMPRESSED AIR

Refer to PUB-3000, Chapter 7, *Pressure Safety and Cryogenics.*

5.6.16 MATERIALS HANDLING AND STORAGE

Refer to PUB-3000, Chapter 5, Part IV, *Materials Handling and Storage*

Lifting and moving of objects must be done by mechanical devices rather than by manual effort whenever this is practical. Employees must not be required to lift heavy or bulky objects that overtax their physical condition or capability. The equipment used must be appropriate for the lifting or moving task. Lifting and moving devices must be operated only by personnel trained and authorized to operate them.

Manual lifting and handling of material must be done by methods that ensure the safety of both the employee and the material. It is Laboratory policy that employees whose work assignments require heavy lifting be properly trained and physically qualified, by medical examination if deemed necessary.

Storage

All areas controlled by the Laboratory must be kept in an orderly and clean condition and used only for activities or operations for which they have been approved.

5.6.17 ELECTRICAL

Refer to PUB-3000, Chapter 8, *Electrical Safety.*

Everyone should be aware of potential electrical hazards and safety practices in their work areas. Use only approved and properly maintained equipment such as 3-conductor extension cords. Do not link extension cords together or run them through doorways or windows or across walkways.

Many research activities involve the use of electrical equipment. Recognizing the degree of hazard is paramount for working safely with such energized equipment. If you work on high-voltage electrical equipment, always work in pairs. Above all, always work on equipment that is in a completely de-energized state. Apply shorting, grounding, and lock-and-tag procedures as appropriate.

5.6.18 SIGNS

Signs alert you to the nature and level of the hazard and the protection required (safety glasses, ear protection, etc.) in an area. For example, signs are used to indicate the presence of radioactive materials, high-voltage electricity, lasers, carcinogens, biohazards, or magnetic fields.

Danger indicates the presence of an immediate danger, requiring special precautions to ensure employee safety. For instance, high-voltage electricity requires a *Danger* sign.

Caution warns against potential hazards or indicates safety practices. These signs indicate a possible hazard for which proper precautions must be taken, for example, the *Caution* signs in an Eye Hazard Area, where safety glasses must be worn.

Notice is used to provide general instructions or information related to safety. Dosimeter areas for radiation workers are indicated by *Notice* signs.

Refer to PUB-3000, Chapter 5, Part IX, *Warning Signs and Devices.*

5.6.19 RESPONSIBLE PARTIES

- All Laboratory employees
- Guests
- Contractors

5.6.20 STANDARDS

- 29 CFR 1910, *Occupational Safety and Health Standards*
- 29 CFR 1926, *Safety and Health Regulation for Construction*

5.6.21 RELATED PUB-3000 CHAPTERS

- *Electrical Safety* (Chapter 8)
- *Fire Prevention* (Chapter 12)
- *Hazardous Waste Disposal* (Chapter 20)
- *Health Service* (Chapter 3)
- *Industrial Hygiene* (Chapter 4)
- *Material Handling and Storage* (Chapter 5)
- *Personal Protective Equipment* (Chapter 19)
- *Pressure Safety and Cryogenics* (Chapter 7)
- *Radiation Protection* (Chapter 21)

5.6.22 REFERENCES

- *Berkeley Lab Environment, Safety and Health Self-Assessment Program,* PUB-5344, June 1996
- ANSI A10.8, *Safety Requirements for Scaffolding*
- *LBNL Chemical Hygiene and Safety Plan (CHSP),* PUB-5341, April 1992

PART VII: POWER AND HAND OPERATED TOOLS

5.7.1 POLICY

It is LBNL's policy to prevent injuries caused by power and hand tools. However, a truly effective program looks beyond specific requirements of law to address all potential hazards.

5.7.2 SCOPE

This policy applies to:

- All Laboratory employees
- Guests
- Contractors

5.7.3 LBNL SUPPORT ORGANIZATIONS

- Engineering Division
- Facilities Department
- EH&S Field Support Department of the Environment, Health and Safety Division

5.7.4 TOOL INSPECTION AND TESTING

Hand and power tools must be visually inspected by the user for external defects, alterations, and damage before the equipment or tool is used. If there is a defect or evidence of damage (such as mushroomed heads on impact tools [e.g., drift pins, wedges, or chisels], cracked body, damaged cutting edges, cracked grinding wheels and saws, or removed or modified guards) that might expose an employee to injury, the defective, altered, or damaged tool must be removed from service. This tool must not be used until necessary repairs and tests to render it safe have been completed.

A tool found altered, modified, damaged, or malfunctioning must not be used and must be removed from service, tagged-out by using "Out of Service" tags (yellow-color 'Need of Repair' Stock Cd# 4280-71327 plus red-color 'Danger Do not Operate' Stock Cd# 4280-71326), and sent to an approved repair or maintenance shop.

As a part of the Laboratory's Divisional Self-Assessment Program, periodic audits will be performed to assist in providing protection from the hazards associated with hand and power tools.

5.7.5 GENERAL REQUIREMENTS FOR ALL TOOLS

All power and hand tools must be maintained in a safe condition, whether supplied by the Laboratory, a contractor, or an employee.

Any powered tool designed to accommodate guarding (such as circular saw guards, airless spray-gun nozzle tip guards, belt sanding machine nip-point guards, or portable grinder abrasive wheel guards) must be equipped with guarding during use.

Special precautions (e.g., bracing) must be employed when using high-torque tools.

Compressed air for cleaning purposes must not be used unless the pressure is reduced to less than 2.1×10^5 Pa (30 psi) at the approved nozzle, and there is effective chip guarding and personal protective equipment (such as safety glasses with side shields, screens, or baffles). The 2.1×10^5 Pa (30-psi) requirement does not apply to concrete forms, mill scale, and similar cleaning.

5.7.6 REQUIREMENTS FOR SPECIFIC TOOL TYPES

5.7.6.1 ELECTRICALLY POWERED TOOLS

Portable electrically powered tools must be of an approved, double-insulated type or grounded to conform to OSHA electrical standards.

Electrically powered hand tools used on construction sites, on temporary wired circuits, or in wet environments must be used in conjunction with an approved ground fault circuit interrupter (GFCI).

The use of electric cords for hoisting or lowering tools is prohibited.

5.7.6.2 PNEUMATICALLY POWERED TOOLS

All pneumatic tools must be secured to the hose or whip by some positive means to prevent the tool from accidentally disconnecting.

Safety clips or retainers for pneumatic-impact (percussion) tools must be securely installed and maintained to keep attachments from being accidentally expelled.

Pneumatic tools such as nailers and staplers with automatic fastener feeds, operating at over 6.9×10^5 Pa (100 psi) pressure at the tool, must have a safety device on the muzzle to prevent ejection of fasteners unless the muzzle is in contact with the work surface.

Pneumatic hand tools must be disconnected from the source, and any pressure in lines must be released before any adjustments or repairs are made.

The manufacturer's safe operating pressure must not be exceeded for hose, pipe, valves, filters and fittings.

The use of hose for hoisting or lowering tools is prohibited.

All hoses over 1.27 cm (1/2 in.) in diameter must have a safety device (pressure regulator) at the source of supply or branch line to reduce pressure if the hose fails. All connections must be provided with a device to prevent whipping.

High-pressure airless spray guns ($\geq 6.9 \times 10^6$ Pa [1,000 psi]) must have automatic or visible manual safety devices to prevent pulling the trigger and releasing paint or fluid until the safety device is manually released. Alternatively, a diffuser nut that prevents high-pressure, high-velocity release while the nozzle tip is removed, plus a guard to prevent contact of the nozzle tip with the operator (or equivalent protection), may be used.

5.7.6.3 FUEL-POWERED TOOLS

All fuel-powered tools must be stopped for refueling, servicing, or maintenance, and fuel must be handled and stored in accordance with 29 CFR 1926, Subpart F.

In enclosed spaces, additional precautions for proper ventilation (to maintain the concentration of flammable vapor at or below 10% of the lower flammable limit) and/or personal protective equipment must be employed in accordance with 29 CFR 1926, Subparts D and E.

(Refer to Chapter 19, *Personal Protective Equipment.*)

5.7.6.4 HYDRAULICALLY POWERED TOOLS

The fluid used in hydraulically powered tools must be fire-resistant fluid and must retain its operating characteristics at the most extreme working temperatures to which it will be exposed.

Refer to the manufacturer's manual for the safe operating pressure of tools hoses, pipes, valves, filters, and fittings.

5.7.6.5 POWDER-ACTUATED TOOLS

Operators must be trained and certified by the supplying manufacturer in the use of the particular tool they will operate.

All tools must be tested according to the manufacturer's recommendations before loading to see that the safety devices are working properly.

Defective tools must not be used.

Use personal protective equipment as required in 29 CFR 1926, Subpart E.

(See Chapter 19, *Personal Protective Equipment.*)

Tools must not be loaded until immediately prior to the intended firing time, and loaded tools must not be left unattended.

Tools, whether loaded or empty, must not be pointed at any person.

Tools must not be used in explosive or flammable atmospheres.

All tools must be used with the correct shield, guard, or attachment recommended by the manufacturer.

5.7.7 TRAINING

Employees using hand or power tools with high hazard potential are to receive instructions on the basic principles of their safe use.

No employee is permitted to use powder-actuated tools unless instructed and licensed.

Employees are required to be properly trained in the operation of any specific tool they must use.

Qualified instructors for use of powder-actuated tools must be trained in accordance with the requirements established by either the tool manufacturer or by the Powder-Actuated Tool Manufacturers Institute (PATMI).

Training courses (required): EHS 0241: Tool-Specific Training
(by supervisor via tool manual)

EHS 0242: Powder-Actuated Tools
(manufacturer- specific, i.e., Hilti)

5.7.8 SAFETY PRACTICES

Any LBNL facility housing shop tools is a shop. It is the responsibility of the person in charge of each shop and the areas where hand or power tools are being used to ensure compliance with the following practices:

- The supervisor-in-charge must take whatever action is deemed necessary to prevent personal injury or damage to equipment.
- Shop machines and tools are to be used only by qualified personnel. It is the responsibility of the person in charge of the shop to render a judgment as to who is qualified.
- Equipment guards and protective devices must be used and must not be compromised.

- Approved eye protection must be worn by anyone working in and/or passing through a shop area.
- Shoes or boots covering the whole foot must be worn in all shop areas.
- Persons using machine tools must not wear clothing, jewelry, or long hair in such a way as to present a safety hazard.

5.7.9 RESPONSIBLE PARTIES

5.7.9.1 SUPERVISORS

The supervisor is responsible for the safe condition of all tools and equipment used by employees, including tools and equipment that may be furnished by employees.

Supervisors are responsible for ensuring and documenting that their employees are properly trained in the operation of any specific tool that they are expected to operate, before the tool is used.

5.7.9.2 EMPLOYEES

Employees must use the correct tool for the work to be performed. If they are unfamiliar with the operation of the tool, they must request instruction from their supervisor before starting the job.

5.7.10 STANDARDS

- 29 CFR 1910, Subpart P, *Hand and Portable Powered Tools and Other Hand-Held Equipment*
- 29 CFR 1910, Subpart S, *Electrical*
- 29 CFR 1926, Subpart D, *Occupational Health and Environmental Controls*
- 29 CFR 1926, Subpart E, *Personal Protective and Life Saving Equipment*
- 29 CFR 1926, Subpart F, *Fire Protection and Prevention*
- 29 CFR 1926, Subpart I, *Tools—Hand and Power*
- California Fire Code, Article 9

5.7.11 RELATED PUB-3000 CHAPTERS

- *Lockout/Tagout* (Chapter 18)
- *Personal Protective Equipment* (Chapter 19)

5.7.12 REFERENCES

- ANSI A10.3-1985

PART VIII: TRAFFIC AND TRANSPORTATION

5.8.1 POLICY

The LBNL policy on operation of motor vehicles is in accordance with the California Vehicle Code, the University of California, and the City of Berkeley traffic code. The primary objective of the LBNL traffic program is to provide a safe environment for both the driver and the pedestrian community.

As a general guide, the speed limit on LBNL or University property is 40 km/hr (25 mph) unless otherwise posted. Temporary conditions such as road repair, wet weather, poor visibility, and pedestrian traffic require a reduction in speed.

Because of peak traffic periods, limited parking, and general congestion, it is recommended that the LBNL shuttle bus and transportation services be used whenever possible.

5.8.2 LICENSE REQUIREMENTS

The LBNL *Regulations and Procedures Manual* (RPM), PUB-201, outlines specific requirements for the use of official vehicles. Drivers of official LBNL vehicles must hold a valid California driver license for the class of vehicle that they are authorized to operate. (For information about training for forklift operation, see Chapter 24.)

5.8.3 VEHICLE USE

Each Division Director and Department Head is responsible for restricting the use of Laboratory vehicles to official Laboratory business and for limiting use of such vehicles to properly authorized personnel. Use of an official vehicle for personal convenience or benefit constitutes misuse. Employees who misuse vehicles are subject to disciplinary action and financial responsibility for any accident.

All drivers of Laboratory vehicles are responsible for reporting any vehicle damage or operating deficiency to the LBNL Motor Pool. Failure to report unsafe vehicle conditions can result in an accident and injury of fellow employees.

5.8.4 SAFETY BELTS

In accordance with the California seat-belt law, all employees riding in Laboratory-furnished vehicles (or in personal vehicles on official Laboratory business) must wear safety belts at all times. The driver must not operate the vehicle until everyone has fastened their seat belts.

5.8.5 VEHICLE ACCIDENTS

The driver of any LBNL vehicle involved in an accident must also complete an LBNL Motor Vehicle Accident Report (SF 91) and submit it to his or her supervisor within one work day of the accident. Within two work days of the accident, the completed form and vehicle must be taken to the Motor Pool so that damages can be estimated and repairs scheduled.

5.8.5.1 ON-SITE ACCIDENTS

Any accident involving any vehicle used on official Laboratory business must be reported by the driver to his or her supervisor. If the driver is unable to make a report, another employee who knows the details of the accident must make the report.

5.8.5.2 OFF-SITE ACCIDENTS

The driver should first report the accident to the local police and then report the accident to his or her LBNL supervisor. It is good business practice not to admit responsibility for vehicle accidents occurring while on official business. The employee should obtain adequate information about the drivers involved as well as about the owners of the vehicles. Names, addresses, driver license numbers, vehicle descriptions, damage level, and registration information are essential. A copy of the police report must be sent to LBNL, so the driver will need the name and department of the investigating officer. A printed card titled "In Case of Accident" is kept in each official vehicle to assist in collecting required information.

The Environment, Health and Safety (EH&S) Division must receive copies of all accident reports and will prepare any required reports for DOE . (See Hazardous Materials Accidents: Section: Pickup and Delivery of Hazardous Material.)

5.8.6 MOVING TRAFFIC VIOLATIONS

Any operator of a vehicle at LBNL who violates the California Vehicle Code may be issued a written warning or citation.

5.8.7 DOT DRUG TESTING PROGRAM

Drug and alcohol testing requirements of the Department of Transportation (DOT) are implemented at LBNL through the Transportation Workplace Drug and Alcohol Testing Program, which is a part of the Laboratory's Substance Abuse in the Workplace Policy.

The DOT rules over all employees and contract labor personnel who hold a Commercial Driver's License (CDL) in order to drive a commercial motor vehicle (CMV) on highways, and/or operate:

- a vehicle with a gross combination or gross vehicle weight of at least 26,001 pounds inclusive of a towed unit with a gross vehicle rating of more than 10,000 pounds;
- a vehicle originally designed or currently designed to transport 16 or more passengers including the driver; or
- a vehicle of any size used to transport hazardous materials found in the Hazardous Materials Transportation Act, and which requires the motor vehicle to be placarded under the Hazardous Materials Regulations.

LBNL employees or contractors may not drive a Laboratory CMV unless that individual's name appears on the current Laboratory CDL-holders list maintained by the Facilities Department. The list indicates that the driver is subject to the random testing provisions of the DOT Rule.

The following classifications are subject to the drug and alcohol use rules and substances abuse testing provisions of the DOT Rule:

- Senior Bus Driver
- Bus Driver
- Truck Driver
- Vehicle Mechanic
- Health/Safety Technician (Senior and Principal)

In addition to being subject to testing any time, while at work, for the use of illegal drugs, such individuals are subject to alcohol testing during those periods of time when they are currently performing, have recently performed, are about to perform, or are required to be in readiness to perform and immediately available to perform any of the following safety-sensitive duties as described in the DOT federal regulations, including:

(a) At a carrier's facility or any public property waiting to be dispatched

(b) inspecting, servicing, or conditioning a CMV

(c) driving a CMV

(d) all time in or upon a CMV except in a sleeper berth

(e) performing, supervising, assisting, or attending CMV loading or unloading, including processing paperwork

(f) performing post-accident duties

(g) repairing, obtaining assistance, or attending a disabled CMV.

Information regarding the DOT Rule or the Transportation Workplace Drug and Alcohol Testing Program can be obtained from the Facilities Department, ext. 8605.

5.8.8 LBNL ON-SITE PARKING RULES

Parking Designation	Meaning
Official Vehicle	Only Laboratory vehicles may park here.
Reserved Parking	Only vehicles with designated license numbers may park here.
Time Zone Lanes	All vehicles must be prepared to move at the time indicated.
Compact Car	Vehicles must not extend beyond the rear limit line.
General Parking	Vehicles must be parked in designated places only and must not extend beyond the stripes, the rear limit lines, or the edge of the road.
Permit Parking	Only holders of designated permits are allowed in the indicated parking place.
Red Zones	No stopping, standing, or parking.
Yellow Zones	Stopping is allowed only for loading or unloading passengers or freight.
Green Zones	Limited-time parking.

5.8.9 BICYCLE SAFETY

Any person who rides a bicycle is subject to the same traffic rules as motor vehicle drivers.

5.8.10 PEDESTRIAN SAFETY

Pedestrians are also subject to the California Vehicle Code. Although they do have the right of way at marked crosswalks and unmarked intersections, they must not move into the paths of moving vehicles so suddenly as to constitute a hazard. At all other points on roadways, pedestrians must give way to vehicles. It is the responsibility of supervisors to explain traffic rules to new members of their staff, who might not be familiar with the California Vehicle Code (e.g., visiting researchers).

5.8.11 TRANSPORTATION OF RADIOACTIVE MATERIALS

5.8.11.1 RADIOACTIVE WASTE TRANSPORTATION

On-Site Transfers

On-site transfers of radioactive wastes are performed by EH&S. Information regarding the segregation and packaging of radioactive wastes for on-site transport can be found in PUB-3092, *Guidelines for Generators to Meet HWHF Acceptance Requirements for Hazardous, Radioactive, and Mixed Wastes at Berkeley Lab*. For additional information, please contact your EH&S Generator Assistance Specialist.

Off-Site Transfers

All off-site transportation of radioactive wastes is performed by EH&S using DOT-approved containers.

5.8.11.2 RADIOISOTOPE TRANSPORTATION

The EH&S Transportation Office coordinates the offsite transportation of radioactive materials for all Berkeley Lab research projects and EH&S functions. This is to ensure that applicable requirements are met, such as 49 CFR (US Department of Transportation) and Property Management approval. These requirements address areas such as training, shipping papers, packaging, vehicle placarding, and monetary accountability. Chapter 21, *Radiation Safety*, provides additional information about the transportation, procurement, and delivery of radioisotopes. Contact your Radiological Control Technician or Health Physicist, or call ext. 7652 for assistance.

On-Site transportation of radioisotopes is also normally conducted by the Radiation Protection Group. Small amounts of radioactive materials may be transported on-site by authorized users if certain requirements are met. This policy is contained in EH&S Procedure 750. Contact your Radiological Control Technician or Health Physicist, or call ext. 7652 for assistance.

THE POSSESSION AND USE OF RADIOACTIVE MATERIALS AND RADIATION GENERATING DEVICES MUST BE FORMALLY AUTHORIZED IN WRITING BY EH&S. CHAPTER 21, "RADIATION SAFETY" IDENTIFIES HOW REQUEST THESE AUTHORIZATIONS AND OUTLINES BASIC RADIATION SAFETY PROGRAM REQUIREMENTS.

5.8.12 ACCIDENTAL RELEASES DURING TRANSPORTATION

ON-SITE SPILL: DIAL 7911.
OFF-SITE SPILL: DIAL 911

If there is an accidental release of hazardous materials during transportation, the driver must take the following actions:

- As the first priority, protect life and property by whatever means are available.
- If the material is flammable, keep all flames and sparking devices away.
- Avoid breathing vapors of spilled material; stay upwind.
- Isolate the area.
- Keep non-emergency people and traffic away.
- Have a responsible person stay at the spill at all times.
- If the severity of the accident or spill warrants it, contact local authorities. Contact the dispatcher (or supervisor) at LBNL or LLNL, whichever site is nearest the accident, and relay the following information:
  - Your name
  - Phone # calling from
  - The location of the accident
  - Personal injuries
  - The extent of damage
  - The identity and quantity of material spilled
  - Possible pollution to the area
  - The emergency procedures initiated
- Try to confine the spilled material to as small an area as possible. Try to prevent leakage into storm drains by damming the drainage area with dirt or by channeling the material to a dirt area.

5.8.13 PICKUP AND DELIVERY OF HAZARDOUS MATERIAL

Procedures for the pickup and delivery of hazardous materials are under the authority of Transportation of Materials.

5.8.13.1 GENERAL PROCEDURE

Transportation of Materials is responsible for movement of certain Laboratory materials on and off the LBNL site. Prescribed routes with specified pickup and delivery points are serviced on a regular basis. Material that cannot be handled on routine runs is assigned on an unscheduled basis. Hazardous materials are handled in accordance with DOT Regulations (49 CFR, Part 172).

5.8.13.2 OFF-SITE WAREHOUSE PICKUP OF HAZARDOUS MATERIAL

Receiving

Receiving must prepare a "Hazardous Shipping Paper" (Fig. 5.25) per 49 CFR, 172.202 that includes the following information:

- The proper shipping name, as presented in column 2 of the Hazardous Materials Table (49 CFR, 172.101).
- The hazard class, as shown in column 3 of the Hazardous Materials Table.
- The identification number, as specified for that material in column 3A. The appropriate alpha prefix must also be included, e.g., "Pine Oil, Combustible Liquid, UN1272."
- Except for empty packages, the total quantity (by weight or volume).
- The appropriate labels, as shown in column 4 of the Hazardous Materials Table (49 CFR, 172.400).

The pink copy of the Hazardous Shipping Paper must be attached to the material. The yellow copy must be placed in a folder. Material and folder must then be given to the transportation warehouse run driver. The white copy of the manifest must be placed in the Receiving purchase-order file.

When staging the load, segregate hazardous material from other materials to be transported, in compliance with compatibility rules of 49 CFR, 177.848:

- Poisons must not be loaded with any other hazardous materials.
- Flammable liquids, oxidizers, organic peroxides, and corrosive liquids must be easily accessible.
- Corrosive liquids must be at least 1 m (3 ft) from any flammable solids, oxidizers, or organic peroxides.

HAZARDOUS SHIPPING PAPER

TO: Lawrence Berkeley Lab
One Cyclotron Road
Berkeley, CA 94720

NAME: ____________________

BLDG: ____________________

FROM: Lawrence Berkeley Lab
☐ Receiving Warehouse
1450 64th Street
Emeryville CA 94608
☐ Central Stores 7-100
☐ Industrial Gases B-69
☐ NAME: ____________________

LOCATION: ____________________

HAZARDOUS MATERIALS

Hazardous Materials Description and Proper Shipping Name (49CFR 172.101)	
Hazard Class & Numerical	ID Number & Packaging Group
Weight or Volume	Type of DOT Label(s) Reqd. Ltd Qty or Exemption Number

P.O ____________ Prepared By: ____________ Date: ____________

Vendor: ____________ Picked Up By: ____________ Date: ____________

****

RECEIVED BY: ______________________________ Date: ____________
Signature & Printed Surname

****

TO: ______________________________ MAIL STOP: ____________

The materials as listed above were delivered to:

BLDG/Location: ______________________________ DATE: ____________

If you have any questions, please call Transportation, Ext. 5404.

SIGNED: ____________________

For Chemical Emergency, Call: LBL EMERGENCY NO. Ext 7911 or 486-7911

RL6632 (Rev. 11/93)

Fig. 5.25. Hazardous Shipping Paper.

Warehouse Run Driver

The warehouse run driver must:

- Place the material in the truck so that its exact location is known and so that it complies with compatibility rules (see under *Receiving*, above).
- Carry manifests in the truck cab so that they are visible and within reach while driving.
- Placard the truck, if required, in accordance with 49 CFR 172.500.
- On arrival at Building 69, turn over the folder with the manifests to the transportation clerk.
- Unload the material at Building 69 and stage it for distribution.

Delivery Driver

The delivery driver must:

- Remove the pink manifest from the material and carry it in the cab of the truck where it is visible and within reach while driving. Turn in the manifest to the transportation clerk at the completion of deliveries.
- Place hazardous material in the truck so that the exact location is known. Load the material in compliance with compatibility rules (see *Receiving*, above). Deliver the material to the customer location.
- Report any concerns about the condition of the material to his or her supervisor.

Transportation Clerk

The transportation clerk must hold the manifests in a suspense file for one year and then discard them.

5.8.13.3 ON-SITE/OFF-SITE MOVEMENT OF HAZARDOUS MATERIAL

Material Handler

The material handler must prepare a "Hazardous Shipping Paper" and place it in the outbound pickup area with the material. The procedure for staging the load and segregating hazardous materials is given under *Receiving*, above.

Delivery Driver

The delivery driver must follow the procedure given for the warehouse run driver, above.

Transportation Clerk

The transportation clerk must hold all manifests in a suspense file for one year and then discard them.

5.8.13.4 ON-SITE/OFF-SITE DELIVERY OF COMPRESSED GAS CYLINDERS

See Chapter 13, *Gases*.

5.8.13.5 DISPOSITION OF WASTE OIL PRODUCTS/NON-DEPOSIT BARRELS

The transportation clerk must refer requesters to EH&S for collection of waste oil products and empty barrels.

5.8.13.6 VEHICLE ACCIDENT WHILE TRANSPORTING HAZARDOUS MATERIALS

Driver

The driver must notify the transportation clerk or his or her supervisor by radio. Clear the channel by stating that you have an emergency. Give the following information:

- Your location.
- Phone number calling from.
- A description of the situation (the hazard, not the material).

Attempt to contain or isolate the hazard until help arrives.

If you are unable to contact the base station by radio, try to get a passerby to telephone (510) 486-7911 so that you can remain with the truck. If necessary, leave the vehicle, go to a phone, and call (510) 486-7911.

Transportation Clerk/Supervisor

Call 7911, and give all the information needed.

5.8.14 STANDARDS

Hazardous Material Transportation

- 49 CFR 106-110, Transportation
- 49 CFR 170-180, Hazardous Materials Regulations
- 49 CFR 397, Routine Designations
- Vehicle Code, State of California and implementing CCR sections to the extent not preempted by DOT requirements
- City of Berkeley provision in Ordinance 5474 prohibiting transportation on specified streets at which purge chamber openings are located

Hazardous Material Transportation—Onsite

- LBNL Health & Safety Manual (PUB-3000, Chapter 5, Part VIII, Section 13)

Mechanical Hazards—Aviation

- DOE 440.2, Aviation

Traffic Hazards

- Vehicle Code, State of California and implementing CCR sections
- 29 CFR 1910, OSHA General Industry Standards
- 29 CFR 1926, OSHA Construction Industry Standards
- 49 CFR 40, Procedures for Workplace Drug Testing Programs
- 49 CFR 382, Controlled Substances and Alcohol Use and Testing

Transportation of Radioactive Materials

- 49 CFR Research and Special Program Administration, Subchapter C, Hazardous Materials Regulations
- 49 CFR Part 397, Subpart D, Radioactive Materials Routing
- IATA, Dangerous Goods Regulations (37th edition)
- On-site transportation of radioactive materials is currently addressed by LBNL, in PUB-3000 and other internal EH&S procedures.

5.8.15 RELATED PUB-3000 CHAPTERS

- *Gases* (Chapter 13)
- *Radiation Safety* (Chapter 21)

5.8.16 REFERENCES

- *Regulations and Procedures Manual,* LBNL PUB-201.
- *Guidelines for Generators to Meet HWHF Acceptance Requirements for Hazardous, Radioactive, and Mixed Wastes at Berkeley Lab,* LBNL PUB-3092.

PART IX: WARNING SIGNS AND DEVICES

5.9.1 POLICY

LBNL uses every reasonable method to warn employees and visitors of hazards and dangers in and around the Laboratory. Signs, characteristic lights, and audible alarms are used as additional safeguards for built-in mechanical and physical protection. To ensure uniform response by Laboratory personnel and visitors, the warning signs and devices must be of the same type for similar hazards. Obtaining and installing the warning systems are the responsibility of the group needing them.

5.9.2 HAZARD AWARENESS

Hazards fall into three categories: chemical, biological, and physical. In describing hazards it is important to stress that hazards are only potential problems. The presence of a hazard does not mean you will experience adverse effects. Hazard signs alert you to the presence, nature, and level of hazard, and to the protection required (safety glasses, hearing protection, etc.) in the area. For example, signs may indicate the presence of radioactive materials, high-voltage electricity, lasers, carcinogens, corrosives, biohazards, or magnetic fields.

5.9.3 WARNING SIGNS

Signs must conform to the colors, symbols, lettering size, and proportions stated in 29 CFR 1910.145. Additional specifications for specific hazards are contained throughout the Work Smart Standards. Every warning sign must include the following components:

- An approved heading that indicates the relative hazard.
- A concise statement of the type of hazard.
- A statement of what to do or not to do in the area.

5.9.4 SIGN CHARACTERISTICS

5.9.4.1 DANGER SIGN

Danger signs are used only where injury or damage is certain to occur if approved operating instructions and procedures are not followed. Personnel must be warned of the serious consequences of ignoring the message. The top of the sign says DANGER in white letters on a red oval that is edged by a rectangular black border. The body of the sign is white with the message printed in black.

5.9.4.2 CAUTION SIGN

Caution signs are used where injury or damage is possible and employees must be on their guard. The top of this sign is yellow with the message printed in black.

5.9.4.3 INFORMATIONAL/NOTICE SIGN

Informational signs are used where instructions are needed. The heading says NOTICE in white letters on a green rectangle when the message is related to safety and on a blue rectangle for other messages. The body of the sign is white with the message printed in black.

5.9.4.4 DIRECTIONAL SIGN

Directional signs are used to indicate exits, fire escapes, evacuation routes, stairways, location of first aid equipment, etc. The direction symbol appears near the top in white on a green rectangle. The body of the sign must have a color contrasting with the general background. It is, however, common practice to use RED as the basic color to identify the location of fire protection equipment and apparatus (e.g., fire extinguisher, fire hose).

5.9.4.5 BIOLOGICAL HAZARD SIGN

Biological hazard signs identify the actual or potential presence of a biological hazard. They identify equipment, containers, rooms, experimental animals, or combinations that contain, or are contaminated with, hazardous biological agents. The information, presented either with lettering or symbols, must be in a contrasting color to the fluorescent orange or orange-red body of the sign.

5.9.4.6 RADIOLOGICAL HAZARD SIGN

Radiological hazard signs identify controlled area access and potential exposure limits within the controlled area. The sign is either yellow with black lettering and the radiation symbol or magenta with black lettering.

5.9.5 OBTAINING SIGNS

The EH&S Division will assist other divisions in signage needs. It is then the responsibility of the division or group needing the signs to order and install them in the appropriate area(s). Copies of all signs and labels are available for viewing at Stores, Building 7. To order, contact Craft Stores, Building 78, ext. 5087.

5.9.6 WARNING DEVICES

Warning devices such as lights and audible alarms must be installed where they are needed to warn personnel against remaining in or entering hazardous areas. Personnel shall receive instructions from the Building Manager, their supervisor, or a Building Emergency Team member about the meaning and the response required when an alarm sounds.

A sign describing the hazard and action to take must be posted near a warning light that when ON indicates danger, caution, high explosive, or radioactivity. In a brightly illuminated area, the warning light should be surrounded by a disk or wide-angled cone of a contrasting color. Table 5.1 lists warning devices and their appropriate uses.

Table 5.1. Accepted Use of Audible and Visual Warning Devices

Warning	Typical Examples	General Use
Red light	Danger	Do not enter
Magenta or red light	Danger—Radiation	Do not enter area
Yellow light	Caution	Limited free access; warn personnel
Green light	Safe	No hazard; no entry restrictions
Klaxon horn—steady	Critical accident toxic release, large fire, or other serious emergency	Leave building or area immediately
Chime, pulsed with magenta or red light	Danger—Radiation	Do not enter
Other sounds (bells, buzzers, etc.)	Warning; hazardous condition exists	Be on alert; follow directions

5.9.7 EVACUATION ALARM SYSTEMS

5.9.7.1 GENERAL

All buildings on-site are equipped with a means of notifying personnel to leave the building, which is typically a public address system. Every dangerous operation area, indoor and outdoor, must be provided with devices to notify personnel to leave the area. The general evacuation alarm is a steady bell sound that means, "Everyone leave the building immediately and go the prearranged assembly point or as directed by either the public address system or a Building Evacuation Team member."

The alarm system should be designed based on the level and type of hazards in the building.

5.9.7.2 AUTOMATIC ALARM SYSTEM

For any operation in which an accident could rapidly endanger employees outside the immediate area, an automatic evacuation alarm must be installed. Such alarms must be triggered by a detector directly sensitive to the nature of the hazard.

5.9.7.3 MANUAL ALARM SYSTEM

A manually operated alarm system must be installed for operations in which accidents would not cause immediate danger to personnel outside the area of the incident, but that could develop into dangerous situations.

NOTE: FOR QUESTIONS REGARDING ALARM TYPES AND INSTALLATION REQUIREMENTS, CONTACT THE LBNL FIRE PROTECTION ENGINEER, BUILDING 48, EXT. 6095.

5.9.8 INSTALLATION OF EVACUATION ALARM SYSTEMS

Acquisition, local installation, and maintenance of evacuation alarm systems are charged to programmatic accounts.

5.9.9 LBNL PUBLIC ADDRESS SYSTEM

The Laboratory Public Address system may be used to advise employees and guests of emergency situations. Most buildings on-site and some off-site are connected to this system. Announcements can be made from three locations on-site: (1) The Fire Department at Building 48; (2) Telephone Operations in Building 50B and (3) The communications room, 020 in Building 90. In addition to the Laboratory-wide PA system, many buildings have a local public address capability which may be accessed by a local microphone or, in some buildings, by dialing a four-digit number on an LBNL ICS phone. This latter method is known as "ICS Paging." The Communications and Networking Resources Department of the Information and Computing Sciences Division and the Communications and Electronics Engineering Group of the Engineering Division will assist those interested in obtaining ICS Paging.

5.9.10 RESPONSIBLE PARTIES

It is the responsibility of all staff and visitors to work safely and to follow all warning signs and alarms.

5.9.11 STANDARDS

- CFR 29-1910.144 & .145, *Safety Color Code for Marking Physical Hazards and Specifications for Accident Prevention Signs and Tags*

5.9.12 RELATED PUB-3000 CHAPTERS

- *Electrical Safety*
- *Fire Prevention and Protection*
- *Industrial Hygiene (Confined Spaces, Biohazards)*
- *Laser Safety*
- *Lockout/Tagout*
- *Occupational Safety*, Part VIII, *Traffic and Transportation*
- *Radiation Protection*
- ANSI Z35.1 (1972) & .4 (1973), *Accident Prevention Signs and Specifications for Informational Signs*

5.9.13 REFERENCES

- *Health and Safety Handbook*, PUB-258, Lawrence Berkeley Laboratory, September 1992
- *Health and Safety Handbook for Subcontractors and Visitors*, PUB-708, Lawrence Berkeley Laboratory, September 1993
- *Health and Safety for Visitors and Guests*, PUB-709, Lawrence Berkeley Laboratory, March 1993

5.10 CHAPTER 5 GLOSSARY

5.10.1 PART I: ACCIDENT INVESTIGATION AND REPORTING

An **accident** is any unplanned happening or event that results in personal injury, property damage, or both.

Accident investigation is the systematic collection and analysis of information about suspected causes of an accident.

The **reporting program** is designed to provide timely identification, categorization, and notification of accidents and to develop corrective action to reduce the likelihood of significant health effects on the public, the Laboratory, or the workforce.

Preservation of an accident scene means preventing movement of equipment or vehicles involved in the accident.

The **SAAR** is the Supervisor's Accident Analysis Report.

A **recordable injury** is any injury or illness that typically results in lost or restricted work days or that requires treatment by a physician beyond first aid.

An **incident** is an unplanned, undesired event that adversely affects completion of a task or has the potential to result in personal injury or property damage.

5.10.2 PART II: ELEVATED WORK LOCATIONS

Elevated work is any work conducted above the ground on ladders, elevating platforms, revolving extension aerial ladders, or extensible boom work platforms. Specialized equipment and facilities are required to enable LBNL personnel to perform tasks at elevated levels, as well as for the lifting and overhead movement of structural components and equipment.

5.10.3 PART III: MACHINE SAFEGUARDING

A **guard** is a barrier that prevents entry of the operator or any part of the operator's body into the point of operation.

A **machine tool** is any powered tool used to shape, form, fabricate, assemble, etc., regardless of the material being worked on or the nature of the power.

Other moving parts are all the parts of the machine that move while the machine is working. These can include reciprocating, rotating, and transverse moving parts, as well as feed mechanisms and auxiliary parts of the machine.

The **point of operation** is that point where a machine performs work on a material, such as cutting, shaping, boring, or forming of stock.

The **power transmission apparatus** includes all components of the mechanical system that transmit energy to the part of the machine performing the work. These components include flywheels, pulleys, shafts, belts, connecting rods, couplings, cams, spindles, chains, cranks, and gears.

Safeguarding is any means of preventing personnel from coming in contact with the moving parts of machinery or equipment during operation or during maintenance and servicing. Machine safeguarding improves productivity and morale because of the protection offered.

5.10.4 PART IV: MATERIAL HANDLING AND STORAGE

An **attachment** is a device other than conventional forks or load backrest extension, mounted permanently or removably on the elevating mechanism of a truck for handling the load. Popular types of attachments are fork extensions, clamps, rotating devices, side shifters, load stabilizers, rams, and booms.

A **carriage** is a support structure for forks or attachments, generally roller-mounted, traveling vertically within the mast of a cantilever truck.

A **crane** is a machine for lifting and lowering a load vertically and moving it horizontally with the hoisting mechanism, an integral part of the machine.

A **forklift truck** is a high-lift, self-loading truck, equipped with load carriage and forks, for transporting and tiering loads.

Forks are horizontal tinelike projections, normally suspended from the carriage, for engaging and supporting loads.

A **hoist** is a device that applies a force for vertical lifting or lowering.

Lift is either (a) the maximum safe vertical distance through which the hook can travel, or (b) the hoisting of a load.

Lifts, critical, are parts, components, assemblies, or lifting operations designated as such because the effect of dropping, upset, or collision of items could: (a) cause significant delay, (b) cause undetectable damage resulting in future operational or safety problems, (c) result in significant release of radioactivity or other undesirable conditions, and/or (d) present a potentially unacceptable risk of personnel injury or property damage.

A **lift, high-consequence,** is the same as lift, critical, defined above.

A **lift, nonroutine,** is a lift that is (a) not repetitive in nature, or (b) has not been accomplished previously, or (c) has special considerations that must be addressed, such as the use of nonstandard equipment.

A **load** is the total superimposed weight on the load block forks or hook.

Material handling is any method for moving material. Material can be moved directly by people lifting the items or using hand carts, slings, and other handling accessories (manual lifting and handling). Material can also be moved by people using machines such as cranes, forklift trucks, and other lifting fixtures (mechanical lifting).

Nondestructive examinations (NDEs) are testing methods or examinations used to reveal below-the-surface defects without damaging the equipment being tested. Nondestructive testing or examinations locate defects that are inherent in metals, defects that result from processing, and in-service defects, such as corrosion, erosion, and sharp changes in section.

The **person-in-charge (PIC)** is the manager or designated person (other than the crane operator) appointed to be responsible for the safe handling of critical loads and for the safe handling of noncritical items in, around, or above spaces in which critical items are located..

The **rated capacity** is the manufacturer's rated capacity. The maximum hook load a piece of hoisting equipment is designed to carry; also the maximum load a sling, hook, shackle, forklift truck, or other rigging tackle is designed to carry.

Reeving is the act or method of threading rope around the drum and sheaves.

The **rigging** is the ropes, chains, and other gear used to support, position, and control equipment or materials.

Secondary lifting equipment is lifting equipment attached between the hook of a hoist or crane and the load (e.g., wire rope slings, clevices, spreader bar/strong back, and shackles).

A **sheave** is a grooved pulley.

Tiering is the process of placing one load on or above another.

5.10.5 PART V: OFF-SITE SAFETY

Off-Site Operations are operations performed by LBNL personnel away from the Laboratory or on the UC Berkeley Campus.

An **Activity Hazard Document (AHD)** is a safety document that identifies hazards and describes mitigation. It is the Laboratory document used to describe the controls necessary to ensure that the risks associated with a potentially hazardous research project or unique activity are at an acceptable level. (Refer to *Health and Safety Manual*, PUB-3000, Chapter 6, *ES&H Documentation and Approvals.*)

The **Memorandum of Understanding (MOU)** is a special agreement between the University of California at Berkeley (UC Berkeley campus) and Berkeley Lab (LBNL) covering operations by LBNL employees on the UC Berkeley campus. (See the MOU, June 1993.)

5.10.6 PART VI: OSHA COMPLIANCE

An **appurtenance** is an accessory object, e.g., part of an apparatus.

A **guy** is a rope, chain, or wire attached to something as a brace or guide.

5.10.7 PART VII: POWER AND HAND OPERATED TOOLS

A **pneumatic power tool** is a compressed-air powered tool that shoots a pin, nail, or similar object into wood or other material.

A **double-insulated tool** is a tool designed so that inner electrical parts are isolated physically and electrically from the outer housing.

A **powder-actuated tool** is a tool that moves a piston (activated by Class C explosive powder) that drives a nail, pin, or fastener into wood or other materials.

A **fuel-powered tool** is a tool equipped with a gasoline-fired internal combustion engine.

A **hydraulic tool** is a tool in which force is transmitted by fluid moved under pressure.

Chapter 6

ES&H DOCUMENTATION AND APPROVALS

Revised December 1997

Reviewed by: Dave T— 12/11/97
Date

Approved by: Don C. McGraw 12/15/97
EH&S Division Director
Date

CONTENTS

Chapter 6

ES&H DOCUMENTATION AND APPROVALS

6.1 POLICY

LBNL will ensure that the safety of all facilities, operations, modifications, and decommissions is reviewed and that they are operating at a low level of risk.

6.1.1 DOE REQUIREMENTS

Requirements for safety analysis of hazards are included in DOE Order 5481.1B, *Safety Analysis and Review System*; DOE Order 5480.23, *Nuclear Safety Analysis Reports*; and DOE Order 5480.25, *Safety of Accelerator Facilities*. These requirements apply in addition to other federal, state, and local safety analysis requirements.

If an activity has hazards of a type and magnitude not routinely encountered or accepted by the general public, a safety analysis is required. A safety analysis is not required for (1) operations involving hazards of a type and magnitude routinely encountered or accepted by the general public, (2) the safety of nuclear weapon designs, and (3) construction-related work.

6.1.2 TYPES OF SAFETY DOCUMENTATION AND HAZARD LEVELS

Types of Safety Documentation Used at LBNL

- Safety analysis reports (SARS) or safety analysis documents (SADS), for which requirements are outlined in the DOE orders cited above. The term SAD is used at LBNL for low-hazard non-nuclear facilities. LBNL does not have any facilities requiring SARS (nuclear facilities or any nonnuclear facilities above the low hazard level); consequently, only the term SAD will be used in the remainder of this chapter.
- Activity Hazard Documents (AHDs) and Radiological Work Authorizations (RWPs), for which requirements are outlined in this manual, PUB-3000 and LBNL's *Chemical Hygiene and Safety Plan*, PUB-5341.
- Other user documentation required by PUB-3000 (e.g., safety notes).

Hazard Levels

LBNL Operations Authorizations requirements are differentiated by hazard level. The DOE orders specify that the higher the hazard, the higher the level of review. DOE Order 5481.1B defines three hazard levels as follows:

- **High-hazard activities:** those having potential for on-site or off-site impacts on large numbers of persons or for major impacts on the environment.
- **Moderate-hazard activities:** those presenting considerable potential for on-site impacts on people or the environment, but at most only minor off-site impacts.
- **Low-hazard activities:** those that present minor on-site and negligible off-site impacts on people or the environment.

The corresponding review levels for LBNL documentation are shown in Table 6-1.

Table 6-1. Examples of Safety Documentation Review and Approval

Document	Review	Approval
Safety Analysis Document (SAD) Low hazard/non-nuclear	LBNL/EH&S	LBNL/Division Director (copy to DOE for information)
Activity Hazard Document (AHD)	LBNL/EH&S	LBNL/Division Director

The Safety Analysis and Documentation System (SADS) Determination Process (described next) and the Activity Hazard Review Process (described later in this chapter) have been developed to implement the DOE requirements.

6.1.3 AUTHORIZATION BASIS

All activities involving potentially hazardous condition shall be carried out in conformance with the guidelines in this manual and appropriate work authorizations. Controls shall be in place before the commencement of activities. Requirements for documentation and authorization basis for activities are included in the technical chapters of PUB-3000.

- **Activity Authorization:** Activities are authorized by either line management or by joint EH&S line management. EH&S Division health and safety professionals provide guidelines in the LBNL Health and Safety Manual, PUB-3000, indicating the authorization level. Lower hazard activities are determined by EH&S safety professionals to be activities where line management review is adequate. Higher hazard activities are determined by EH&S safety professionals to require joint EH&S line management review and authorization.
- **Line Management Authorization:** Bench-level activities that do not require EH&S participation in hazard identification and mitigation are authorized by line management. Appropriate hazards and controls must be established for activities even though they fall below the threshold of EH&S Division review level. Guidelines for hazards and controls are indicated in PUB-3000. The hazard review and establishment of controls are the responsibility of line management. EH&S Division safety professionals will assist if

requested. Examples of hazards at the line management authorization level are health hazard compressed gases with a NFPA Class 1 hazard classification.

- **EH&S Level Authorization:** Activities requiring EH&S participation in the hazard identification and mitigation process are identified in the technical chapters of PUB-3000. Hazard identification, establishment of controls, and authorization are the joint responsibility of line management and appropriate EH&S safety professionals. Examples of hazards at the joint EH&S/line management authorization level are health hazard compressed gases with a NFPA class 3 or 4 hazard classification. Examples of documents include Activity Hazard Documents (AHDs) and Radiological Work Authorizations (RWAs).

6.2 DETERMINATION PROCESS

6.2.1 INTRODUCTION

The SADS Determination Process determines whether a SAD is required. This process must be implemented for all new projects funded by DOE and is initiated at the time that funding is requested.

This process reviews the safety of the end use of a project. The term "end use" refers to the project's use after construction is completed. For example, the SADS Determination Process for a project involving the construction of a new laboratory would review the safety of the operation of the completed laboratory and not safety during construction.

The SADS Determination Process as applied at Berkeley Lab for facilities is different than that for research activities. SADS determination for construction of major modifications resulting in new facilities is initiated by the Facilities Department, whereas those for research activities are initiated by the responsible research program.

6.2.2 PROJECTS MANAGED BY THE FACILITIES DEPARTMENT

When a project is managed by the Facilities Department, the SADS Determination Process is conducted as indicated in Flow Diagram A (Appendix A). The process consists of the following steps:

1. The Facilities Project Manager and a representative of the program, with assistance from the EH&S Division Liaison (DL) completes the "Information for NEPA/CEQA/SADS Review Form" (Appendix B).

   These documents are used as a basis for information to be included in the SADS Compliance Checklist (Appendix C).

2. Part 1 of the SADS Compliance Checklist is filled out by the Facilities Project Manager and a representative of the program with the assistance of the Division Liaison . The following items must be considered:

- Off-Site Work. SADS documentation is required for work on the LBNL site including Buildings 1 and 3 on the UC Berkeley Campus and any other location with applicable hazard levels.
- Ordinary Hazard. This category includes all activities that do not involve the storage, dispensing, or use of chemicals or radiological materials as part of the end use. "End use" refers to the activity that takes place after construction is completed. Common petroleum products are considered an "ordinary hazard."

  Examples of ordinary-hazard activities:

  - Project to provide a new electrical substation.
  - Project to provide a new office building.
  - Project to provide a new underground petroleum storage tank.
  - Addition of an air-conditioning unit to an existing research laboratory.

  Example of a non-ordinary hazard:

  - Project to **establish** a new research laboratory that uses chemicals and radioactive materials.

When Part 1 is complete, the form is signed by the designated parties. If neither Box 1 nor Box 2 is checked, the document is forwarded to the EH&S Hazard Assessment Program (HAP). If Box 1 or 2 is checked, the document is filed by Facilities Department in the facilities project folder.

3. Part 2 of the SARS Compliance Checklist must be filled out by the EH&S Hazard Assessment Program to determine the ultimate disposition.

   - **Standard Industrial Hazard**. Activities that utilize chemicals and/or radiological materials in quantities below the threshold cited in 40 CFR 302 are not required to prepare a compliance process analysis. The safety requirements for these activities are given in this manual (PUB-3000).

     If Box 3 is checked, the HAP notifies the DL and the Facilities Department that the process has determined that the low-hazard threshold has not been exceeded; thus safety documentation will meet requirements identified in this manual, PUB-3000; or the *Chemical Hygiene and Safety Plan*. Facilities then notifies DOE.

   - **Covered Under DOE-Approved SADS Documentation**. The activity is included in an existing SAD with comparable work and associated hazards. A SAD has been prepared for some buildings.

     If Box 4 is checked, the HAP notifies DL and Facilities that the safety of the activity is included in an existing Safety Review Document and no additional documentation is required. Facilities notifies DOE.

- **Safety Analysis Review**. If the process determines that none of the above four conditions are present, then a Safety Analysis Review must be prepared. The review may result in a SAD or a SAR, depending on the analysis of the hazard level.

  If Box 5 is checked, the HAP notifies the DL and Facilities that a Safety Analysis Review is required. Facilities then notifies DOE. The DL prepares a Safety Analysis Review with the assistance of the HAP .

6.2.3 RESEARCH PROPOSALS

Research proposals include work for others (OSRAs—Office of Sponsored Research Activities), cooperative research and development agreements (CRADAs), Laboratory-directed research and development projects (LDRDs), and field task proposals (FTPs). Initiation of hazard assessment process for proposals is the responsibility of Line Management. Appendix B is an example (for an LDRD) of the proposal review checklist. If additional safety documentation is needed for the work, Line Management requests assistance from the EH&S Division Liaison to determine the appropriate hazard mitigation and documentation. The process is initiated at the time that the funding is requested.

6.3 ACTIVITY HAZARD REVIEW PROCESS

6.3.1 INTRODUCTION

If an activity meets the criteria for a Activity Hazard Document (AHD) stated in this manual (PUB-3000) or the *Chemical Hygiene and Safety Plan*, an activity hazard review is required unless the hazard identification and mitigation of the activity has been included in a SAR or a SAD.

The AHD is a Safety Document that identifies hazards and describes mitigation. It is the Laboratory document used to describe the controls necessary to ensure that the risks associated with a potentially hazardous research project or unique activity are at an acceptable level. The responsible user must identify and evaluate any potential hazards associated with the proposed project or activity and develop satisfactory measures to reduce these hazards to an acceptable level.

The responsible user is defined as the Principal Investigator, Group Leader, or other person responsible to the Division Director for the research or activity. Divisions determine whether an AHD is needed The Hazard Assessment Guide Table (Appendix E) or comparable hazard assessment process is recommended to determine whether an AHD is needed. The AHD must be completed before the beginning of the work. When reviewed and approved, the AHD becomes the principal safety document for the research project or activity. The ultimate determination of the appropriate operational authorization is the responsibility of the using Division Director. The AHD is reviewed by EH&S health and safety professionals and line management. It is approved by the using Division Director.

The process of determining whether an AHD is required is illustrated in the Safety Documentation Process Flow Diagrams (Appendix D).

6.3.2 NEW PROJECTS

For new projects, the process consists of reviewing the various categories of hazards (as illustrated in Appendix D):

- **Chemical Hazards.** Review *Chemical Hygiene & Safety Plan* requirements. Use the Hazard Assessment Guide Table (Appendix E) as a guide. If an AHD is required, prepare it and send it to the EH&S Field Support Dept. If an SSP is required, prepare it and file it in the Facility or Project Notebook.
- **Radiation Hazards.** Use the Hazard Assessment Guide Table (Appendix E) as a guide. If an AHD is required, prepare it and send it to the EH&S Field Support Dept. If an AHD is not required, fill out the Radiation Use Authorization form and send it to the Radiation Assessment Group. Radiation Assessment will issue a Radiological Work Permit.
- **Other Hazards.** Review requirements in PUB-3000. Use the Hazard Assessment Guide Table (Appendix E) as a guide. If an AHD is required, prepare it and send it to the EH&S Field Support Dept.. If an AHD is not required but other documentation is required, follow the requirements in PUB-3000.

6.3.3 PREPARATION OF AN AHD

Appendix G outlines the information required in an AHD.

6.3.4 REVIEW AND APPROVAL

Review Process

The review process for new AHDs, illustrated in Appendix F , consists of the following steps:

1. PI works with Division Safety Committee (DSC) to identify AHD requirements.
2. AHD is sent to EH&S Division Group Leader (GL).
3. GL identifies AHD review team and Review Team Leader (RTL), assigns document number, and logs document: AHD numbers are designated by groups.
4. RTL is responsible for AHD review.
   - Arranges Team Meeting with PI
   - Manages meeting, assures resolution of issues and gets signatures:
     - — Reviewers
     - — Group Leaders
     - — Division Director
   - Coordinates activities with Division Safety Coordinator

- Arranges and manages follow-up, if required
- Distributes copies of final signed AHD

5. Using Division Director approves the AHD after it has been reviewed by EH&S Health and Safety professionals and line management.

6. Distribution of Final Signed Copies

   - PI
   - DSC — DSC File
   - GL — Group File
   - EH&S Division Hazard Assessment Program Tracking File

Annual Renewal Process

The Division reviews AHDs annually or when there is change in the hazard. The approval process, illustrated in Appendix H , consists of the following steps:

1. New hazards or increase in hazard level: AHD sent to GL for new review.

2. No new hazards or increase in hazard level: Division logs/files and sends copy to EH&S Division Hazard Assessment Program (MS 90-0026)

6.3.5 RECORDS

The Original AHD will be filed in the Division where the project resides in accordance with that Division's own requirements. Copy distribution is described above.

6.3.6 ANNUAL REVIEWS AND REVISIONS

After approval, AHDs will be reviewed by the Division Safety Committee annually or in accordance with the review schedule in the original document. Review by the EH&S Field Support Dept. will be required only if:

1. The *level* of hazard has increased (e.g., new use of a gas with a higher toxicity), or

2. The *type* of hazard has changed (e.g., new use of a highly toxic gas in addition to current use of a Class 3 laser).

6.4 LINE MANAGEMENT LEVEL AUTHORIZATION

Line Management is responsible for initiation of hazard assessment, establishment of controls and authorization for activities which do not require EH&S joint authorization. Hazards and authorizations are summarized in the Hazard Assessment Guide Table (Appendix E).

6.5 RESPONSIBLE PARTIES

6.5.1 DIVISION DIRECTORS

Division Directors are responsible for ensuring that hazards are evaluated and safety controls are specified and implemented in accordance with the requirements of DOE Order 5481.1B, *Safety Analysis and Review System*. Division Directors approve Safety Analysis Documents and Activity Hazard Documents. If an activity has hazards of a type and magnitude not routinely encountered or accepted by the general public, a safety analysis is required.

6.5.2 EH&S DIVISION LIAISON

The EH&S Division Liaison is responsible for ensuring that the SADS Determination Process is implemented for all new activities.

6.6 STANDARDS

- DOE Order 5480.23, Nuclear Safety Analysis Reports
- DOE Order 5480.25, Safety of Accelerator Facilities, Paragraphs 9d-j, 10, and 11
- DOE Order 5481.1B, Safety Analysis and Review System

6.7 REFERENCES

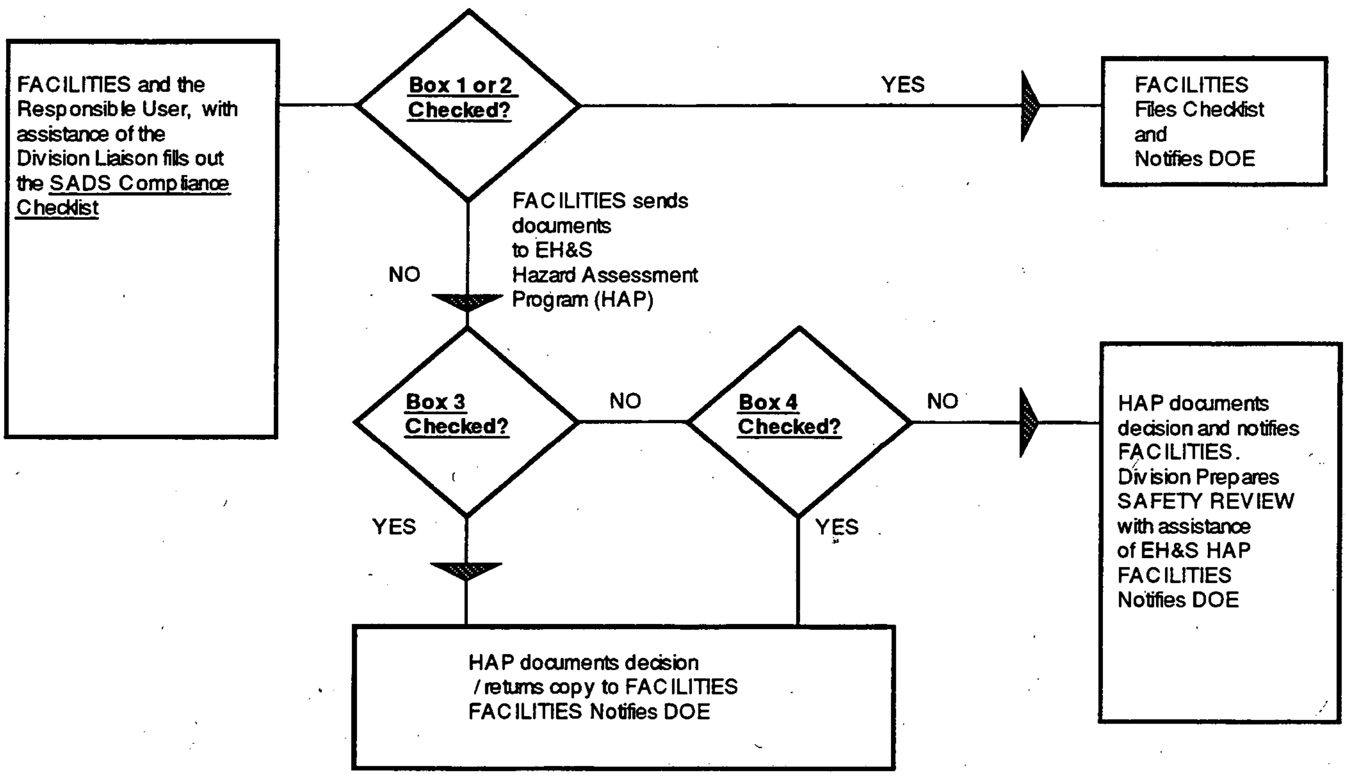
- *Chemical Hygiene and Safety Plan*, PUB-5341, Lawrence Berkeley Laboratory, August 1992.

6.8 APPENDICES

- Appendix A: Flow Diagram A—SADS Compliance Checklist, Projects Managed by the Facilities Department
- Appendix B: Information for NEPA/CEQA/EH&S Review for Work to be Conducted at LBNL Sites
- Appendix C: Lawrence Berkeley National Laboratory/SADS Compliance Checklist
- Appendix D: New Projects Safety Documentation Process
- Appendix E: Hazard Assessment Guide Table
- Appendix F: Activity Hazard Document (AHD) Outline
- Appendix G: AHD Review Process: New AHDs
- Appendix H: AHD Review Process: Annual Review

APPENDIX A

FLOW DIAGRAM A—SADS COMPLIANCE CHECKLIST, PROJECTS MANAGED BY THE FACILITIES DEPARTMENT



APPENDIX B

INFORMATION FOR NEPA/CEQA/EH&S REVIEW FOR WORK TO BE CONDUCTED AT LBNL SITES

Lawrence Berkeley National Laboratory
OFFICE OF PLANNING AND COMMUNICATIONS
Information for Laboratory-Directed Research & Development (LDRD) Project

PRINCIPAL INVESTIGATOR:______________________________________**DIVISION:**______________

PROPOSAL TITLE:____

NEPA/CEQA and EH&S REVIEW

Location and Modifications

Identify the buildings in which work will be performed (include LBNL, UCB, and offsite locations):

Are building modifications necessary to perform this project? ___ yes ___ no If yes, describe:

Potential Impact to the Environment

Would the project result in hazardous emissions, wastes, or effluents outside permit limits?
___ yes ___ no If yes, describe:

Is new or additional safety documentation needed for the work? ___ yes ___ no If yes, describe:

Complete for offsite work at non-DOE facilities only:

If any portion of the work will be performed outdoors, will the proposed activities result in changes and/or disturbances to: a) threatened or endangered species or critical habitats, b) floodplains or wetlands, c) archaeological resources, d) surface water, groundwater or contaminated soils e) specially designated areas, such as wilderness, refuges, parks ?
___ yes ___ no If yes or uncertain, describe concern:

______________________________ ______________

Principal Investigator ***Date***

To be completed prior to beginning work:

Proposed Classification: ______________	Determination approved by:
LBNL NEPA/CEQA Program Manager Date	DOE NEPA Compliance Officer Date

APPENDIX C

LAWRENCE BERKELEY NATIONAL LABORATORY/SADS COMPLIANCE CHECKLIST

PROPOSAL NUMBER: ______________
PRINCIPAL INVESTIGATOR: ____________________________
PROJECT TITLE: ____
PROJECT LOCATION: ____

<u>PART 1 (To be Filled Out by the Division)</u>

<u>Check Appropriate Box</u>

1. ❑ OFF-SITE WORK / SADS DOCUMENTATION NOT REQUIRED. Proposed activities will take place off-site. DOE SADS documentation, therefore, is not required.
2. ❑ ORDINARY HAZARD / SADS DOCUMENTATION NOT REQUIRED. Proposed activities involve only hazards of a type and magnitude routinely encountered and accepted by the public, and no additional Safety Analysis is required. DOE SADS documentation, therefore, is not required.

<u>SIGN BELOW</u>: IF NEITHER BOX 1 OR 2 IS CHECKED, SEND DOCUMENT TO EH&S HAZARD ASSESSMENT PROGRAM. IF BOX 1 OR 2 IS CHECKED, FILE DOCUMENT.

______________________________________ ________________
Principal Investigator or Project Manager — Date

______________________________________ ________________
Division Liaison — Date

______________________________________ ________________
Division Director or designee — Date

<u>PART 2 (To be Filled Out by EH&S)</u>

<u>Check Appropriate Box</u>

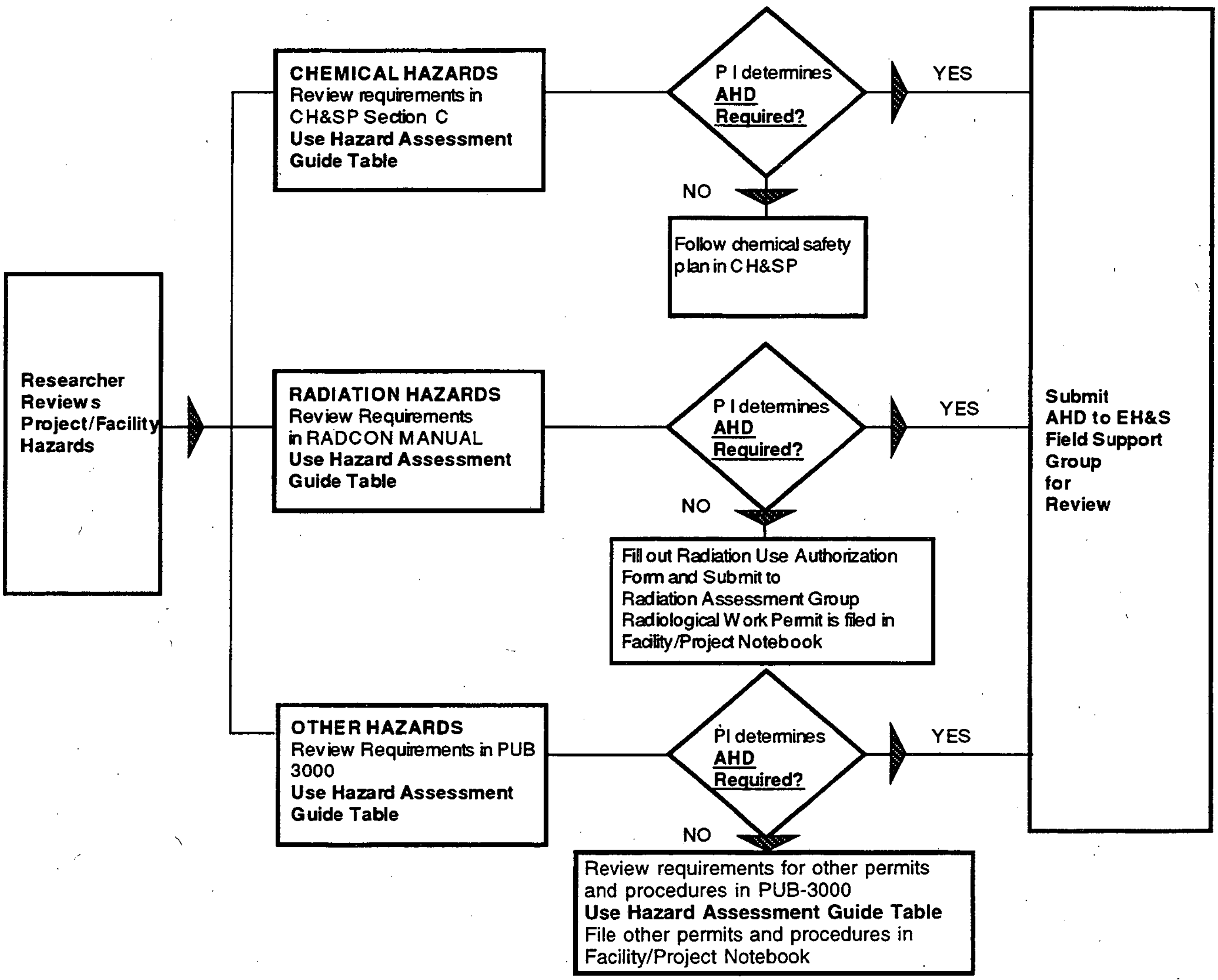
3. ❑ STANDARD INDUSTRIAL HAZARD / SADS DOCUMENTATION NOT REQUIRED. Proposed activities include the storage, dispensing or use of hazardous chemicals and/or radiological materials in quantities below threshold requirements. No SADS documentation is required. Safety documentation will meet requirements of the LBNL Health and Safety Manual, Publication 3000.
4. ❑ ACTIVITY IS COVERED UNDER DOE-APPROVED SADS DOCUMENTATION. The proposed action is addressed in existing SADS documentation. No further evaluation is necessary.

   Document: (Title: ____).
5. ❑ SAFETY ANALYSIS DOCUMENT . None of the above applies, and therefore a Safety Analysis Document is required.

______________________________________ ________________
Hazard Assessment Program Reviewer — Date

APPENDIX D

NEW PROJECTS SAFETY DOCUMENTATION PROCESS



APPENDIX E

HAZARD ASSESSMENT GUIDE TABLE

Date: ______________________

Principal Investigator: ______________________

Location of Work: ______________________

Name of Project: ______________________

Account Number: ______________________

Names of Other Staff Members: ______________________

INSTRUCTIONS:

Use attached TABLE as a guide to determining requirements for safety documentation.

Procedure:

1. **Read down Hazard column and mark hazards in Yes/No column.**
   Hazard definitions are located in the references under the column Procedures, Permits. For example: The compressed gas classified as toxic or pyrophoric is found in the CH&SP, Sec C.3, p. C-4 (C.3 states requirement for AHD and refers to list of compressed gases in Section D.3 or G.4).

2. **Read across to Procedures, Permits column to determine documentation requirements and references for items checked YES.**

3. **Read across to Haz Categorization & Tracking column to determine if EH&S coordinates approval review.**

4. **Read across to Approval Requirements column to determine who approves the required document.**

Contact the EH&S Hazard Assessment Program **if there are questions.**
File One Copy in the Facility/Project Notebook.

Hazard Assessment Guide Table

Item	Chapter	HAZARD	YES /NO	REF SOURCE	PROCEDURES, PERMITS	HAZ CATEGORIZATION & TRACKING	APPROVAL REQUIREMENTS
1	4	INDUSTRIAL HYGIENE					
		Chemicals / Biohazards Levels 1 & 2		CH&SP	SSP Required		Line Management
					See CH&SP, Sec C.4, p C-5		
		Unstable / Reactive		CH&SP	AHD Required	EH&S	Line Mgt & EH&S
					See CH&SP, Sec C.3, p C-4		
		Biohazards Levels 3 & 4		CH&SP	AHD Required	EH&S	Line Mgt & EH&S
					See CH&SP, Sec C.3, p.C-4		
2	5	OCCUPATIONAL SAFETY					
		Crane Operators / Riggers		PUB 3000	Gov't Identification cards		EH&S
					Ch 5		
		Forklift Truck Operators		PUB 3000	Forklift Operator Certificate		EH&S
					Ch 5		
		Custom Lifting Devices and Fixtures		PUB 3000	Inspection by NDT Laboratory		Line Management
					Ch 5		
		Off-Site Operations when		PUB 3000	AHD or Other Documentation Required		Line Mgt & EH&S
		documentation required by other chapters			Ch 5		
3	7	PRESSURE SAFETY & CRYOGENICS					
		Off-Site Pressurized Shipment		PUB 3000	DOT Approval or DOE-OAK exemption		Line Management
					Ch 7		
		Toxic, Radioactive, or Irritant Contents		PUB 3000	Safety Note Required + AHD if materials	EH&S	Line Mgt, Mechanical Engineering Dept & EH&S
		Flammable Contents			meet requirements of Chapter 13 or 21		
		Pressure System over 150 psi			or Designer Determines		
					Ch 7		
4	8	ELECTRICAL SAFETY					
		Work on Intermittently Energized		PUB 3000	Implied Approval & General Supervision		Line Management
		Utility Services			Ch 8		
		Work on Continuously Energized		PUB 3000	Written Supervisory Authorization		Line Management
		Utility Services			Ch 8		
		R&D Electronic/Electrical - Work		PUB 3000	Implied Approval & General Supervision		Line Management
		on energized equipment >50 volts			or Written Supervisory Authorization		
					Ch 8		

Hazard Assessment Guide Table

Item	Chapter	HAZARD	YES /NO	REF SOURCE	PROCEDURES, PERMITS	HAZ CATEGORIZATION & TRACKING	APPROVAL REQUIREMENTS
5	10	CONSTRUCTION SAFETY					
		Contract Work over $50K		PUB 3000	Safety & Health Program / Site Specific		EH&S
					Safety Plan & Hazard Communication Program.		
					Ch 10		
		Contract Work under $50K		PUB 3000	Construction Subcontractor Prejob		EH&S
					Checklist and Hazard Communication Program.		
					Ch 10		
		Burning			Burn Permit		EH&S (Fire Department)
					Ch 10		
6	11	ENVIRONMENTAL PROTECTION					
		Emission of Air Pollutants		PUB 3000	BAAQMD Permit (Bay Area Air Quality	EH&S	BAAQMD
					Management District)		
					Ch 11		
		Wastewater Discharge		PUB 3000	Wastewater Discharge Permit	EH&S	EBMUD
					Ch 11		
7	12	FIRE PROTECTION					
		Welding, Soldering,Torch Work, Tar Pots		PUB 3000	Fire Department Permit	EH&S	EH&S (Fire Department)
		Open Fire, Spray Painting			Ch 12		
8	13	GASES					
		Health Hazard Gases NFPA Class 3 & 4		PUB 3000	AHD Required	EH&S	Line Mgt & EH&S
		& Class 2 w/ poor warning properties			Ch 13		
				PUB 3000	Safety Note Required	EH&S	Line Mgt & Mechanical Engineering Dept.
					Ch 13		
		Flammable Gas		PUB 3000	AHD Required	EH&S	Line Mgt & EH&S
		Quantity greater than 400 c.f.			Ch 13		
		Pyrophoric Gases		PUB 3000	AHD Required	EH&S	Line Mgt & EH&S
					Ch 13		
		Gases w/ Potential		PUB 3000	AHD Required	EH&S	Line Mgt & EH&S
		for Oxygen Deficiency locations			Ch 13		
9	16	LASERS					
		Class 3b & 4		PUB 3000	AHD Required	EH&S	Line Mgt & EH&S
					Ch 16		

Hazard Assessment Guide Table

Item	Chapter	HAZARD	YES /NO	REF SOURCE	PROCEDURES, PERMITS	HAZ CATEGORIZATION & TRACKING	APPROVAL REQUIREMENTS
10	18	LOCK OUT/TAGOUT					
		Servicing, Maintenance, Modification of de-energized equipment		PUB 3000	Training, Ch 18		EH&S
					Authorization, Ch 18		Line Management
					Recordkeeping, Ch 18		Line Management
11	20	HAZARDOUS WASTE DISPOSAL					
		Hazardous Waste Disposal		PUB 3000	Hazardous Waste Disposal Requisition & related documentation Ch 20	EH&S	Line Mgt. & EH&S
12	21	RADIATION SAFETY					
		Radionuclide Work		PUB 3000	Radiation Work Auth., Ch 21	EH&S	EH&S (Radiation Assessment)
					Radiation Work Permit, Ch 21		
		Accelerators		PUB 3000	SAD Required	EH&S	EH&S / DOE
					DOE Order 5480.25 & See Chapt 21		
		Irradiators		PUB 3000	AHD Required Ch 21	EH&S	Line Mgt & EH&S
		X-Ray Machines		PUB 3000	X-Ray Machine Safety Document Ch 21	EH&S	EH&S (Radiation Assessment)
13	22	RESEARCH WITH HUMAN AND ANIMAL SUBJECTS					
		Human Subjects		PUB 3000	Human Subject Protocol Ch 22	EH&S	LBL Human Subjects Committee & Committee for Protection of Human Subjects
		Radioactive Drugs		PUB 3000	Human Subject Protocol Ch 22	EH&S	LBL Radioactive Drug Research Committee
		Animal Subjects		PUB 3000	Animal Use Protocol Ch 22	EH&S	LBL Animal Welfare & Research Committee
14	23	SEISMIC SAFETY					
		Seismic Securing of Shielding near Building Structural Elements		PUB 3000	Design or Analysis Ch 23		Seismic Safety Subcommittee

TERMS

AHD - Activity Hazard Document
SSP - Specific Safety Procedure
SRC - LBL Safety Review Committee
PUB 3000 - LBL Health and Safety Manual Publication 3000
CH&SP - Chemical Hygiene and Safety Plan

APPENDIX F

ACTIVITY HAZARD DOCUMENT (AHD) OUTLINE

1. GENERAL INFORMATION:

    A. Title:

    B. Location of Work:

    C. Date of Preparation:

    D. Division:

    E. Activity Supervisor: Name of person having authority to designate operators of equipment.

    F. Preparation Signatures:

    Division Safety Coordinator:

    Principal Investigator:

2. DESCRIPTION OF ACTIVITY:

    A. Description of Activity including unique equipment (its application) or activity and principal parameters.

    B. Duration.

3. IDENTIFICATION OF HAZARDS: Identification of potential hazards associated with the activity. Use Hazard Assessment Guide Table (ATTACHMENT H) for guidance.

4. MITIGATION OF HAZARDS: Controls to reduce the potential hazards.

5. HAZARDOUS MATERIAL HANDLING: Hazardous material involved, quantity, handling and labeling requirements.

6. HAZARDOUS WASTE: Identification of hazardous waste generated by the activity and its disposal.

7. EMERGENCY PROCEDURES: Emergency procedures and the location of emergency equipment.

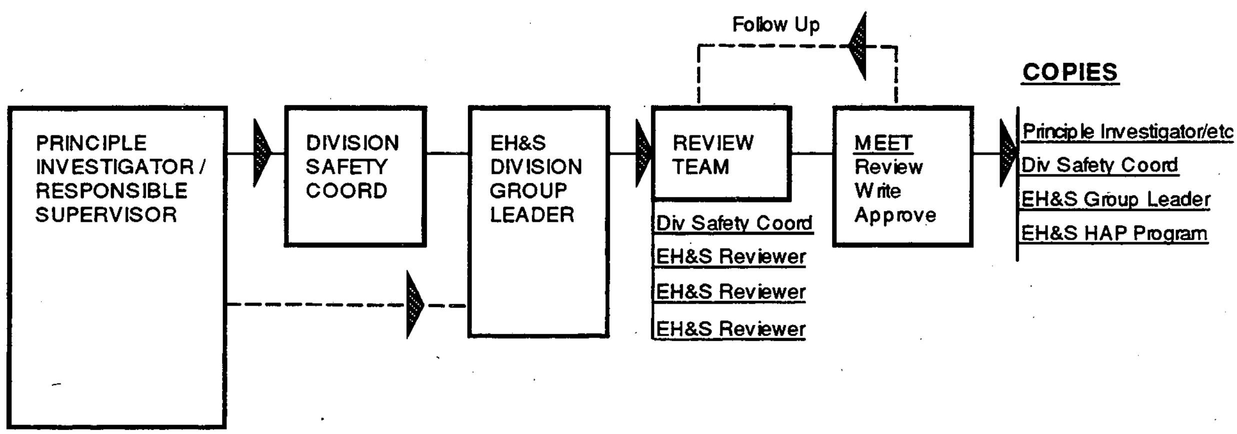
8. MAINTENANCE: Maintenance procedures to ensure safety and/or environmental protection.

9. AUTHORIZED USERS & TRAINING: List of authorized users and training requirements.

10. ANNUAL REVIEW SCHEDULE: Schedule for reviewing and revising the AHD.

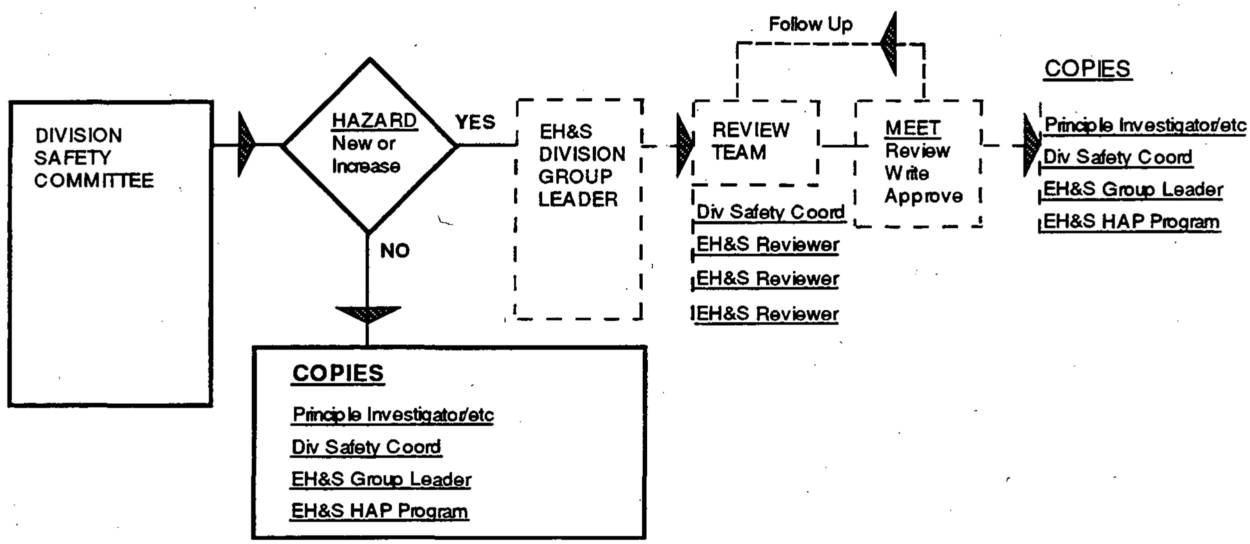
APPENDIX G

AHD REVIEW PROCESS: NEW AHDS



APPENDIX H

AHD REVIEW PROCESS: ANNUAL REVIEW



Chapter 7

PRESSURE SAFETY AND CRYOGENICS

Revised December 1997

Reviewed by: Jeffrey Y. Chung 12/12/97
Date

Approved by: D. C. McGraw 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 7

PRESSURE SAFETY AND CRYOGENICS

7.1 POLICY

Berkeley Lab makes every effort to assure that no injury or property loss will occur from pressure system failures or collapse of systems under vacuum. Whenever possible, Berkeley Lab designs, builds, tests, maintains, and operates pressure vessels and systems in accordance with applicable codes and standards, including the State of California Unfired Pressure Vessel Safety Orders.

For research pressure vessels and systems, Berkeley Lab follows and/or advances the best current industry practice for assuring personnel safety and protection against environmental releases.

7.2 SCOPE

These safety requirements apply to all work at Berkeley Lab involving air, liquids, or gases at, above, or below atmospheric pressure. They also apply to any use of cryogenic liquids, since these liquids pose serious potential for over-pressurization in the case of inadvertent confinement.

7.3 PRESSURE SAFETY PRINCIPLES AND REQUIREMENTS FOR ALL SYSTEMS

Pressure system safety is achieved by careful engineering, assuring structural integrity of the components, regulation of pressures and flow, and provision for pressure relief. In some form these principles must be addressed in every pressure system. Therefore, the following concepts and terminology are basic to any discussion of pressure safety. Note that this information is not intended to provide sufficient guidance to design pressure systems, but only to facilitate implementation of Laboratory policies. General guidance is provided in Appendix A, Guidelines for Responsible Designers, and specific design guidance can be obtained through the Engineering Division.

7.3.1 MAXIMUM ALLOWABLE WORKING PRESSURE (MAWP) AND MAXIMUM OPERATING PRESSURE (MOP)

The pressure on which the design of pressure systems is based is the Maximum Allowable Working Pressure (MAWP). At MAWP, the lowest rated component in a manned, ductile system typically has a design safety factor of at least 4.0. To assure that the MAWP is not exceeded, pressure relief devices must be provided. Pressure relief devices must not be set higher than the MAWP for the system. It is important to note, however, that pressure systems cannot actually be operated at the MAWP because the relief devices will open at that pressure.

The highest pressure at which any pressure system may be operated is the Maximum Operating Pressure (MOP). The MOP should be 10 to 20% below the MAWP to minimize borderline actuation of pressure relief devices. Pressure system design begins with establishment of the desired MOP, since all else follows from this.

Standard components often support an MAWP that is substantially in excess of the MOP for any given system. In such a case, the pressure relief device still should be set at 15 to 20% above the desired MOP. This is recommended because operations with unforeseen pressure excursions in excess of 15 or 20% may be out of control.

7.3.2 TEST PRESSURE

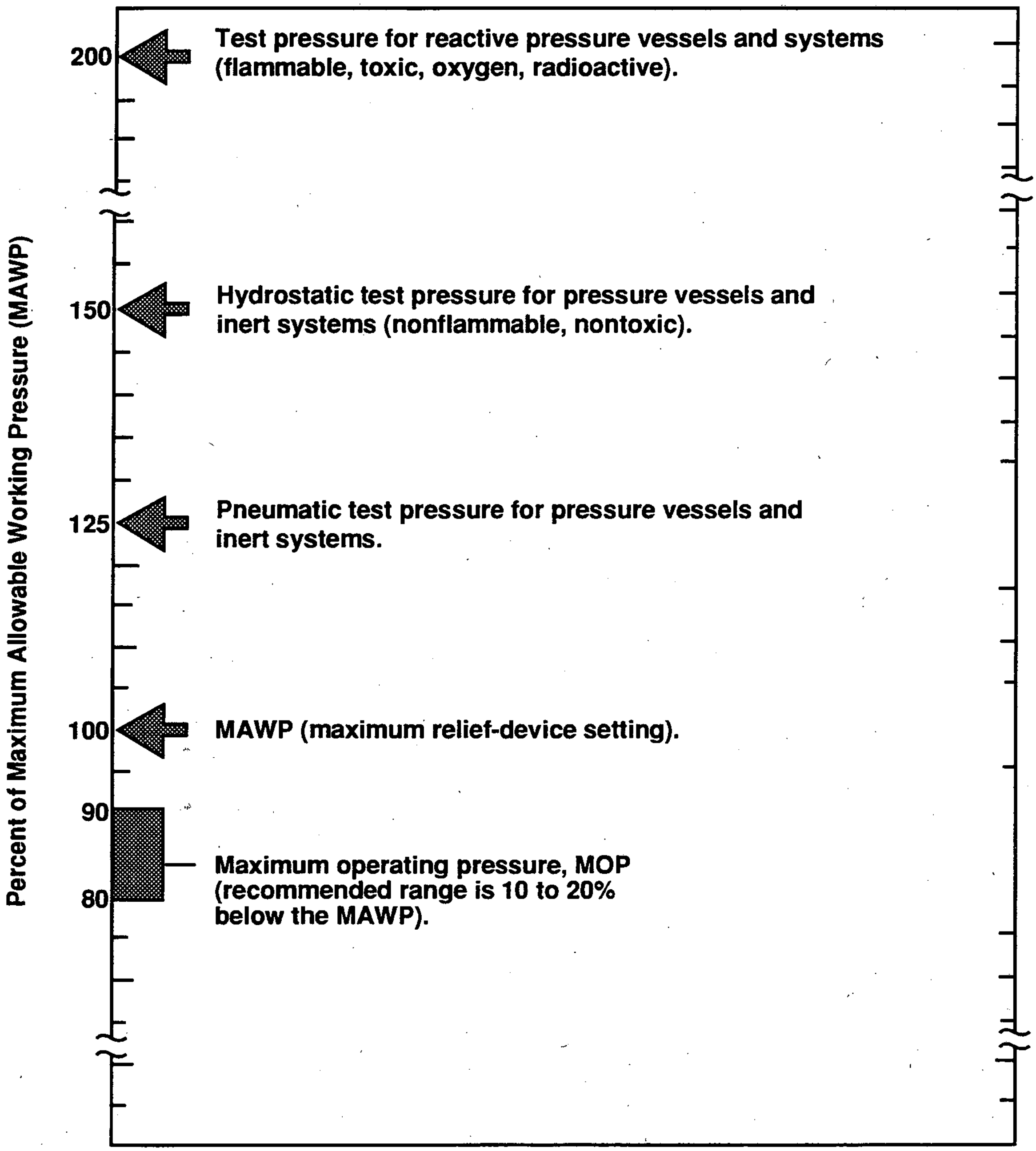
All pressure vessel systems must be tested to assure their integrity. Low pressure piping or tubing without vessels may be leak checked only. Commercial systems that have been tested by the vendor need not be re-tested. Depending on the contents and system configuration, the *responsible designer* will specify hydrostatic or pneumatic testing. Test pressures vary from 125% to 200% of the MAWP. (See Appendix D.)

The above pressure relationships are illustrated in Table 1.

7.3.3 PRESSURE RELIEF DEVICES

Pressure relief devices are required for all systems unless the supply pressure is inherently limited to less than the MAWP of the lowest rated component. Pressure relief valves and rupture disks must be set at no more than the MAWP. The capacity of the pressure relief device must be calculated for systems containing pressure vessels and systems with potentially reactive contents. For pressure vessels, relief capacity must be sufficient to vent the contents of the vessel without exceeding the MAWP by more than 10% under all conditions. For systems with potentially reactive contents, the pressure relief device must be capable of venting the contents of the vessel without exceeding the MAWP by more than 10% when the contents undergo an exothermic reaction at the fastest possible rate.

Table 1. Relationships of Defined Pressure Terms.



Adjustable pressure relief valves may only be set by authorized personnel in the Berkeley Lab Facilities Department Regulator Shop, ext. 7669. Rupture-disk assemblies must be certified by the manufacturer or pressure tested by rupturing three disks selected at random that have been made from the same sheet. Permanent test records must be kept.

Relief devices used with hazardous (flammable, toxic, oxygen depletion, noise, etc.) gases must be vented to a location that will be safe in the event of a large release of gas. Flammable gases must be vented to prevent accumulation of ignitable gas/air mixtures. Health hazard gases (as defined in Chapter 13) must be vented to a location that will not cause inhalation of an unsafe concentration of gas. Venting to a suitable exhaust system is typically required. Contact EH&S Field Support for specific guidance. Venting to a building's exterior may be acceptable for flammable gases. Exceptions for small quantities or concentrations of gas may be approved by EH&S.

In use, the activation of a safety relief device is a danger signal, like the blowing of a fuse. The system should not be put back into operation until the cause of the over-pressurization has been determined and corrected.

7.3.4 COMPONENT REQUIREMENTS

Pressure systems must be constructed of components rated for the intended service. Typically, this means ductile metal tubing and rated pressure fittings that are compatible with the contents of the system. Hoses and flexible tubing may be used, but additional protective measures may be required. See also Chapter 13, *Gases*.

Non-rated components, such as tygon tubing, surgical rubber tubing, hose barbs, RL fittings, etc., are unreliable for pressure use and may not be used where failure could create a hazard. However, such components may be used with low pressure inert gases, or in fume hoods which could safely vent any leaks or ruptures.

7.3.5 BRITTLE COMPONENTS

Pressure systems (including vacuum systems) with brittle components will generally be operated behind a barrier that can contain shrapnel from failed components. This includes systems with glass and quartz components. The use of safety glasses with side shields is usually adequate for work around view ports and glass feed-throughs on vacuum systems. Pressure systems with brittle components that must be operated without a barrier must have a safety factor of at least 8 and must be specifically designated for such operation in the Safety Note. The Safety Note is the Engineering Division mechanism for assuring safe design of pressure systems.

7.3.6 PRESSURE REGULATION

Pressure systems must have a reliable means of pressure regulation. All systems supplied by compressed gas cylinders must be equipped with industry standard regulators. It is recommended that regulators be inspected and that regulator relief devices be set by the

Facilities Department Regulator Shop. Specifically, the use of needle valves and other manual flow controllers without pressure regulators is prohibited on gas cylinder systems.

7.3.7 PRESSURE SYSTEM DESIGN

Pressure vessels and systems are to be designed, tested, and installed in accordance with applicable codes.

Research pressure vessels and systems often pose challenges that require a deviation from standard designs (e.g., target vessels with thin film windows that do not provide a safety factor of 4). In such cases, the design must provide equivalent personnel safety through alternate means, and these alternate means must be analyzed and documented in the Safety Note. General guidance for pressure system design is contained in Appendix A, Guidelines for Responsible Designers, and additional guidance for utility systems and other facility pressure systems is contained in Appendix B, Facility Pressure Systems.

Safety Note requirements are illustrated in the flow chart shown in Table 2. A template for Safety Notes is provided in Appendix C.

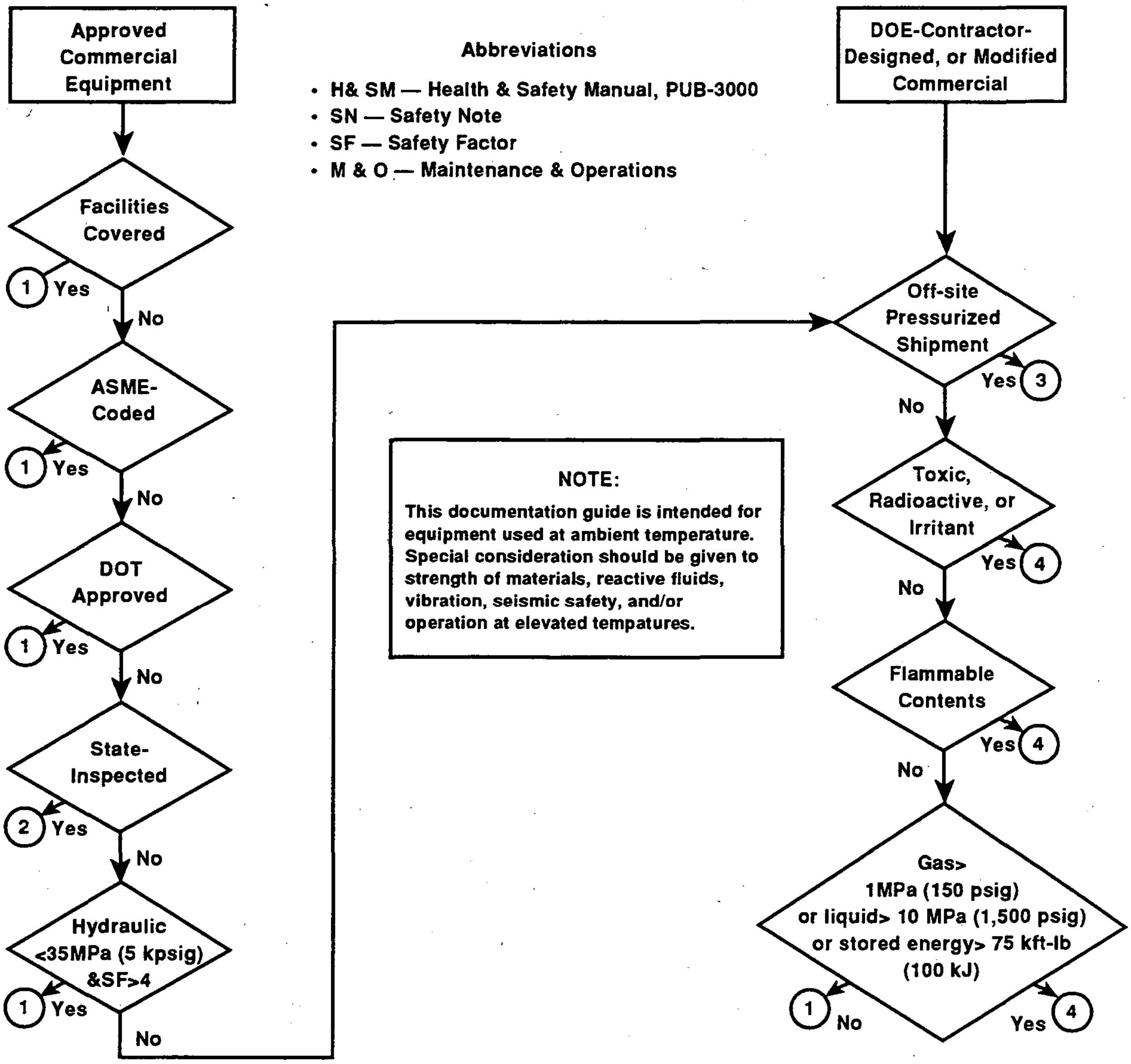
Excellent technical guidance for pressure system design is found in the DOE *Draft Pressure Safety Manual,* Contact the Facilities Department for questions about conventional plant systems and the Engineering Division for questions about research pressure vessels or systems.

7.3.8 PRESSURE SYSTEM INSTALLATION

Pressure systems may only be installed by competent personnel. For personnel who routinely install pressure systems, completion of the LLNL Course Intermediate Pressure Safety (HS-5040) is recommended. Technicians from the Engineering Division and from the Maintenance and Operations section of the Facilities Department are available to assist with installation of pressure systems.

Pressure systems operating at pressures greater than 20 Mpa (3,000 psig) gas or 35 Mpa (5,000 psig) liquid may only be installed by certified *Pressure Installers.* Contact the Facilities Department Regulator Shop for assistance.

Table 2. Documentation Guide for Pressure-Equipment Safety Notes.



Abbreviations

- H& SM — Health & Safety Manual, PUB-3000
- SN — Safety Note
- SF — Safety Factor
- M & O — Maintenance & Operations

NOTE:

This documentation guide is intended for equipment used at ambient temperature. Special consideration should be given to strength of materials, reactive fluids, vibration, seismic safety, and/or operation at elevated tempatures.

Documentation Requirements

1. No SN required (documented or hazards are low).
2. No SN required but notify M & O.
3. Requires DOT approval or DOE-SAN exemption.
4. SN required.

7.3.9 PRESSURE TESTING AND INSPECTION

All pressure systems which include pressure vessels require testing, re-testing, and inspection in accordance with the requirements of the Safety Note. (Exception: utility systems tested and inspected in accordance with State of California Boiler and Pressure Vessel Safety Orders.) Detailed procedures for pressure testing and inspection are given in Appendix D.

7.3.10 PRESSURE SYSTEM USE

A responsible user must be identified for each pressure system.. This responsible user is accountable for the safe use and maintenance of the equipment, and for assuring that all training requirements have been met. Typically, this individual is the principal investigator or researcher who is responsible for the overall effort.

7.4 LOW PRESSURE GAS SYSTEMS

Low Pressure Gas Systems are pressure systems operating below 1 Mpa gauge (150 psig) and consisting only of regulator, tubing, gauges, valves and fittings. Low Pressure Gas Systems represent the lowest hazard category of pressure systems at the Berkeley Lab

7.4.1 LOW PRESSURE GAS SYSTEM INSPECTIONS

Prior to initial operation, all Low Pressure Gas Systems must be inspected by the user. The purpose of this inspection is to verify the suitability of the components, the quality of the installation, and the absence of vessels or components that pose a serious hazard.

7.4.2 LOW PRESSURE GAS SYSTEM DOCUMENTATION

Low Pressure Gas Systems may be covered by a *Safety Note* or an Activity Hazard Document (AHD), but such documentation is not required unless mandated by the hazards of the contents. See description of documentation below.

7.4.3 TRAINING REQUIREMENTS FOR LOW PRESSURE GAS SYSTEMS

The user must complete the Berkeley Lab course *Compressed Gas Safety* (EHS-231) prior to use of any pressure system utilizing compressed gases.

7.5 LOW HAZARD PRESSURE SYSTEMS

7.5.1 GENERAL

Low hazard pressure systems consist of equipment with a low hazard level, involving routine risks that are accepted as such by the general public.

Low hazard pressure systems include:

- **Low Pressure Gas Systems**
- Air and inert gas systems to 1 MPa gauge (150 psig) and inert liquid systems to 10 MPa gauge (1,500 psig), with a total stored energy of not more than 100 kJ (75,000 ft-lb).

  To determine stored energy, see Appendix E.
- Utility systems to 2 MPa gauge (300 psig), including water, compressed gas, natural gas, butane, propane, and steam systems in compliance with Facilities Department standards. These systems are inspected and maintained by the Facilities Department.
- Compressed gas cylinder manifolds assembled by the Facilities Department Regulator Shop.
- Unmodified, commercially-manufactured hydraulic systems to 35 MPa gauge (5,000 psig) such as hydraulic presses, machine tools, and motorized vehicles, provided routine inspection and maintenance are done.
- Department of Transportation (DOT) shipping containers supplied by regular commercial suppliers.
- Air pressure tanks, boilers and certain other vessels inspected periodically in accordance with the Unfired Pressure Vessel Safety Orders or the Boiler and Fired Pressure Vessel Safety Orders of the State of California.

7.5.2 TRAINING REQUIREMENTS FOR LOW HAZARD PRESSURE SYSTEMS

The user must complete the Berkeley Lab course *Compressed Gas Safety* (EHS-231).

7.6 HIGH HAZARD PRESSURE SYSTEMS

Pressure systems that do not fall into the low hazard category are high hazard pressure systems. Specifically, high hazard pressure systems include:

- All pressure vessel systems that contain irritant, toxic, infectious, and/or radioactive fluids at any pressure.
- All pressure vessel systems with oxygen or flammable contents.
- All pressurized equipment (including ASME-coded vessels that have been structurally modified) that operates at gas pressures over 1 MPa gauge (150 psig) or at liquid pressures over 10 MPa gauge (1,500 psig), or that contains over 100 kJ (75,000 ft-lb) of stored energy.

7.6.1 DOCUMENTATION REQUIREMENTS FOR HIGH HAZARD PRESSURE SYSTEMS

All high hazard pressure systems must be covered by an approved *Safety Note* or by manufacturer's documentation or certification that represents an equivalent degree of safety. In borderline cases, an engineer shall review the manufacturer's specification and verify that appropriate safety factors are present.

A *Safety Note* documents the system's engineering design and defines its operating parameters, as well as pressure test procedures, to assure the safety of the system. For commercial systems, the vendor's documentation may be substituted for a Safety Note. *Safety Notes* or the equivalent vendor's documentation must be approved by the Engineering Division Director or his or her designated *Designated Pressure Engineer.* A template *Safety Note* is provided in Appendix C.

An AHD is required for high hazard pressure systems when:

- The material contained in the pressure system is hazardous and requires an AHD (see also Chapter 13, *Gases*, and the *Chemical Hygiene and Safety Plan*, PUB-5341).
- The responsible designer has determined that the system poses pressure or process hazards that demand an AHD.

AHDs for pressure systems require approval by the Engineering Division Director or his or her designee.

7.6.2 TRAINING REQUIREMENTS FOR HIGH HAZARD PRESSURE SYSTEMS

Personnel training requirements for high hazard pressure systems shall be reviewed and agreed on by the user in conjunction with the EH&S Division pressure safety representative. Prior to use of any high hazard pressure system, each user must also be trained in the requirements contained in the AHD for the given system and in the operating requirements contained in the Safety Note. Additional training requirements may be specified in the Safety Note.

7.6.3 OTHER REQUIREMENTS

Requirements for pressure testing, retesting, periodic maintenance of pressure systems, barricades, use limitations, and special procedures may be contained in the Safety Note or AHD for any given system.

7.7 VACUUM SYSTEMS

Vacuum systems that are back-filled from a pressurized supply must be equipped with a pressure relief valve to assure that the system will not be subjected to pressures in excess of the MAWP. The MAWP of vacuum systems containing commercial glass view ports is limited to 3 psig, unless a higher MAWP has been determined and documented by the responsible designer in a Safety Note. Pressure testing of new vacuum systems is not generally required.

7.8 CRYOGENIC SYSTEMS

The most severe hazard of cryogenic systems is the possible confinement of even small amounts of cryogenic liquid. Closed cryogenic systems will quickly become pressure systems when trapped cryogenic fluids warm up and cause pressure build-up. Any system that contains valves or fittings that could possibly separate cryogenic fluid from a direct connection with the atmosphere is a closed system.

7.8.1 REQUIREMENTS FOR CLOSED CRYOGENIC SYSTEMS

In addition to the requirements applying to all pressure Safety Notes, cryogenic systems must have:

- Independent pressure relief devices for each component or segment of tubing that can be isolated by valves.
- Independent pressure relief for each closed space that is in contact with cryogenic temperatures (e.g., vacuum insulation spaces). This is because air may leak in, liquefy, and accumulate in these spaces.
- Low temperature rating of relief valves or thermal isolation for relief valves to prevent ice formation, which will disable the relief valve.
- Assurance of air exclusion for flammable cryogens and for cryogens capable of solidifying air.
- No pressurized components subject to low temperature embrittlement.
- Compatible shrink rates of materials.
- Adequate ventilation provisions in case of large scale spills or continuous venting. See Chapter 13, *Gases*, for detailed requirements pertaining to oxygen deficiency alarms.

7.8.2 GENERAL REQUIREMENTS FOR LIQUID NITROGEN HANDLING

Small scale use of inert cryogenics that are not confined (e.g., the filling of cold traps with liquid nitrogen) poses few hazards and does not require safety documentation. The following rules apply to such use:

- Wear eye protection appropriate to the hazard. When pouring liquid nitrogen from a dewar, use safety glasses with side shields. However, when transferring liquid nitrogen from a pressurized dewar, use face shields.
- Wear loose fitting gloves (e.g., welding gloves) when working on systems with exposed components at cryogenic temperatures to assure that skin will not freeze to cold pipes or metal parts. Gloves need to be loose fitting so they can be thrown off readily if cryogen is spilled into them. This assures that the cryogen will not be trapped against the skin. Small spills of liquid nitrogen on the skin will evaporate without damage unless the liquid is trapped against the skin.
- Do not use cryogens in unventilated spaces, such as closets or experimental caves, without exhaust ventilation.

- When transferring cryogen from pressurized dewars with hoses or tubing, be sure to verify that there are pressure relief devices between all valves because it is easy to trap cryogen in the transfer hose or in the tube between two valves. In such a case, the hose will rupture and whip around out of control.

7.9 RESPONSIBLE PARTIES

7.9.1 DIVISION DIRECTORS

Division Directors are responsible for assuring that all pressure systems are designed, assembled, and operated in accordance with the requirements of this chapter.

7.9.2 EH&S FIELD SUPPORT DEPARTMENT

The EH&S Field Support Department administers and maintains the Laboratory Pressure Safety Program. The EH&S Field Support Department is also responsible for arranging the Laboratory Pressure Safety Training Courses, and for maintaining copies of all AHDs and Safety Notes.

7.9.3 ENGINEERING DIVISION

The Engineering Division is responsible for reviewing and approving the design, fabrication, installation, and testing of research pressure systems, including vacuum systems, as required by this chapter.

The Engineering Division is responsible for reviewing and approving pressure-system Activity Hazard Documents (AHDs), which are written to assure that pressure operations are within the design limitations of such systems. This is in addition to the normal review process for AHDs, and it does not cover AHDs required for other reasons.

7.9.4 ENGINEERING DIVISION DIRECTOR

The Engineering Division Director is responsible for designating qualified engineers as *Designated Pressure Engineers* to provide guidance on pressure vessel and pressure system design, and to review such designs prepared by vendors and by Laboratory personnel.

The Engineering Division Director or designee is responsible for approving any Safety Notes for pressure systems.

7.9.5 FACILITIES DEPARTMENT

The Facilities Department is responsible for the design, fabrication, installation, and testing of all plant facility pressure equipment, as well as the requisite AHDs.

The Facilities Department is responsible for maintaining a sufficient staff of qualified and certified pressure installers, who are available to all groups at Berkeley Lab.

7.9.6 DESIGNATED PRESSURE ENGINEER

Designated Pressure Engineers are experienced mechanical design engineers who have specific knowledge pertaining to pressure safety and have been designated as Designated Pressure Engineers by the *Engineering Division Director*. *Designated Pressure Engineers* are responsible for:

- Completing the Berkeley Lab course *Compressed Gas Safety* (EHS-231) and the LLNL courses *Pressure Safety* (HS-5030), *High Pressure Safety* (HS-5050), and *Pressure Seminar for Engineers* (HS-5060) before undertaking review of pressure vessel or system design. (HS-5030 and HS-5050 are prerequisites for HS-5060.)
- Providing advice and guidance to Berkeley Lab staff in matters pertaining to pressure safety.
- Reviewing and approving pressure related Safety Notes and AHDs on behalf of the Engineering Division Director.

7.9.7 RESPONSIBLE DESIGNER

The *responsible designer*, a competent mechanical designer and usually a member of the Engineering Division, is responsible for:

- Developing or selecting a safe design in accordance with all applicable codes and standards.
- Specifying procurement, fabrication, installation, maintenance, testing, re-testing and labeling requirements.
- Preparing all required Safety Notes.

Completion of Berkeley Lab course *Compressed Gas Safety* (EHS-231) and of the LLNL courses *Pressure Safety* (HS-5030), *High Pressure Safety* (HS-5050), and *Pressure Seminar for Engineers* (HS-5060) is recommended before undertaking the design of a pressure vessel or system. (HS-5030 and HS-5050 are prerequisites for HS-5060.)

7.9.8 PRESSURE INSTALLER

Pressure installers are usually technicians or mechanics in the Facilities Department who have completed specialized training, and who have been designated and certified as such by their Department Head. Pressure installers must complete the Berkeley Lab course *Compressed Gas Safety* (EH&S 231) and the LLNL courses *Pressure Safety* (HS-5030), *Intermediate Pressure Safety* (HS-5040), and *High Pressure Safety* (HS-5050). Pressure installers may be assigned to work for responsible designers directly.

7.9.9 RESPONSIBLE USER

The *responsible user* is the individual responsible for the safe use and maintenance of pressure equipment, including re-testing of pressure systems in accordance with the requirements of the Safety Note or AHD. Usually, this is the principal investigator or researcher who is responsible for the overall work. As a minimum, *responsible users* must complete the Berkeley Lab course *Compressed Gases* (EH-231).

For work at higher pressures, completion of the LLNL course *Intermediate Pressure Safety* (HS-5040) is recommended. For work with pressures in excess of 20 MPa (3,000 psig) gas or 35 MPa (5,000 psig) liquid, completion of the LLNL course *High Pressure Safety* (HS-5050) may be required.

7.9.10 EMPLOYEES

Employees who work with compressed gas systems, must complete the Berkeley Lab course *Compressed Gases* (EHS-231).

Employees who work with pressure systems over 1 Mpa (150 psig) or with pressure vessel systems at any pressure must review training requirements with the EH&S Division pressure safety representative.

For work at higher pressures, completion of the LLNL course *Intermediate Pressure Safety* (HS-5040) is recommended. For work with pressures in excess of 20 MPa (3,000 psig) gas or 35 MPa (5,000 psig) liquid, completion of the LLNL course *High Pressure Safety* (HS-5050) may be required.

7.10 TRAINING

7.10.1 BERKELEY LAB COURSE *COMPRESSED GAS SAFETY* (EHS-231)

Required for all employees using compressed gas systems.

7.10.2 LLNL COURSE *PRESSURE SAFETY ORIENTATION*/(HS-5030)

Prerequisite for:

- LLNL course Intermediate Pressure Safety (HS-5040)
- LLNL course High Pressure Safety (HS-5050)
- LLNL course Pressure Seminar for Engineers (HS-5060)

Recommended for responsible users.

7.10.3 LLNL COURSE *INTERMEDIATE PRESSURE SAFETY* (HS-5040)

Required for:

- Designated Pressure Engineers
- Pressure installers

Recommended (and may be required by a *Safety Note*) for:

- Responsible users for systems up to 20 MPa (3,000 psig) gas or 35 MPa (5,000 psig) liquid
- Employees operating systems up to 20 MPa (3,000 psig) gas or 35 MPa (5,000 psig) liquid

7.10.4 LLNL COURSE *HIGH PRESSURE SAFETY* (HS-5050)

Required for *Pressure installers* for systems operating at pressures greater than 20 MPa (3,000 psig) gas or 35 MPa (5,000 psig) liquid.

Recommended (and may be required) for:

- Responsible users for systems operating at pressures greater than 20 MPa (3,000 psig) gas or 35 MPa (5,000 psig) liquid
- Employees using systems operating at pressures greater than 20 MPa (3,000 psig) gas or 35 MPa (5,000 psig) liquid

7.10.5 LLNL COURSE *PRESSURE SEMINAR FOR ENGINEERS* (HS-5060)

Required for Designated Pressure Engineers.

Recommended for responsible designers.

7.11 STANDARDS

- 29 CFR 1910.101, Compressed Gases--General Requirements
- 29 CFR 1910.102, Acetylene
- 29 CFR 1910.103, Hydrogen
- 29 CFR 1910.104, Oxygen
- 29 CFR 1910.110, Storage and Handling of Liquefied Petroleum Gases
- 29 CFR 1910.253, Oxygen Fuel Gas Welding & Cutting
- 29 CFR 1910.120(q), Emergency Response
- 29 CFR 1910 Subpart C, General Safety and Health Provisions
- 29 CFR 1910 Subpart I, Personal Protective Equipment

- 29 CFR 1926.350, Gas Welding & Cutting
- 29 CFR 1926.55, Gases, Vapors, etc.
- 29 CFR 1926.153, Liquefied Petroleum Gas
- 29 CFR 1926.306, Air Receivers
- 29 CFR 1926 Subpart C, General Safety and Health Provisions
- 49 CFR 171 - 179, Storage & Transportation Guidance
- CAC Title 24, Part 9, California Fire Code, Article 49, Welding & Cutting
- CAC Title 24, Part 9, California Fire Code, Article 74, Compressed Gases
- CAC Title 24, Part 9, California Fire Code, Article 80, Hazardous Materials
- CAC Title 24, Part 9, California Fire Code, Article 51, Semi-conductor fabrication
- CAC Title 24, Part 9, California Fire Code, Article 82, Liquefied Petroleum Gas
- 29 CFR 1910, OSHA General Industry Standards
- 29 CFR 1926, OSHA Construction Industry Standards
- CFC Article 74, Compressed Gas
- CFC Article 80, Hazardous Materials
- 29 CFR 1910.169, Air Receivers
- 29 CFR 1910.106 (b) (1) (v)
- 29 CFR 1910.217 (b) (12)
- Title 8 Industrial Relations, State of California Admin. Code Part 1, Chapter 4, Subchapter 1, Unfired Pressure Vessel Safety Orders
- 29 CFR 1910.101 (Compressed gases - general requirements) Pressure Relief Device
- CGA pamphlet S-11-1963 and 1965 addenda
- CGA pamphlet S-1.2-1963, Pressure Relief
- Title 8, *Industrial Regulations*, State of California Administrative Code, Part 1, Department of Industrial Relations, Chapter 4, Division of Industrial Relations, Subchapter 1, *Unfired Pressure Vessel Safety Orders*

7.12 RELATED PUB-3000 CHAPTER

- *Gases* (Chapter 13)

7.13 REFERENCES

- Berkner, Klaus, *Chemical Hygiene and Safety Plan,* Lawrence Berkeley Laboratory, PUB-5341, 1992
- Compressed Gas Association Pamphlet P1, Safe Handling of Compressed Gas in Containers
- Scott, L. E., Advances in Cryogenic Engineering, Vol. 9, 1963, *Neck Plug Hazards in Cryogenic Shipments*
- American National Standards Institute (ANSI) B31, *Piping Code*
- American National Standards Institute (ANSI) B57.1 and Compressed Gas Association (CGA) V-1, *Compressed Gas Cylinder Valve Outlet and Inlet Connections*
- American Society of Mechanical Engineers, New York, ASME Boiler and Pressure Vessel Code
- Compressed Gas Association (CGA) V-7, Standard Method for Determining Cylinder Valve Outlet Connections for Industrial Gas Mixtures
- DOE Draft Pressure Safety Manual (Guidance only.)

7.14 APPENDICES

- Appendix A: Design Criteria for Responsible Designers
- Appendix B: Facility Pressure Systems
- Appendix C: Safety Note Template
- Appendix D: Pressure Testing and Inspection
- Appendix E: Stored Energy of a Pressurized Gas Vessel

APPENDIX A. DESIGN CRITERIA FOR RESPONSIBLE DESIGNERS

The following criteria apply to all pressure systems designed at Berkeley Lab. These criteria are intended to supplement required codes and standards and do not provide exemptions from more stringent code requirements.

1. GENERAL

The MAWP must be stated on all pressure-system (and pressure-vessel) assembly drawings.

2. RELIEF DEVICES

The following requirements apply:

- Pressure relief devices are required for all systems unless the supply pressure is inherently limited to less than the MAWP of the lowest rated component. Primary relief devices (relief valves or rupture disks) must be set at no more than the MAWP. Secondary or back-up relief devices are encouraged. They may be set at up to 120% of MAWP. The capacity of the pressure relief device must be calculated for systems containing pressure vessels and systems with potentially reactive contents. For pressure vessels, relief capacity must be sufficient to vent the contents of the vessel without exceeding the MAWP by more than 10% under all conditions. For systems with potentially reactive contents, the pressure relief device must be capable of venting the contents of the vessel without exceeding the MAWP by more than 10% when the contents undergo an exothermic reaction at the fastest possible rate.
- When the pressure of an evacuated vacuum vessel is raised to the level of atmospheric pressure with a pressurized-gas source, a relief device must be installed between the gas source and vacuum vessel.
- Berkeley Lab personnel are *not* permitted to set, seal, or stamp relief devices on utility water boilers, steam boilers, and compressed-air receivers that are under the jurisdiction of the State of California.

Only authorized Facilities Maintenance technicians and other specifically authorized persons are permitted to set and seal adjustable relief devices on noncoded pressure vessels and systems.

3. PIPE AND TUBING

The following requirements apply. See also Chapter 13, *Gases*.

Use flexible nonmetallic hose only when it is impractical to use rigid metal pipe or tubing.

- Keep hose lengths as short as possible, protect them from mechanical damage, and anchor the ends to prevent whipping in case of hose or hose-fitting failure.

- Avoid sharp hose bends, and do not bend hoses more sharply than recommended by the manufacturer.
- Replace or repair any hose showing leaks, burns, wear, or other defects.
- Do not use nonmetallic hose on flammable, toxic, and/or radioactive gas systems. (Gases tend to permeate nonmetallic hose.)
- On liquified-gas systems, ensure that all terminal-block (liquid-withdrawal) valves are rated above the vapor pressure of the liquid gas at 38 C (100 F) or that a properly set relief valve is permanently installed on the outlet side of each terminal-block valve.
- All work on pressure equipment requiring a Safety Note must be performed by trained personnel under the direction of a *responsible designer* or *responsible user*.
- All systems must be securely fastened to resist seismic forces.
- For gas systems, use gauges graduated to about twice the MAWP of the system; for liquid systems, use gauges graduated to at least the test pressure.
- Calibrate pressure gauges, switches, and other devices through 120% of their maximum operating points. These devices must be capable of withstanding the operational and emergency, temperatures of the system, and their material must be compatible with the system fluid.
- When large pressure gauges (over 100 mm in face diameter) are used on gas systems with MAWPs over 1.4 MPa (200 psig) or on liquid systems over 140 MPa (20,000 psig), they must be of a special safety-type design. Such gauges have shatterproof faces, solid fronts, and blow-out or generously vented cases. If such a gauge is not installed, operators must be protected by a Lexan safety shield securely mounted over the existing gauge face.
- Protect a gauge subject to pressure surges or cyclic pulses by installing a needle valve or orifice for damping.
- Ensure that there is no oil in gauges used on gas systems. This is important on oxygen systems because hydrocarbons and oxygen can combine explosively. Clean all gauges to be used on high-purity gas systems.
- Equip every flammable-gas drop or regulator-hose connection with a flash arrester or a check valve, a pressure gauge, and a shut-off valve. If the flammable gas is to be (or could be) cross connected with oxygen or compressed air, a flash arrester must be installed in the flammable-gas line and a check valve in the oxygen or compressed-air line.
- Equip all oxygen drops with a check valve. This applies to all single- and multiple-station installations and portable equipment.

4. PRESSURE-SYSTEM INSPECTION

The responsible designer must review newly completed pressure vessels and systems to ensure that they are free from manufacturing defects.

5. SAFETY MARKINGS AND SIGNS

Experimental pressurized gas equipment operating at pressures greater than 3-1/3 MPa (500 psig) must be painted yellow, must have the operating pressure clearly marked thereon, and must bear the sign: "DANGER, HIGH-PRESSURE EQUIPMENT."

Table A-1. Pressure Vessels in Pressure Range of 1/10 to 34 MPa (15 to 5,075 psig).

Title	Design Notes	Safety Note Required
HAZARD CATEGORIES FOR PRESSURE EQUIPMENT		
Low-Hazard Pressure Equipment		
Air and inert gas systems.	Maximum Allowable Working Pressure (MAWP) up to 1 MPa (150 psig).	No
Inert liquid systems.	MAWP up to 10 MPa (1,500 psig) and energy < 100 kJ.	No
Utility systems: water, gas, butane, propane, and steam are to be designed to Plant Engineering Department standards.	MAWP up to 2 MPa (300 psig).	Refer design to Facilities Department.
Compressed-gas cylinder manifolds assembled by the Regulator Shop.	Comply with Chapter 13, *Gases*.	No
Manifolds on tube banks and tube trailers.	Periodic retest required if rated at 20 MPa (3,000 psig).	Yes if > 20 MPa (3,000 psig).
Unmodified ASME pressure vessels that are ASME code stamped and operate with inert fluid.	Low hazard when operating with less than 1 MPa (150 psig) gas pressure, less than 10 MPa (1,500 psig) liquid pressure, or less than 100 kJ stored energy.	Yes if > 1 MPa (150 psig) gas, > 10 MPa (1,500 psig) liquid, or if > 100 kJ.
Refrigeration systems that comply with ASME and Air Conditioning and Refrigeration Institute (ARI) codes.		No
Pressure vessels DOT stamped used to supply and transport fluids.	Retest per Federal Regulation, CFR-49, Transportation, parts 100–199.	No
Air pressure tanks, LPG tanks, anhydrous-ammonia tanks, and fired steam boilers (M&O inspects **LBNL** air pressure tanks and boilers. Materiel Management, Industrial Gas Section, ensures that vendor-owned LPG and anhydrous-ammonia tanks are inspected).	Inspect periodically in accordance with Unfired Pressure Vessel Safety Orders or Boiler and Fired Pressure Vessel Safety Orders of State of California.	Responsible user must notify M&O before installing.
Unmodified commercially manufactured hydraulic systems (used on hydraulic presses, motorized vehicles, machine tools, and the like).	MAWP up to 34 MPa (5,075 psig). Periodically inspected and maintained by user.	No
High-Hazard Pressure Equipment		
Containing hazardous materials or pressures.	Must be reviewed by the **Engineering Division Director** or his or her designee.	
Vessels and systems containing irritant, toxic, infectious, and/or radioactive fluids.	EH&S approval required.	**Yes, except where LBNL Gas System Inspection Certificate is allowed**
Vessels and systems containing oxygen or flammable fluids.		**Yes, except where LBNL Gas System Inspection Certificate is allowed**
Vessels and systems operated at gas pressures over 1 MPa or liquid pressures over 10 MPa or for systems that contain more than 100 kJ isentropic energy, including structurally modified ASME-coded vessels.		Yes
PRESSURE VESSEL DESIGN	Pressure vessels within the scope of ASME codes must comply with the code except for Research Pressure Vessels approved by the **Engineering Division Director** or his or her designee.	Yes
CONTAINMENTS FOR PRESSURE VESSELS		
Outer protective vessel enclosing gas pressurized vessels containing hazardous fluids.		
Designing Safety Factors		
Containment vessel for a contained pressure vessel made of ductile material.	Design for a safety factor of 4 to ultimate stress.	Yes
Containment vessel for a contained pressure vessel made of brittle material.	Design for a safety factor of 8 to ultimate stress.	Yes
Testing and Labeling	Pressure test to 1.5 times the maximum permissible equilibrium pressure. No leak > 1.0 E-08 atm cc/sec permitted.	Fix label showing working pressure and operating temperature range.
PRESSURE SYSTEM REQUIREMENTS	Show MAWP on all assembly drawings.	Yes
Relief Devices	Requirements of Chapter 7 apply.	
Pipe and Tubing	Requirements of Chapters 7 and 13 apply.	
Piping for nonflammable fluid.	Pressure Test to 1.5 times MAWP or 1 MPa (150 psig), whichever is greater.	
Piping for nonflammable cryogenic fluid surrounded by a vacuum jacket.	Test to 1.5 times maximum allowable differential working pressure.	
Flexible Nonmetallic Hose	Not recommended, **must be approved by a *Designated Pressure Engineer*.**	
Pressure Gauges	Calibrate gauges to at least 1.2 times MAWP.	
Gauges for gas systems.	Use gauges graduated to about 2 times MAWP.	
Gauges for liquid systems.	Use gauges graduated to at least the test pressure.	
Safety-type gauges for gas systems.	Use safety-type gauges when gauge is over 100 mm in diameter and graduated to over 1.33 MPa (200 psig).	
Safety-type gauges for liquid systems.	Use safety-type gauges when gauge is over 100 mm in diameter and graduated to over 133 MPa (20,000 psig).	

APPENDIX B. FACILITY PRESSURE SYSTEMS

The following information applies to utility systems and other Facility pressure vessels and systems.

1. GENERAL

The safety requirements for Plant-Facility *utility* unfired or fired pressure vessels and boilers have been defined earlier in this chapter and by the State of California Administrative Codes, as described below.

2. UNFIRED PRESSURE VESSELS

Requirements for unfired pressure vessels are contained in:

State of California Administrative Code
Title 8: *Department of Industrial Relations*
Part 1: Department of Industrial Regulations
Chapter 4: Division of Industrial Safety
Subchapter 1: *Unfired Pressure Vessel Safety Orders*

The Safety Orders of this subchapter of Title 8 establish *minimum standards* for the following:

- The design and construction of all unfired pressure vessels for plant-facility pressure systems.
- The installation, operation (including issuance of permits), inspection, and repair of air-pressure tanks and liquified-petroleum-gas (LPG) tanks.
- The design, construction, repair, or alteration of storage tanks for liquified natural gas (LNG) at 1/10 MPa (15 psig) or less.
- The installation, use, and repair of anhydrous-ammonia tanks.
- The design and construction of pressure vessels for storing and dispensing natural gas for motor fuel and of motor-fuel tanks installed on vehicles not licensed to travel on highways.
- The installation, use, and repair of natural-gas vessels and systems that are not a part of hazardous research equipment.

The Safety Orders of subchapter 1 of Title 8 are *not applicable* to the following:

- Pressure vessels that are under the jurisdiction and inspection of the United States Government that are specifically exempted by the Labor Code.
- Pressure vessels, except for LNG tanks, that are subject to an internal or external pressure of not more than 1/10 MPa (15 psig) with no limitation on size, and vessels having an inside diameter less than 6 in, with no limitation on pressure. (However, such vessels must be

designed and constructed in accordance with recognized standards, when applicable, or in accordance with good engineering practices concerning pressure-vessel design, with a safety factor of at least 4, and must be fitted with controls and safety devices necessary for safe operation.)

- Natural-gas vessels and installations subject to the jurisdiction and inspection of the California State Public Utilities Commission, Department of Transportation, or Highway Patrol; air-brake tanks installed on vehicles, including trucks, buses, trains, and streetcars, that are operated by any person, firm, or corporation subject to the jurisdiction and inspection of the Public Utilities Commission, the Department of Transportation, or the Highway Patrol.

The following vessels must be constructed, inspected, and stamped in accordance with the appropriate American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code section.

- Air-pressure tanks
- LPG tanks
- Anhydrous-ammonia tanks
- All Plant-Facility pressure vessels

LNG tanks for low-temperature storage at 1/10 MPa (15 psig) or less must be designed, constructed, inspected, and certified in accordance with American Petroleum Institute (API) Standard 620.

LPG vaporizers having a volume greater than one U.S. gallon must be constructed in accordance with the State of California Boiler and Fired Pressure Vessel Safety Orders, Title 8, Subchapter 2.

State of California Permits to Operate are required for LPG tanks and for air tanks larger than 0.04 m^3 (1.5 ft^3) within relief valves set to open above 1 MPa (150 psig).

3. BOILERS AND FIRED PRESSURE VESSELS

Requirements for boilers and fired pressure vessels are contained in:

> State of California Administrative Code
> Title 8. *Industrial Relations*
> Part 1. Department of Industrial Relations
> Chapter 4. Division of Industrial Safety
> Subchapter 2. *Boiler and Fired Pressure Vessel Safety Orders*

The Safety Orders of this subchapter of Title 8 establish *minimum standards* for the design, construction, installation, inspection, operation, and repair of (1) all power boilers, including nuclear power boilers, (2) all low-pressure boilers and high-temperature-water boilers, and (3) any other fired pressure vessels in California not specifically exempted from these Orders.

These Safety Orders are *not applicable* to (1) boilers and fired pressure vessels under the jurisdiction of and inspected by the United States Government, (2) boilers and fired-pressure vessels used in household service, and (3) boilers used exclusively to operate highway vehicles, including automobiles.

4. DESIGN AND CONSTRUCTION

All new power boilers, high-temperature water boilers, and low-pressure boilers must be constructed, inspected, and stamped in full compliance with the ASME Boiler and Pressure Vessel Code.

Pressure vessels not included in the scope of the ASME Boiler and Pressure Vessel Code must be designed and constructed in accordance with good engineering practice , with a safety factor of at least 4, so that they can accommodate the pressures and temperatures required of them. "Good engineering practices" as defined in this chapter encompasses details of design and construction that are at least as safe as those required by the rules in the ASME Boiler and Pressure Vessel Code, including those rules covering shop inspection.

State of California Permits to Operate are required on all boilers and fired-pressure vessels except for

- Low-pressure boilers.
- Miniature boilers.
- High-temperature water boilers.
- Boilers, including forced-circulation boilers, in which none of the following is exceeded: 9.29 m^2 (100 ft^2) of heating surface, 0.41 m-(16-in) steam-drum inside diameter, 2/3 MPa (100-psig), MAWP, 35-gal normal water capacity, and 400,000-Btu/hr burner power input.

APPENDIX C. SAFETY NOTE

A Berkeley Lab Safety Note is generally used to document engineering calculations or tests of specific equipment or activities where there is a safety concern. The following guidelines have been prepared to assist in writing Safety Notes for pressure vessels and pressure systems.

In preparing a Safety Note, consider the following:

- Description
- Hazards
- Calculations
- Tests and/or Certifications
- Labeling
- Associated Procedures
- References
- Signature Authority
- Distribution (see Safety Note Template title page)

SAFETY NOTE TEMPLATE

(*Sample Title Page Format*)

(*Appropriate Department Title*) Safety Note

Title

Safety Note Serial Number: ____________

Date: ___________

Prepared by: ____________________________________
Responsible Designer

Reviewed by: ____________________________________
Project Mechanical Engineer, Physicist, etc.

Approved by: ____________________________________
Engineering Division Director or Designee

Standard Distribution:

Author

EH&S Field Support Department

Project Mechanical Engineer, Physicist, etc.

Engineering Division Director

Responsible User

Appropriate Safety File

A. DESCRIPTION

What kind of vessel is it? What is its configuration? Its size?

What will be its use?

What are the vessel's pressure ratings, Maximum Allowable Working Pressure (MAWP), and Maximum Operating Pressure (MOP)?

Is it an ASME-coded vessel?

What are its operating temperature and environment?

Is the vessel DOT-approved?

Are there drawing numbers or sketches of the vessel you can cite?

Where will the vessel be located? Building ________ Room ________.

Who will be the responsible experimenter or user?

From the above description, could a person find this vessel or system several years from now?

B. HAZARDS

What are the hazards in using this vessel?

What is the stored energy (in gas-filled vessels)?

Is a flammable, cryogenic, radioactive, toxic and/or corrosive material involved? Identify the material and the amount used in the equipment, etc.

What happens if a loss of power, coolant, instrument, air, etc., occurs?

What can be done to eliminate or lessen the hazards—e.g., hoods, barricades, protective clothing, design, special operating procedure?

C. CALCULATIONS

What are the design specifications of the vessel?

What are the material specifications?

Are materials certifications required?

Include calculations for the MAWP (see ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, UG-98).

Where applicable, show calculations for parameters such as:

Weld shear stress

Tensile stress on bolts, plates, etc.

Hoop stress

Thread shear

Safety factors

All components rated at or above MAWP do not require calculations.

Cite manufacturers' ratings, stores-catalog ratings, and identifications.

Show calculations for barricades or shields, if used.

D. PRESSURE TESTING

All pressure testing requires a procedure. Use this section to write the test procedure. Specify: barricade requirements, test sequence, test pressure, test fluid, test temperature, hold time, and acceptance leak rate. Record actual test procedure and results.

Is a retest procedure required? Is it different from the original procedure? Should the frequency of inspection or retest be specified?

E. LABELING

Attach a copy of the completed LBNL Pressure Tested label here.

LBL PRESSURE TESTED
DWG. NO. ______
SAFETY NOTE ______
WORKING PRESS. ______ PSI
WORKING FLUID ______
WORKING TEMP. ______ °F
REMARKS ______
TEST NUMBER ______
BY ______ DATE ______

F. ASSOCIATED PROCEDURES

List all procedures to be read and understood by all personnel operating the equipment.

G. REFERENCES

List the references you have cited in your Safety Note.

H. SIGNATURE AUTHORITY AND DISTRIBUTION

The signature authority and standard distribution are shown on the sample title page. Distribute the Safety Note to others having safety responsibility for this equipment, such as Building Managers, Division Safety Coordinators, and Area Operations Management.

APPENDIX D. PRESSURE TESTING AND INSPECTION

1. GENERAL

Whenever practical, pressure vessels and systems should be sent to the Facilities Maintenance Technician Shops (Building 76, ext. 7669) for pressure testing. When this is not practical, the vessel or system must be tested in accordance with the in-place pressure testing procedures described in Section 2, below. Pressure tests performed at Berkeley Lab must be conducted by a certified pressure installer, and must be observed (or conducted) and certified by the Engineering Division Director or his or her designee.

A summary of pressure-vessel and pressure-system testing is given in Table D-1.

The person who certifies the test must complete the Pressure Test Record form (Fig. D-1) and then attach an "LBNL Pressure Tested" label (Fig. D-2) to the vessel or system if it has passed the test.

Table D-1. Summary of Pressure-Vessel and Pressure-System Testing.

Testing of pressure vessels and systems in the pressure range of 15 to 20 MPa (3000 psig). Set pressure-relief device no higher than the Maximum Allowable Working Pressure (MAWP). Pressure Test Record and LBNL Pressure Tested Label are required.	
Title	Pressure Test
Pressure Vessels (Testing)	
Pressure vessels for low-hazard systems. See Table A-1 for definition.	Hydrostatic test to 1.5 times MAWP or pneumatic test to 1.25 times MAWP. Pneumatic test only if electrical or research requirements prohibit hydrostatic test. Use an inert liquid.
Pressure vessels for high-hazard systems. See Table A-1 for definition.	**Test to 1.5 times MAWP with inert liquid (preferred) or gas. Reinspect and retest at MAWP as specified in Safety Note or AHD. Reproduce special temperature conditions or cycles as closely as possible.**
Pressure Systems (Testing)	
Pressure systems (containing low-hazard substances) that will operate with nonhazardous liquids, inert gases, or compressed air.	Hydrostatic test to 1.5 times MAWP (preferred) or pneumatic test to 1.25 times MAWP. Pneumatic in-place testing is limited to 20 MPa (3,000 psig) maximum. Use an inert liquid.
Pressure systems (containing high-hazard substances) that will operate with oxygen or with flammable, toxic, and/or radioactive fluids.	Test to 2 times MAWP using an inert liquid (preferred) or gas. Pneumatic in-place testing is limited to 20 MPa (300 psig) maximum. Reinspect at least every 3 years. Retest at MAWP at least every 6 years unless otherwise specified in Safety Note or AHD.

LAWRENCE BERKELEY NATIONAL LABORATORY
PRESSURE-TEST RECORD

Date: ____________

Location of vessel (or system): Build. _____ Rm. _____

Description: ______________________________

____

____

Pressure Vessel ❑ Pressure System ❑ (check box)

"Pressure-Tested" Label attached ❑

LBL PRESSURE TESTED	
DWG. NO.	
SAFETY NOTE	
WORKING PRESS.	PSI
WORKING FLUID	
WORKING TEMP.	°F
REMARKS	
TEST NUMBER	
BY	DATE

TEST INFORMATION:

1. Test pressure __________ Pa (__________ kpsi)
2. Testing Fluid (oil, He, etc.) _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ ____________________
3. Test Temperature __________ °C (__________ °F)
4. Design Temperature _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ __________ °C (__________ °F)
5. Safety Case ____________________
6. Responsible Designer _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Name: ____________________
7. Responsible User _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Name: ____________________

   Dept. ____________________

   Divn: ____________________

8. Diameter measurements (for pressure-vessel tests only)

Location (marked)	Before testing	After testing	Difference (+ or –)

Remarks: ______________________________

Test by: ______________________________

M&O, Mech. Shop

CERTIFICATION:

The vessel identified above has been pressure tested and is approved for operation within these test conditions.

Certified by: ______________________________

Fig. D-1. Pressure Test Record.

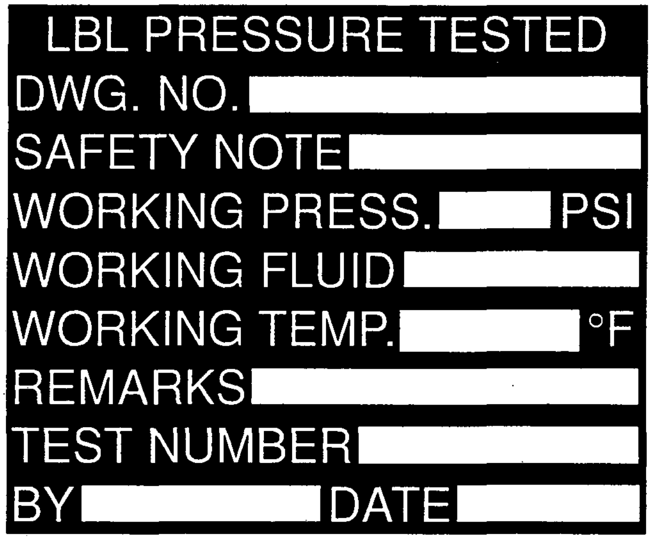


Fig. D-2. LBNL Pressure Tested Label.

When pressure vessels or systems are fabricated for Berkeley Lab by outside vendors, pressure testing may be performed by the vendor, but must be witnessed and documented by a Berkeley Lab responsible designer.

Pressure-test and pressure-inspection records must be maintained for the life of the vessel by the Facilities Maintenance Technician Shop, ext. 7669.

a. Testing of Pressure Vessels

Pressure vessels must be tested in accordance with the rules in this section, using an inert fluid.

Pressure vessels for low-hazard inert systems for operation with nonflammable, nontoxic, and nonradioactive fluids

> These vessels must be hydrostatically tested to at least 1.5 times the MAWP or pneumatically tested to at least 1.25 times the MAWP (*only* when safety considerations or research requirements do not permit a hydrostatic test). Any special temperature conditions or temperature cycles to which these vessels will be subjected in use must be reproduced as closely as possible during the test. ASME pressure-test procedures are in ASME Boiler and Pressure Vessel Code, Division 1, UG-99, 100.

Pressure vessels for high-hazard reactive systems for operation with oxygen or flammable, toxic, and/or radioactive fluids

These vessels must be hydrostatically tested to at least 1.5 times the MAWP or pneumatically tested to at least 1.25 times the MAWP (*only* when safety considerations or research requirements do not permit a hydrostatic test). Any special temperature conditions or temperature cycles to which a vessel will be subjected while in use must be reproduced as closely as possible during testing In addition, vessels may need to be inspected ultrasonically, or for surface cracks using the magnetic-particle test or (for nonmagnetic vessels) the fluorescent-penetrant test.

During tests of pressure vessels in which the yield strengths of their construction materials are approached, strain-gauge measurements must be made at high-stress locations. Diameter measurements accurate to within ± 0.025 mm (0.001 in) must also be taken both before and after testing to determine whether detectable plastic yielding has occurred during pressurization.

When the strength of the vessel is questionable (old or unknown design), strain-gauge measurements must be made during testing, and diameter measurements must be taken before and after testing. In this case, the MAWP for ASME-Code pressure vessels made of the acceptable ductile materials listed in the Code, must not exceed 0.4 times the test pressure and must comply with ASME Boiler and Pressure Vessel Code, Division 1, UG-101, *Proof Test to Establish MAWP*.

b. Testing of Pressure Systems

Inert-substance (low-hazard) pressure systems that will operate with nonhazardous liquids, inert gases, or compressed air

These pressure systems must be tested hydrostatically (preferred), using an inert fluid, to at least 1.5 times the MAWP or pneumatically to at least 1.25 times the MAWP.

Reactive-substance (high-hazard) pressure systems that will operate with oxygen or with flammable, toxic, and/or radioactive fluids

These pressure systems may be tested using an inert liquid (preferred) or gas, to at least 2.0 times the MAWP.

c. Leak Testing

Pressure vessels and systems may be leak tested at their MAWP level after successful pressure testing. Preliminary leak testing of nonpressure-tested or nondocumented pressure vessels or systems must be limited to a maximum of 20% of the test pressure (or proposed test pressure).

d. Repairs

If a leak is detected during pressure tests of a vessel or system, and it is decided to locate the leak before completing the test, the pressure must be reduced to not over one-half the immediately preceding test pressure while the leak is being located.

A system or vessel must not be repaired while it is pressurized unless this is specifically authorized by the responsible designer.

e. Modifications

Any modification to a pressure vessel or system, other than repair or replacement with an exact duplicate of existing components, must be approved by the responsible designer and recorded in a revision to the applicable engineering drawing, to the Safety Note, and to the AHD (if applicable). The initial pressure test must be repeated before any further use of the modified vessel or system.

If an ASME-Code vessel is modified, the Code stamping must be obliterated, and the Engineering Division Director must be so notified.

When pressure equipment has been modified for use at a pressure below the original design pressure, all modifications (e.g., use of fewer bolts in flanged joints) must be approved by the responsible designer. All safety requirements for the lower pressure must be met, and the reduced working pressure and the number of bolts or other supports required must be clearly marked on the equipment. If high-strength bolts or other special bolts are required, this must also be clearly marked on the equipment near the bolt holes.

Instructions on precautions for operation of the modified equipment must be sent to all concerned personnel, and one copy must be filed in the Safety Note file of the Engineering Division.

f. Reinspection and Retesting

All high-hazard equipment that is neither a part of Facilities nor under the jurisdiction of the State of California must be as specified in the Safety Note or AHD.

Pressure reinspection is performed by a pressure inspector or by a responsible designer and is recorded on a Pressure Inspection Record form (Fig. D-3). The completed form must be signed by the responsible user and sent to the Facilities Maintenance Technician Shop, where it is kept for the life of the vessel.

The results of the retest must be certified on a Pressure Test Record Form (Fig. D-1) to be filed with the initial Pressure Test Record by the testing organization, and an LBNL Pressure Tested label (Fig. D-2) must be affixed on the vessel or system.

2. In-Place Pressure Testing

If it is impractical to pressure test a vessel or system at the Mechanical Shop, M&O Shop, or some other approved location, pressure test it in place, in accordance with the provisions of this section.

The responsible user must ensure that in-place retesting of pressure equipment is performed for which he or she is responsible. Although other individuals may be designated to observe and direct testing or retesting, responsibility for safe conduction of the test and safe functioning of tested pressure equipment cannot be delegated.

The responsible designer must prepare the required test procedure, direct the test personnel, and witness in-place pressure testing of vessels and systems for which he or she is responsible.

a. Test Procedures

A written test procedure must be prepared for every high-hazard pressure test conducted in the field. When in-place pressure testing occurs, the test procedure must be included in (or appended to) the Safety Note.

Procedures for in-place testing of high-hazard vessels and systems must be approved by the Engineering Division Director or his or her designee.

The Building Manager or Area Supervisor must be advised of pressure tests planned in his or her facility, and EH&S must be notified if toxic and/or radioactive material is involved.

All pressure tests must be conducted by either the responsible designer or a person designated by the responsible designer, or by a Facilities Maintenance Technician, Facilities Mechanic, or Machinist in the Assembly Shop. Pressure tests must be observed and certified by the responsible designer or a pressure inspector.

b. Precautions

For in-place testing with liquids, all air must be carefully removed from both the testing system and the equipment to be tested. This is because compressed air will expand violently in case of vessel failure. Spongy action of pumping equipment usually indicates the presence of trapped air.

Pressure testing with a gas is far more dangerous than testing with a liquid. Therefore, tests must be conducted with liquids, whenever practical.

Before testing, barricade the equipment being tested, shield the controls and operators, and evacuate all unauthorized personnel from the test area. Signs reading "Danger—High-Pressure Test in Progress—Keep Out" must be posted at all approaches to the test area.

LAWRENCE BERKELEY NATIONAL LABORATORY
PRESSURE INSPECTION RECORD

Date: ______________

Location of vessel (or system): Bldg. ________ Rm. ________

Is vessel or system still in use? Yes _____ No ______

Pressure Vessel ❑ Pressure System ❑ (check box)

INSPECTION INFORMATION:

Inspect the following and check (✔) appropriate column, explaining under Remarks as required. (Enter N/A under Remarks if item is not applicable.)

	Satis-factory	Unsatis-factory	Remarks
1. General appearance of system (or vessel).			
2. Relief devices are a. Properly set (have been checked; reset as required).			
b. Properly sealed.			
c. Pointed in safe direction or safely vented.			
3. All fittings are tight.			
4. Replaced or added fittings, gauges, valves (and piping) are properly rated.*			
5. All system components are adequately secured			
6. Valve packing nuts are tight and locked (if of the locking type).			
7. Oil is not apparent on or in gas (especially oxygen) systems.*			
8. The outside surface of the vessel shows no evidence of strain, damage, or corrosion.			
9. The inside surface of the vessel shows no evidence of strain, damage, or corrosion.			
10. Lined-vessel vent path is unobstructed; check with helium.			
11. Vessel or system seals are leaktight. Have replaced as required.			
12. The vessel or system is safe for continuing operation.			

Inspected by: ________________________________
PRESSURE INSPECTOR

____
RESPONSIBLE USER

Send this completed form to the Facilities Maintenance Technician Shop.

*Assurance by the responsible user is considered satisfactory verification.

Fig. D-3. Pressure Inspection Record.

APPENDIX E. STORED ENERGY OF A PRESSURIZED GAS VESSEL

Although the pressure section of this publication is not intended to be a primer on pressure calculation, the following formula is used sufficiently frequently, but is obscure enough, that it has been included.

When a gas is compressed, energy is stored in it. If the energy is released in an unfavorable way, it will cause damage. Stored energies in excess of 100 kJ are considered high hazard. Sometimes it is helpful to think of stored energy in terms of grams of TNT. One gram of TNT contains 4.62 kJ of energy.

V_h = The volume of the vessel.

P_h = The absolute pressure of the vessel.

P_l = The absolute pressure to which the vessel would drop if it burst. Generally this would be one atmosphere (14.696 psi or 101,300 pascals). A pascal is a newton per square meter.

γ = The adiabatic exponent or ratio of specific heats, C_p/C_v. The value is 1.666 for monatomic gases such as argon and helium; 1.4 for diatomic gases such as nitrogen, oxygen, hydrogen, and air; and variable for polyatomic gases such as methane, water, and carbon dioxide but generally very nearly 1.3.

$$U = \frac{P_h V_h}{\gamma - 1}\left[1 - \left(\frac{P_l}{P_h}\right)^{\frac{\gamma-1}{\gamma}}\right]$$

Note that the bracketed value is dimensionless but that $P_h V_h$ is not. Therefore, the length units used in P_h and V_h must match.

Example:

The gas is air ($\gamma = 1.4$)

V_h = 1.0 stere (1.0 cubic meter) or 35.3 cubic feet

P_h = 10 atmospheres (150 psi) gage or 11 atm absolute or 1.1 mPa

P_l = 1 atmosphere or 100 kPa or 14.7 psi

$$U = \frac{(11 * 10^5\ N/m^2)(1.0\ m^3)}{1.4 - 1}\left[1 - \left(\frac{1 * 10^5\ N/m^2}{11 * 10^5\ N/m^2}\right)^{\frac{1.4-1}{1.4}}\right] = 1.4 * 10^6\ N - m$$

A N-m is a joule so the stored energy is 1.4 mJ which is equivalent to somewhat more than half a pound of TNT.

Chapter 8

ELECTRICAL SAFETY

Revised December 1997

Reviewed by: [signature] 12-11-97
Date

Approved by: [signature] 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 8

ELECTRICAL SAFETY

8.1 POLICY

It is LBNL policy to comply with DOE and OSHA regulations, the National Electrical Code, and other established safety standards to reduce or eliminate the dangers associated with the use of electrical energy. Every person on Laboratory property is exposed to electricity to some extent. The electrical safety program is intended to give those persons who may come in proximity with energized electrical parts in their work activities the minimum knowledge of safety and recommended practices necessary to protect against electrical shock or burns. It also provides hazard awareness information to those who use electrical equipment.

Reading this chapter does not qualify the reader to perform electrical work. Guidelines that are beyond the scope of this document must be established at each work area. They should include, as a minimum, the safety concerns outlined herein.

All electrical wiring and equipment must comply with the National Electrical Code, OSHA regulations, and numerous other established safety and engineering standards. This chapter is in no way to be construed as a synopsis of all electrical requirements, nor as a substitute for formal study, training, and experience in electrical design, construction, and maintenance.

8.2 AUTHORITY HAVING JURISDICTION

8.2.1 OVERVIEW

The **Authority Having Jurisdiction** (AHJ) is responsible for making interpretations and granting special permission as contemplated in the rules of the National Electrical Code. The AHJ is responsible for determining the acceptability of electrical installations.

The **Department of Energy** is ultimately the AHJ for all facilities in the DOE complex and reserves the right to exercise this authority as necessary.

The **Deputy Laboratory Director for Operations** is the AHJ for all electrical installations within LBNL. In the daily operation of the Laboratory, this responsibility is delegated as follows:

8.2.2 FACILITIES MANAGER

The Facilities Manager is delegated by the Deputy Laboratory Director for Operations the responsibility for assuring compliance with all electrical safety and code requirements in the design, erection, construction, enlargement, alteration, moving, demolition, conversion, maintenance, and repair of all Laboratory buildings, structures, and utilities. Electrical code and safety AHJ decisions are vested in the Facilities Manager during the course of these activities.

8.2.3 ENVIRONMENT, HEALTH AND SAFETY DIVISION DIRECTOR

The Environment, Health and Safety Division Director is delegated major responsibility by the Deputy Laboratory Director for Operations for assuring compliance with all electrical safety requirements that pertain to maintaining a safe working environment and protecting Laboratory employees and contract and subcontract personnel from injury or death as a result of electrical hazards. As the authorized representative of the EH&S Director, the Electrical Safety Engineer has the responsibility to:

- Ensure the acceptability of experimental electrical wiring and apparatus. In this capacity the Electrical Safety Engineer will, as needed:
  - Review drawings, tests and other documentation provided by the project engineers, principal investigators (PIs), or other responsible parties for compliance with accepted safety criteria and code intent.
  - Consult with the appropriate specialists to verify that engineering, design, and construction parameters have been correctly applied.
  - Inspect power systems and incidental wiring related to the experiment.
  - Conduct other inspections and analyses as necessary to verify the acceptability of the apparatus involved.
- Evaluate existing workplace safety by inspecting or assisting in the inspections of the workplace for National Electrical Code (NEC) compliance, as needed. For the purposes of this policy, a facility becomes a *workplace* once construction is completed and the facility is occupied by LBNL employees. Prior to completion of construction, all NEC compliance is vested in the Facilities Manager , although EH&S may monitor construction sites for safety-related work practices and construction safety orders.
- Render independent NEC and OSHA interpretations, answer code questions, and provide NEC and OSHA information, as needed.
- Approve alternatives to specific NEC requirements under exceptional circumstances as permitted by NEC and OSHA.

8.2.4 ENGINEERING DIVISION DIRECTOR

The Engineering Division Director is delegated the responsibility by the Deputy Laboratory Director for Operations to:

- Assure compliance with all electrical safety requirements for design, installation, maintenance, and repair of research equipment.
- Provide testing and evaluation, as needed, for unique equipment.

8.2.5 APPEALS

The Deputy Laboratory Director for Operations is responsible for adjudicating any appeals of AHJ decisions and for resolving conflicts between different AHJ entities. All appeals must be submitted to the SRC via the Electrical Safety Subcommittee. These groups review the appeal and make recommendations to the Deputy Laboratory Director for Operations for a final decision.

8.2.6 OVERLAPPING RESPONSIBILITIES

Many LBNL activities and projects progress through different areas of responsibilities. Some or all of the delegated AHJ bodies may be involved in a given project at various times. Cooperation between groups is essential to assure safety and efficiency of execution. The AHJ at each level should notify others who may be involved in subsequent decision making. If agreement cannot be reached, the appeals channels should be used to obtain an early resolution.

8.3 HAZARDS

8.3.1 ELECTRICAL SHOCK

Electricity is one of the most commonly encountered hazards in any facility. Under normal conditions, protection from shock is afforded by the inherent safety features of the electrical utilization equipment. Nonetheless, accidental contact with electricity can cause serious injury or death. Most electrical systems establish a voltage reference point by connecting a portion of the system to an earth ground. Because these systems use conductors that have voltages with respect to ground, a shock hazard exists for workers who are in contact with the earth and exposed to the conductors. If people come in contact with a "live" (ungrounded) conductor while they are in contact with the ground, they become part of the circuit and current passes through their bodies.

The effects of electric current on the human body depend on the following:

- Circuit characteristics (current, resistance, frequency, and voltage—60 Hz is the most dangerous frequency).
- Contact and internal resistance of the body.
- The current's pathway through the body, determined by contact location and internal body chemistry.
- Duration of contact.
- Environmental conditions affecting the body's contact resistance.

The most damaging route of electricity is through the chest cavity or brain. Fatal ventricular fibrillation of the heart (stopping of rhythmic pumping action) can be initiated by a current flow of as little as several milliamperes. Nearly instantaneous fatalities can result from either direct paralysis of the respiratory system, failure of rhythmic pumping action, or immediate heart stoppage. Severe injuries, such as deep internal burns, can occur even if the current does not pass through the vital organs or nerve center.

Table 8.1 is based on limited experiments performed on human subjects in 1961. These figures are not completely reliable due to the unavailability of additional data and the inherent physiological differences between people. Electricity should be considered potentially lethal at lower levels than those cited.

Table 8.1. Quantitative Effects of Electric Current on Man[a]

Effects	Current, mA					
	Direct Current		Alternating Current			
			60 Hz		10 kHz	
	Men	Women	Men	Women	Men	Women
Slight sensation on hand	1	0.6	0.4	0.3	7	5
Perception threshold, median	6.2	3.5	1.1	0.7	12	8
Shock—not painful and no loss of muscular control	9	6	1.8	1.2	17	11
Painful shock—muscular control lost by 1/2%	62	41	9	6	55	37
Painful shock—let-go threshold, median	76	51	16	10.5	75	50
Painful and severe shock—breathing difficult, muscular control lost by 99.5%	90	60	23	15	94	63
Possible ventricular fibrillation:						
Three-second shocks	500	500	100	100		
Short shocks (T in seconds)			$165/\sqrt{T}$	$165/\sqrt{T}$		
High-voltage surges	50[b]	50[b]	13.6[b]	13.6[b]		

[a]*Deleterious Effects of Electric Shock*, Charles F. Dalziel, p. 24. Presented at a meeting of experts on electrical accidents and related matters, sponsored by the International Labour Office, World Health Office and International Electrotechnical Commission, Geneva, Switzerland, October 23–31, 1961. Reproduced by Berkeley Lab, Berkeley, California, with permission of the author.

[b]Energy in joules (watt·seconds).

8.3.2 BURNS

Burns suffered in electrical accidents are of three basic types: electrical burns, arc burns, and thermal contact burns. In electrical burns, tissue damage (whether skin deep or deeper) occurs because the body is unable to dissipate the heat from the current flow. Typically, electrical burns are slow to heal. Arc burns are caused by electric arcs and are similar to heat burns from high-temperature sources. Temperatures generated by electric arcs can melt nearby material, vaporize metal in close vicinity, and burn flesh and ignite clothing at distances up to 3 m (10 ft). Thermal contact burns are those normally experienced from skin contact with the hot surfaces of overheated electric conductors.

8.3.3 DELAYED EFFECTS

Damage to the internal tissues may not be apparent immediately after contact with the current. Delayed internal tissue swelling and irritation are possible. Prompt medical attention can help minimize these effects and avoid death or long-term injury.

8.3.4 OTHER HAZARDS

Voltage sources that do not have dangerous current capabilities may not pose serious shock or burn hazards in themselves and therefore are often treated in a casual manner. However, they are frequently used adjacent to lethal circuits, and even a minor shock could cause a worker to rebound into a lethal circuit. Such an involuntary reaction may also result in bruises, bone fractures, and even death from collisions or falls. Electricity poses other hazards. An arc is often created when a short circuit occurs or current flow is interrupted. If the current involved is strong enough, these arcs can cause injury or start a fire. Fires can also be started by overheated equipment or by conductors that carry too much current. Extremely high-energy arcs can cause an explosion that sends fragmented metal flying in all directions. Even low-energy arcs can cause violent explosions in explosive or combustible atmospheres.

8.3.5 PRINCIPLES (IMPLEMENTATION POLICY)

It is LBNL policy to follow the fundamental principles of safety described below. A clear understanding of these principles increases the safety of those who work with or around electrical equipment.

- **Practice proper housekeeping and cleanliness.** Poor housekeeping is a major factor in many accidents. A cluttered area is likely to be both unsafe and inefficient. Every employee is responsible for keeping a clean area, and every supervisor is responsible for ensuring that his or her areas of responsibility remain clean.
- **Identify hazards and anticipate problems.** Think through what might go wrong and the consequences of that action. Do not hesitate to discuss any situation or question with your supervisor and co-workers.
- **Resist "hurry-up" pressure.** Program pressures should not cause you to bypass thoughtful consideration and planned procedures.

- **Design for safety.** Consider safety to be an integral part of the design process. Protective devices, warning signs, and administrative procedures are supplements to good design—not a substitute for it. Engineering controls are always preferable to administrative controls. Completed designs should include provisions for safe maintenance.
- **Maintain for safety.** Good maintenance is essential to safe operations. Maintenance procedures and schedules for servicing and maintaining equipment and facilities, including documentation of repairs, removals, replacements, and disposals, should be established.
- **Document your work.** An up-to-date set of documentation adequate for operation, maintenance, testing, and safety should be available to anyone working on potentially hazardous equipment. Keep drawings and prints up to date. Dispose of obsolete drawings and be certain that active file drawings have the latest corrections. All facilities drawings are to be archived with the Records Analyst and Control Specialist (ext. 5259).
- **Have designs reviewed.** All systems and modifications to systems performing a safety function or controlling a potentially hazardous operation must be reviewed and approved at the level of project engineer or above.
- **Have designs and operation verified.** All systems performing safety functions or controlling a potentially hazardous operation must be validated by actual test procedures before being placed in service, at least once a year, and anytime the system is suspected of malfunction. Both the procedures and actual tests must be documented.
- **Test equipment safety.** Conduct tests with the electrical equipment de-energized, or, if the equipment cannot be de-energized, with reduced hazard.
- **Know emergency procedures.** All persons working in areas of high hazard (with high-voltage power supplies, capacitor banks, etc.) must be trained in emergency response procedures, which should include cardiopulmonary resuscitation (CPR) certification.

8.4 SAFE WORK PRACTICES

- **Beware of wet areas.** While working with liquids (e.g., washing, mopping, and spraying), exercise extra care to avoid contact with electrical outlets or devices. Cover electrical openings if liquids can penetrate them. If the openings cannot be covered, the power must be disconnected and locked. (See Chapter 18, *Lockout/Tagout.*)
- **Use electrical devices only as intended.** Electrical devices may not be modified beyond the intent of their design. Electrical equipment is only safe when it is used according to its intended purpose. Some examples of misuse of electrical equipment are:
  - Pulling out a plug by the cord rather than by the plug.
  - Inserting wires or objects other than a standard plug into a receptacle outlet.
  - Constructing home-made extension cords from standard junction boxes and receptacles (a "radar box").
  - Deforming a contact to enable it to fit a receptacle for which it was not intended.

- **Always consider electrical equipment energized unless positively proven otherwise.** When working on electrical equipment, treat the equipment as live until it is tested, locked, tagged, shorted and/or grounded, as appropriate.
- **Re-set circuit breakers only after the problem has been corrected.** When a circuit breaker or other overcurrent device trips, it is usually due to an overload or fault condition on the line. Repeated attempts to re-energize the breaker under these conditions may cause the breaker to explode. Do not attempt to re-set a circuit breaker unless the problem has first been identified and corrected or isolated.

8.5 QUALIFIED AND AUTHORIZED PERSONNEL

A **qualified person** is an individual recognized by Laboratory management as having sufficient understanding of the equipment, device, system, or facility to positively control any hazards it presents. Recognition for qualification for operating complex devices, systems, equipment and facilities, as determined by the appropriate Department Manager, should be in writing.

Only those persons who are qualified and authorized may install, fabricate, repair, test, calibrate, or modify electrical wiring, devices, systems, or equipment.

Qualification and authorization to perform electrical or electronics work is based on a combination of formal training, experience, and on-the-job training.

On-the-job training should be documented to ensure that training is consistent for all employees with similar tasks. This document should be reviewed and approved by a person knowledgeable in safe work practices and familiar with the hazards of the apparatus.

If work on energized components is anticipated, this training should cover:

- Specific operations in which live work is anticipated.
- Features of the equipment including any specialized configuration.
- Location of energy-isolating devices.
- Techniques, tools, and personal protective equipment used for this specific equipment.
- Relevant documents such as wiring diagrams, schematics, service manuals, design packages and operating, testing, and calibrating procedures.
- Systems energy control procedures, including energy-isolating devices, grounding and shorting procedures, and other energy control procedures.
- Record-keeping and logging requirements.

8.5.1 SPECIFIC QUALIFICATIONS

Only authorized Facilities Department personnel are considered by Laboratory management to be qualified to perform electrical wiring or other work directly connected to any facility electrical distribution system. This does not include the connection of cord- and plug-connected equipment into an appropriate facility receptacle, but does include permanent connections of (hard-wired) equipment to a facility system.

Only appropriately qualified persons may build, modify, or repair electronic or electrical equipment used at LBNL. Supervisors are responsible for ensuring that employees or others under their supervision are qualified. The Electrical Safety Subcommittee advises Laboratory management of qualifying criteria for various work descriptions.

8.6 ENERGIZED SYSTEMS

It is Laboratory policy to de-energize live parts, when possible, before an employee works on or near them (see Chapter 18, *Lockout/Tagout*). This is the preferred method for protecting employees from electrical hazards. Personnel are permitted to work on or near exposed live parts only if an overriding reason necessitates the practice. Overriding reasons might include situations in which de-energizing would introduce additional or increased hazards or those in which de-energizing is not feasible due to equipment design or operational limitations.

Recognizing the hazards associated with various types of electrical procedures and equipment is of paramount importance in developing and applying safety guidelines for working on energized equipment.

It is not feasible to develop a single set of safety requirements for energized work that covers every electrical task. It is the collective responsibility of worker, supervisor, and management to assure that the safeguards for a specific operation effectively protect the worker against electrical hazards.

In general, electrical work at LBNL can be organized into seven classifications, according to the degree of energy present, and three modes, according to the operational status of the equipment or system. See Tables 8.2 and 8.3.

8.6.1 MODES OF OPERATION

Mode 1 ("COLD")

All operations are conducted in a positively de-energized state. All external sources of electrical energy are disconnected by some positive action—for example, with a locked and tagged out circuit breaker—and all internal energy sources are rendered safe. See Chapter 18, *Lockout/Tagout*.

Mode 2 ("COLD to HOT")

All manipulative operations of uninsulated parts are conducted with the equipment in the positively de-energized state. When all manipulative operations are suspended, measurements and observation of equipment functions are conducted with the equipment energized and with some or all normal protective barriers removed and interlocks bypassed. Some Mode 2 examples are:

- Making connections or alterations to normally energized components.
- Working in close proximity to normally energized, exposed components.

Mode 3 ("HOT")

Manipulative operations are conducted with the equipment fully energized and with some or all normal protective barriers removed.

Mode 3 work in excess of 50 volts is a high-risk situation that is permitted only when justified. Tasks performed in this mode must be conducted under close supervision and control. Written approval of the documented justification and plan of work is frequently required.

8.7 GUIDELINES FOR SAFE WORK PRACTICES BY ENERGY LEVEL AND WORKING CONDITION

The following two tables define the classifications, minimum restrictions, and conditions for electrical work. Table 8.2 applies generally to work on utility power sources. Table 8.3 applies generally to work on power which is derived from equipment related to electronic or R&D functions.

Table 8.2. Utility Sources: Work Normally Performed by Qualified Electricians

	Voltage [a]	Current Capacity	Hazard	Remarks
Class 1A	Secondary ≤ 50 V	≤ 50 A	Low	Low-voltage control circuits
Mode 1	• A qualified person may work alone.			
Mode 2	• A qualified person may work alone.			
Mode 3	• A qualified person may work alone.			
[a]Voltage is line-to-ground or line-to-line, whichever is higher.				

	Voltage [a]	Hazard	Remarks
Class 2A	50 < V < 250	Medium	Low-voltage utility power
Mode 1	• A qualified person may work alone.		
Mode 2	• Insulated gloves and/or insulated tools and/or other insulating personal protective equipment, as appropriate to the task, are required. • Implied approval and general supervision are required.		
Mode 3	• Insulated gloves and/or insulated tools and/or other insulating personal protective equipment, as appropriate to the task, are required. • An applicable written and approved plan is required for all work. An open permit is allowed for routine maintenance and operations work. • A Safety Watch may be required when the hazard level is elevated by environmental or physical circumstances; it must be noted on the written work approval. • Specific approval from a lead electrician or supervisor is required. Implied approval is acceptable for routine maintenance and operations work. • Access must be restricted by ropes, barriers, or other means to exclude unauthorized personnel.		
[a]Voltage is line-to-ground or line-to-line, whichever is higher.			

Table 8.2. (Continued)

	Voltage[a]	Hazard	Remarks
Class 3A	250 < V < 600	High	Medium-power utility (< 600 V)
Mode 1	• At least two qualified persons must be present until it has been clearly verified that the equipment has been de-energized. Then, one qualified person may work alone.		
Mode 2	• While equipment is energized, at least two qualified persons must be present throughout the Mode 2 operation. • Insulated gloves and/or insulated tools and/or other insulating personal protective equipment, as appropriate to the task, are required. • Implied approval and general supervision are required		
Mode 3	• At least two qualified persons are required. One is a Safety Watch, stationed outside normal protective barriers and in continuous sight and sound communication with the worker(s). • Insulated gloves and/or insulated tools and/or other insulating personal protective equipment, as appropriate to the task, are required. • An applicable written and approved plan is required for all work. Specific approval from a lead electrician or supervisor is also required. Implied approval is acceptable for routine maintenance and operations work. • Access must be restricted by ropes, barriers, or other means to exclude unauthorized personnel.		

[a]Voltage is line-to-ground or line-to-line, whichever is higher.

Table 8.2. (Continued)

	Voltage[a]	Hazard	Remarks
Class 4A	≥ 600 V	Extreme	High-power utility
Mode 1	• At least two qualified persons must be present until it has been clearly verified that the equipment has been de-energized. Then, one qualified person may work alone. • Workers must wear eye protection, use insulated tools or insulated gloves, and use an insulating floor mat. All equipment must be rated for use with the expected hazards.		
Mode 2	• At least two qualified persons are required. One is a Safety Watch, stationed outside normal protective barriers and within continuous sight and sound communication with the worker(s). The Safety Watch must not be distracted from this assignment at any time. • Insulated gloves and/or insulated tools and/or other insulating personal protective equipment, as appropriate to the task, are required. • Implied approval and general supervision must exist.		
Mode 3	• LBNL personnel must not work on Class 4A equipment in Mode 3, except for certain testing procedures performed under a Facilities Department Switching Tag. • Insulated gloves and/or insulated tools and/or other insulating personal protective equipment, as appropriate to the task, are required. • Only commercial power utility personnel or their subcontractors will work on energized Class 4 equipment, and they will follow their own procedures. • Access must be restricted by ropes, barriers, or other means to exclude unauthorized personnel.		

[a]Voltage is line-to-ground or line-to-line, whichever is higher.

Table 8.3. R&D Electronic/Electrical: Work Performed by Electronics Technicians or Other Qualified Personnel

	Voltage[a]		Current Capacity	Hazard	Remarks
	Primary < 150 V rms		Primary ≤ 20 A	Low	See Class 1A requirements
Class 1B	and	Secondary ≤ 50 V	≤ 100 A		Low voltage, low power
	or	Secondary > 50 V	≤ 5 mA		High voltage, very low current
	and	≤ 5 J stored energy			
Mode 1	• A qualified person may work alone.				
Mode 2	• A qualified person may work alone. • Work on primary side of transformer must be performed according to utility power requirements.				
Mode 3	• If exposed voltages are less than 50 V differential or to ground, a qualified person can work alone with implied approval and general supervision. • Otherwise, a qualified worker with implied approval and general supervision, must be in the presence of a required Safety Watch—another individual who can provide or summon assistance.				

[a]Voltage is line-to-ground or line-to-line, whichever is higher.

		Voltage[a]	Current Capacity	Hazard	Remarks
	any	≤ 50 V	> 100 A	Medium	Low voltage, high current
Class 2B	of	50 < V ≤ 250	> 5 mA		Medium to high voltage and medium current
	these	V > 250	I ≤ 500 W/V		
Mode 1	• One qualified person may work alone.				
Mode 2	• At least two qualified persons must be present with implied approval and general supervision. • Insulated gloves and/or insulated tools and/or other insulating personal protective equipment, as appropriate to the task, are required.				
Mode 3	• At least two qualified persons, including the worker, must be in continuous sight and sound communication. • Insulated gloves and/or insulated tools and/or other insulating personal protective equipment, as appropriate to the task, are required. • A written procedure must describe how the work is to be accomplished safely and why the work must be done with energized equipment. The work supervisor must sign the procedure and provide general supervision. • Access must be restricted by ropes, barriers, or other means to exclude unauthorized personnel.				

[a]Voltage is line-to-ground or line-to-line, whichever is higher.

Table 8.3. (Continued)

	Voltage[a]	Current Capacity	Hazard	Remarks
Class 3B	> 250 V	I > 500 W/V	High	DANGER
	>5 J stored energy			
Mode 1	• At least two qualified persons must be present until it has been clearly verified that the equipment has been de-energized. Then, one qualified person may work alone.			
Mode 2	• Implied approval and general supervision are required. • Insulated gloves and/or insulated tools and/or other insulating personal protective equipment, as appropriate to the task, are required. • At least two qualified persons are required, one as a Safety Watch, stationed outside normal protective barriers and in continuous sight and sound communication with the worker(s). The Safety Watch shall not be distracted from this assignment at any time.			
Mode 3	• A written procedure must describe how the work is to be accomplished safely and why the work must be done with the equipment energized. The work supervisor must sign the procedure and provide general supervision. • Insulated gloves and/or insulated tools and/or other insulating personal protective equipment, as appropriate to the task, are required. • Access must be restricted by ropes, barriers, or other means to exclude unauthorized personnel.			

[a]Voltage is line-to-ground or line-to-line, whichever is higher.

8.8 AUTHORIZATION

All energized electrical work above 50 volts in Mode 3 requires advance written supervisory authorization. (See sample sign-off sheet in the Appendix.) In the case of recurrent activities, such as maintenance, an open authorization may be used. In this case, a written record must be made of the open authorization, and the worker must understand the specific circumstances under which the energized work is permitted. Such circumstances may include verbal confirmation of each task.

If circumstances dictate that written authorization cannot be obtained, such as during off-shift hours, the work may proceed with verbal authorization from the cognizant supervisor. This authorization should be transcribed to a sign-off sheet as soon as practicable.

8.9 FABRICATION AND MAINTENANCE PRACTICES

Design and construct equipment to protect personnel. First-line and backup safeguards should be provided to prevent personnel from accessing energized circuits. Establish periodic tests to verify that these protective systems are operative.

8.9.1 EQUIPMENT ACCEPTABILITY

Electrical equipment is considered safe only when it is used as specifically intended by its listing and design. Equipment must not be altered beyond the original design intent and must not be used for any purpose other than that for which it was constructed.

Any equipment that is being re-commissioned must be examined and/or tested, as appropriate, to verify the status of all safety features and the integrity of construction.

Electrical equipment must be listed or labeled by a Nationally Recognized Testing Laboratory (NRTL). An NRTL is recognized by OSHA as being capable of independently assessing equipment for compliance to safety requirements and applicable standards. As of this printing, OSHA has accredited the following organizations:

- Canadian Standards Association (CSA).
  NOTE: CSA acceptance is limited to a range of specific products which conform to U.S. standards.
- Communication Certification Laboratories (CCL).
- ETL Testing Laboratories, Inc. (ETL).
- Factory Mutual Research Corporation (FMRC).
- MET Laboratories, Inc. (MET).
- Southwest Research Institute (SWRI).
- Underwriters Laboratories, Inc. (UL).
- United States Testing Company, Inc. California Division (UST/CA).
- Wyle Laboratories.

EXCEPTION: With respect to equipment for which no NRTL acceptance exists, such as custom-made equipment, the following alternate methods of ensuring the safety of the product are acceptable:

- The product must be designed and constructed according to applicable ANSI, UL, NEMA, and/or IEEE standards.
- The division responsible for the equipment must maintain all documentation pertaining to the design safety features of the equipment, including any test data. This documentation must be available to any safety inspector.
- The inspector may require that equipment that is not NRTL-listed undergo inspection and/or testing for conformance to standards. Such testing should be documented and submitted to EH&S for approval. The inspection record must specify, at minimum:
  - Equipment identification.
  - Evaluator name, date, mailstop, and extension.
  - Standard to which equipment is being evaluated.

- Specific tests, results, and areas of examination.
- Any conditions of product acceptability or limitations of use.

8.9.2 EQUIPMENT SAFETY PRACTICES

Cable Clamping

A suitable mechanical-strain-relief device such as a cord grip, cable clamp, or plug **must** be used for any wire or cable penetrating an enclosure where external movement or force can exert stress on the internal connection. Grommets, adlets, or similar devices **must not** be used as strain relief.

Emergency Lighting

Make emergency lighting available in case normal lighting fails when work is being conducted on energized components. (Emergency lighting is not necessary for 1A and 1B work. See Tables 8.2 and 8.3.)

Flammable and Toxic Material Control

Keep the use of flammable or toxic material to a minimum. A catch basin or other approved method must be provided to prevent the spread of these materials should the normal component case fail.

Isolation

Isolate all sources of dangerous voltage and current with covers and enclosures. Access to lethal circuits (>50 V) must be either via screw-on panels (each containing no fewer than four screws or bolts) or via interlocked doors, panels, covers, etc. The frame or chassis of the conductive enclosure must be connected to a good electrical ground with a conductor capable of handling any potential fault current.

Lighting

Provide adequate lighting for easy visual inspection.

Disconnecting Means and Overload Protection

Provide overload protection and well-marked disconnects. Local "off" controls must be provided on remote-controlled equipment.

All disconnects and breakers must be clearly labeled to identify the loads they control.

Power

All ac and dc power cabling to equipment not having a separate external ground but having line-to-line or line-to-ground voltage of 50 V or more must carry an equipment grounding conductor unless cabling is inside an interlocked enclosure, rack, grounded wireway, or conduit or feeds a commercial double-insulated or UL-listed ungrounded device. If the grounding of equipment introduces a greater hazard, the equipment must not be grounded.

Rating

Operate all conductors, switches, resistors, etc., within their design capabilities. Pulsed equipment must not exceed either the average, the rms, or the peak rating of components. The equipment must be derated as necessary for the environment and the application of the components.

Safety Grounding of Capacitive Components

Use automatic-discharge devices on equipment with stored energy of 5 J or more. Suitable and visible manual-grounding devices must also be provided to short-to-ground all dangerous equipment while work is being performed.

Electrical Equipment Rooms

Place an identifying label or sign on the door when equipment that may require servicing, manipulation, or inspection is concealed in an equipment closet or otherwise is obscured behind doors or panels.

Re-Use of Circuit Breakers

Do not purchase used or reconditioned circuit breakers from vendors outside LBNL. Re-use of LBNL circuit breakers is permitted only after the circuit breaker has been tested by the Electric Shop.

8.9.3 ENCLOSURES

The following specifications apply to circuits operating at 50 V or more or storing more than 5 J. An enclosure may be a room, a barricaded area, or an equipment cabinet.

Access

Interlock easily opened doors, hinged panels, etc. that allow ready access to exposed energized components so that the act of opening de-energizes the circuit. Automatic discharge of stored-energy devices must be provided. See the section *Large Capacitor Hazards* in this chapter.

Doors should be key-locked, and the same key should also be used for the locks in the control-circuit interlock chain, if applicable. This key must not be able to be removed from the door unless the door is closed and locked.

Heat

Mount heat-generating components, such as resistors, so that heat is safely dissipated and does not affect adjacent components.

Isolation

Ensure that the enclosure physically prevents contact with live circuits. The enclosure can be constructed of conductive or nonconductive material. If conductive, the material must be electrically bonded and connected to a good electrical ground. These connections must be adequate to carry all potential fault currents.

Seismic Safety

Secure all racks, cabinets, chassis, and auxiliary equipment against movement during earthquakes. (See Chapter 23, *Seismic Safety*.)

Strength

Ensure that enclosures are strong enough to contain flying debris caused by component failure.

Temporary Enclosure

Temporary enclosures (of less than six-month duration) not conforming to the normal requirements may be used but must be considered Mode 3 hazards.

Ventilation

Ensure that ventilation is adequate to prevent overheated equipment and to purge toxic fumes produced by an equipment fault. Ventilation openings must not be obstructed.

Visibility

Ensure that enclosures large enough to be occupied by personnel allow exterior observation of equipment and personnel working inside the enclosure.

Warning Indicators

When systems other than conventional facilities represent Class 4A or 3B hazards (see Tables 8.2 and 8.3), provide those systems with at least one of these safety measures:

- A conspicuous visual indicator that is clearly visible from any point where a person might make hazardous contact or entry.
- A clearly visible primary circuit breaker or "off" control button on the front of the enclosure.

Be aware, however, that industrial systems may vary from these standards.

8.9.4 CLEARANCE AROUND ELECTRICAL EQUIPMENT

Maintain clearance space around power and lighting circuit breaker panels, motor controllers, and other electrical equipment. This clearance space ensures safe access for personnel who inspect, adjust, maintain, or modify energized equipment.

For equipment operating at 600 V (nominal) or less, the minimum required clearance is an unobstructed space 76 cm (30 in.) wide, 91 cm (36 in.) deep, and 198 cm (78 in.) high (measured from the floor). Some installations may require greater clearances.

Clearance space must not be used for storage or occupied by bookcases, desks, workbenches, or similar items.

Clearance space is not required for wall switches, disconnect switches, Ramos-box-type combination multiple circuit breaker/outlet receptacle assemblies, and similar electrical equipment if:

- Equipment can be positively de-energized for inspection, adjustment, or maintenance using approved lockout/tagout procedures, and
- Readily accessible space is maintained around such equipment at all times.

Readily accessible space enables an employee to quickly and effectively operate any circuit breaker handle or switch toggle, insert or remove any connector, or perform any similar act associated with the equipment without moving apparatus, climbing, or resorting to a ladder.

Some Laboratory buildings, because of their age, have power and lighting circuit breaker panels that were installed prior to present working clearance codes and regulations. These installations may be acceptable, but must be evaluated to determine whether additional safety measures are necessary. The division occupying the building space should contact the EH&S Electrical Safety Engineer for evaluation.

If a reduction in clearance is granted, the AHJ must attach a sign to the equipment indicating, at minimum:

- Any special conditions on which the acceptance is based, such as:
  - Working conditions
  - De-energization
  - Lighting

- The new clearance dimensions.

8.9.5 FLEXIBLE CORDS

This instruction covers use of flexible cord as a wiring method and cord-and-plug assemblies that provide ac power for machines, laboratory equipment, and other scientific research apparatus. Because cord and plug connections are generally well understood, this instruction does not cover portable hand-operated power tools, small kitchen appliances, office equipment, electronic instruments, personal computers, and other similar equipment.

Allowed Uses

Flexible cords and cables may be used for:

1. Pendants.
2. Wiring of fixtures.
3. Connections of portable lamps or appliances.
4. Elevator cables.
5. Crane and hoist wiring.
6. Connecting stationary equipment that requires frequent interchange.
7. Preventing transmission of noise or vibration.
8. An appliance or equipment with fastenings and mechanical connections specifically designed to permit removal for maintenance and repair and intended or identified for flexible cord connection.
9. Power cables (ac) for data processing equipment as permitted by NEC Article 645-5.
10. Connecting moving parts.

When flexible cords and cables are used in conditions 3, 6, or 8, above, they must be equipped with an approved attachment plug and energized from a receptacle outlet. Only qualified persons may install cord caps on cords.

Flexible cord and cable, attachment plugs, and receptacles must be of the proper type, size, and voltage and current rating for the intended application.

Branch circuits that feed cord-and-plug connected equipment must be designed in accordance with NEC Article 210, have overcurrent protection in accordance with NEC Article 240, and be properly grounded in accordance with NEC Article 250.

All cord- and plug-connected equipment must be grounded with a correctly sized and identified equipment grounding conductor that is an integral part of the ac power cord or cable. Exception: Listed equipment that is protected by a double insulation system or its equivalent.

It is LBNL policy to allow cord and plug connection of equipment that operates at 250 V or less and has a maximum circuit rating of 30 A. Any equipment operating at higher voltages or currents should be permanently connected. If a higher voltage or current cord and plug connection is desired, contact EH&S Electrical Safety (ext. 7067) for requirements and guidelines.

Forbidden Uses of Flexible Cables

Article 400-8 of the NEC forbids flexible cord and cable to be:

- Substituted for the fixed wiring of a structure.
- Run through holes in walls, ceilings, or floors.
- Run through doorways, windows, or similar openings.
- Attached to building surfaces.
- Concealed behind building walls, ceilings, or floors.
- Installed in electrical raceways, unless specifically allowed by NEC provisions covering electrical raceways.

Except for the temporary wiring provisions of NEC Article 305, the NEC does not allow the cord-and-plug connection of equipment to be energized from extension cords. Extension cords are not legal substitutes for the fixed wiring of a structure such as a receptacle outlet.

In industrial locations, a suitable guard or cover must protect the interface between attachment plug and receptacle from intrusion of process waste or other foreign material.

8.9.6 EXTENSION CORDS

Extension cords provide a convenient method of bringing ac power to a device that is not located near a power source. They are used as temporary power sources.

Extension cords are probably involved in more electrical code and safety violations than any other device at the Laboratory. They are stepped on, stretched, cut, overloaded, and, in general, used improperly.

Guidelines for the Safe Use of Extension Cords

- Use only approved and properly maintained extension cords that have no exposed live parts, exposed ungrounded metal parts, damage, or splices.

- Use only heavy-duty or extra-heavy-duty rated cable.
- Use extension cords that are protected by a ground fault circuit interrupter (GFCI) around construction sites, in damp areas, or in an area where a person may be in direct contact with a solidly grounded conductive object (e.g., working in a vacuum tank). The GFCI can consist of a special circuit breaker, a GFCI outlet, or an extension cord with a built-in GFCI.
- Ensure that the extension cord is of sufficient current-carrying capacity to power the device. Use of an undersized cord results in an overheated cord and insufficient voltage delivered to the device, thus causing device or cord failure and a fire hazard.
- Always use three-conductor (grounded) extension cords—even if the device has a two-conductor cord. Never use two-conductor extension cords at the Laboratory.

Avoiding Misuse of Extension Cords

Observe the following restrictions to avoid misuse of extension cords:

- Do not use extension cords in place of permanent facility wiring.
- Avoid running extension cords through doors, ceilings, windows, or holes in the walls. If it is necessary to run a cord through a doorway for short term use, ensure that the cord is:
  - Protected from damage.
  - Removed immediately when no longer in use.
  - Not a tripping hazard.
- Do not daisy chain extension cords (i.e., plug one extension cord into another extension cord).
- Do not overload extension cords. Make sure that the wire size is sufficient for the current required.
- Do not cut off the ground pin of an extension cord or compromise the ground protection in any way.
- Do not use extension cords with a ground conductor that has less current-carrying capacity than the other conductors.
- Do not use frayed or damaged extension cords.
- Never splice extension cords, even for a repair. If an extension cord is damaged, it may be made into two cords, provided the proper connectors are used in a proper manner. Only qualified personnel may install cord caps for use with potentials greater than 50 V.
- Only qualified personnel may make repairs of extension cords.

Acceptable Combinations

There are very few acceptable combinations of extension cords and devices. Some acceptable combinations are:

- Extension cord to device (electrical utilization equipment).
- Power strip to device.
- Surge protector (with cord) to device.
- Direct surge protector to extension cord to device.
- Direct surge protector to power strip to device.

The following four conditions are not recommended, but will be accepted to provide power to personal computer systems when there is no other reasonable way to do so. Only one extension cord will be allowed in each configuration. The conditions are:

- Power strip (with overcurrent protection) to extension cord (single outlet) to device.
- Extension cord (single outlet) to power strip (overcurrent protection) to device.
- Direct surge protector to power strip (overcurrent protection) to extension cord (single outlet) to device.
- Direct surge protector to extension cord (single outlet) to power strip (overcurrent protection) to device.

8.9.7 POWER STRIPS

A power strip is a variation of an extension cord, where the cord terminates in a row or grouping of receptacles. Power strips are commonly used in offices to provide multiple receptacles to office equipment. In general, all rules pertaining to extension cords also apply to power strips.

Additional considerations are:

- Only use approved LBNL Stores items. The presence of a UL (or other NRTL) label does not necessarily mean the device is approved for LBNL usage.
- Do not permanently mount power strips to any facility surface. Power strips are classified as temporary devices. It is acceptable to hang them from screws or hooks if they are manufactured with slots or keyholes.
- In equipment racks, the preferred method of supplying 120/208-V utility power to rack-mounted instruments is via a special power strip specifically designed to be rack-installed.

8.9.8 GROUND FAULT CIRCUIT INTERRUPTERS (GFCIs)

GFCIs are designed to protect a person from electric shock when he or she simultaneously contacts a "live" (usually 120 V) wire or part and a grounded object. The GFCI works by sensing a difference between the supply and return currents. When the difference exceeds 5 mA—indicating that current is flowing to ground (through the person)—the device switches off.

Although the GFCI is an effective safety device, it is not a guarantee against shock in every situation. The GFCI does not protect against a line-to-neutral or a line-to-line shock. Also, if GFCI-protected equipment contains transformers, a ground fault (shock) on the secondary side of the transformer may not trip the GFCI.

GFCIs are normally installed as either circuit breakers or receptacles. In either case, the GFCI may be wired to protect multiple receptacles. Individual GFCI plug-in adapters are also available.

LBNL requires GFCI protection for the following conditions:

1. Any 120-V convenience outlet located within 2 m (6 ft) of a sink.

2. Any 120-V convenience outlet located outdoors.

3. Any 120-V convenience outlet located within 2 m (6 ft) of a "massive ground." (A massive ground is a large area of metal, wet earth, or other highly conductive surface that enhances the conductivity to ground of the person touching it.)

4. Any extension cord providing power for construction activities.

5. Any resistance heating equipment not having a metal covering, such as heating tapes.

It is LBNL policy to implement the GFCI requirements in conditions 1, 2, and 3 above on a phase-in basis. Any new or remodel construction will include the GFCIs as specified. Existing locations should be prioritized for retrofitting according to relative risk. For example, locations near sinks with heavy electrical use should be retrofitted immediately with GFCI protection.

GFCIs must be tested at least at 30-day intervals. Push the "test" button and observe the "reset" button pop out and the receptacle turn off. If this does not happen, the GFCI is not functional and must be replaced.

CAUTION: Testing of a GFCI will disconnect **all** receptacles protected by the GFCI. Before testing, determine which receptacles are protected. Verify that the interruption of power will not adversely affect other activities.

8.9.9 PORTABLE WORKBENCHES

This section covers laboratory and shop workbenches that can be moved by sliding, rolling, etc. It does not cover built-in workbench assemblies that are permanently attached to structure surfaces. Such built-in assemblies must use appropriate fixed-wiring methods to provide power for receptacles, lighting fixtures, ventilation fans, etc., as described in Chapter 3 of the NEC.

Flexible cord and plug assemblies may be used to provide ac power to portable workbenches only when:

- The branch circuit voltage supplying the workbench is 150 V or less.
- The overcurrent protection device rating on the branch circuit supplying the workbench is 20 A or less.
- The flexible cord is no longer than 4.5 m (15 ft), is attached to the workbench with an approved tapered rubber bushing cord grip fitting, is no smaller than #14 AWG, is type-listed under NEC Article 400 as "Extra Hard Usage" (Type SO, G, W, etc.), is protected from physical damage, is routed to prevent tripping hazards, and is terminated in a Listed attachment plug and mating receptacle interface that has the proper voltage and current rating for the branch circuit feeding the workbench.
- Each workbench has its own cord, attachment plug, and branch circuit receptacle. Workbenches must not be parallel fed or daisy chained by plugging their power cords into a receptacle located on another workbench.
- Each workbench wiring system has equipment grounding protection that consists of a correctly sized and identified equipment grounding conductor. This grounding conductor must be an integral part of the flexible cord. Grounding circuit continuity must be provided by the branch circuit wiring feeding the workbench and at the interface between attachment plug and receptacle.
- All metal surfaces of the workbench assembly that are likely to become energized by an electrical fault are properly bonded to the equipment grounding conductor in accordance with NEC Article 250.
- The number of workbench receptacle outlets is limited to no more than 10 duplex receptacles or 3 linear meters (10 linear ft) of wire mold plug strip on a 15-A branch circuit, or 13 duplex receptacles or 4 linear meters (13 linear ft) of an approved multi-outlet assembly on a 20-A branch circuit. In any case, the continuous load fed by the workbench outlet receptacles must not exceed 80% of the rating of the branch circuit that feeds the workbench.
- Each workbench has proper seismic anchoring or other restraint against unintentional movement so that the cord-and-plug AC input power assembly is protected from damage resulting from tension, pinching, crushing, etc. (See Chapter 23, *Seismic Safety*.)
- If the bench is fitted with a metallic or otherwise conductive work surface, the workbench wiring system is protected by an approved GFCI.

8.9.10 NON-COMBUSTIBLE INSULATED ELECTRICAL CABLE

DOE and NFPA 70, the National Electrical Code, require the use of flame retardant electrical cables in buildings. Specifically, cables installed in open cable trays, in building vertical shafts (risers), and in air plenums must have a flame retardant outer jacket.

The extra-flexible cables AWG #2 and AWG #12 with the transparent covers designed for use with ground hooks (Stock Nos. 6145-51726 and 6145-71376, respectively) are not rated for use in plenums, risers, or trays.

All Laboratory research divisions and support groups are responsible for ensuring that properly rated and listed cables are used in installations where the cable is exposed in cable trays, air plenums, building risers, or in experimental areas. For assistance in determining the correct type of cable to use in wiring buildings, contact Facilities (ext. 5220). For assistance with the wiring of research equipment, contact Electronics Engineering (ext. 6287).

8.9.11 POWER SUPPLIES

Primary Disconnect

Provide a lockable means of positively disconnecting the input on large power supplies (most Class 2A-, 3A-, and 3B-rated units—see Tables 8.2 and 8.3). This disconnect must be clearly marked and accessible.

If provided with a built-in lock that is part of an interlock chain, the key must not be removable unless the switch or breaker is in the "off" position.

Overload Protection

Overload protection must be provided on the input and should be provided on the output.

8.9.12 FLOATING POWER SUPPLIES

Some research equipment (e.g., electrophoresis devices, x-ray tubes, and ion-bombardment power supplies) employs ungrounded (floating) power supplies. This equipment may operate in voltages ranging from 50 V to kilovolts with output capacities in excess of 50 mA and must be considered a lethal electrical hazard. Users of such equipment must take special precautions to minimize electrical hazards. Follow all manufacturers instructions for equipment use, testing, and training. The following general guidelines also apply:

- Locate equipment away from water and large metal areas.
- Do not use connectors and jack fittings that allow accidental skin contact with energized parts.
- Interlock readily accessible enclosures.
- Use non-metallic secondary containment if liquids or gels are involved.
- Verify the power supply is floating when commissioning and recommissioning the equipment and at least once a year.

8.9.13 LARGE-CAPACITOR HAZARDS

This section describes the hazards associated with capacitors capable of storing more than 5 J of energy.

Capacitors may store hazardous energy even after the equipment has been de-energized and may build up a dangerous residual charge without an external source. "Grounding" capacitors in series, for example, may transfer rather than discharge the stored energy. Another hazard exists when a capacitor is subjected to high currents that may cause heating and explosion.

Capacitors may be used to store large amounts of energy. An internal failure of one capacitor in a bank frequently results in an explosion when all other capacitors in the bank discharge into the fault. The threshold energy for explosive failure of metal cans is approximately 10^4 J.

High-voltage cables should be treated as capacitors because they have capacitance and thus can store energy.

The liquid dielectric in many capacitors, or its combustion products, may be toxic.

Safety Practices for Capacitors

• Automatic Discharge

Use permanently connected bleeder resistors when practical. Capacitors in series should have separate bleeders. Automatic-shorting devices that operate when the equipment is de-energized or the enclosure is opened must be used. The time required for a capacitor to discharge to safe voltage (50 V or less) must not be greater than the time needed for personnel to gain access to the voltage terminals. In no case must it be longer than 5 min.

In the case of equipment with stored energy in excess of 5 J, an automatic, mechanical-discharging device must be provided that functions when normal access ports are opened.

This device must be contained locally within a protective barrier to ensure wiring integrity and should be in plain view of the person entering the protective barrier so that the individual can verify its proper functioning. Protection also must be provided against the hazard of the discharge itself.

• Safety Grounding

Provide fully visible, manual-grounding devices to render the capacitors safe while they are being worked on. Clearly mark grounding points and use caution to prevent transferring charges to other capacitors.

• Ground Hooks

All ground hooks must:

- Have crimped and soldered conductors.
- Be connected such that impedance is less than 0.1 Ω to ground.
- Have the cable conductor clearly visible through its insulation.

- Have a cable conductor size of at least #2 extra flexible, or in special conditions a conductor capable of carrying any potential current.
- Be in sufficient number to conveniently and adequately ground all designated points.
- Be grounded and stored in the immediate area of the equipment in a manner that ensures they are used.

In equipment with stored energy in excess of 5 J, a discharge point with an impedance capable of limiting the current to 500 A or less should be provided. This discharge point must be identified with a yellow circular marker with a red slash and must be labeled "HI Z PT" in large, readable letters. A properly installed grounding hook must first be connected to the current-limiting discharge point and then to a low-impedance discharge point (less than 0.1 Ω) that is identified by a yellow circular marker. The grounding hooks must be left on all of these low-impedance points during the time of safe access. The low-impedance points must be provided, whether or not the HI-Z current-limiting points are needed. Voltage indicators that are visible from all normal entry points should also be provided.

- **Fusing**

Capacitors used in parallel should be individually fused when possible to prevent the stored energy from dumping into a faulted capacitor. Care must be taken in placement of automatic-discharge safety devices with respect to fuses. If the discharge will flow through the fuses, a prominent warning sign must be placed at each entry indicating that each capacitor must be manually grounded before work can begin. Demonstrated experience and/or engineering training is required for high voltage or high energy capacitor fusing. It is the responsibility of the cognizant supervisor to determine the level of qualification necessary for any particular task.

- **Unused Terminal Shorting**

Terminals of all unused capacitors representing a hazard or capable of storing 5 J or more must be visibly shorted.

8.9.14 INDUCTOR AND MAGNET HAZARDS

This section describes inductors and magnets that can store more than 5 J of energy or that operate at 50 V or more. The following are some hazards peculiar to inductors and magnets:

- The ability of an inductor to release stored energy at a much higher voltage than that used to charge it.
- Stray magnetic fields that attract magnetic materials.
- Time-varying stray fields that induce eddy currents in conductive material thereby causing heating and mechanical stress.
- Time-varying magnetic fields that may induce unwanted voltages at inductor or magnet terminals.

Safety Practices

- **Automatic Discharge.** Use freewheeling diodes, varistors, thyrites, or other automatic shorting devices to provide a current path when excitation is interrupted.
- **Connections.** Pay particular attention to connections in the current path of inductive circuits. Poor connections may cause destructive arcing.
- **Cooling.** Many inductors and magnets are liquid-cooled. The unit should be protected by thermal interlocks on the outlet of each parallel coolant path, and a flow interlock should be included for each device.
- **Eddy Currents.** Units with pulsed or varying fields must have a minimum of eddy-current circuits. If large eddy-current circuits are unavoidable, they should be mechanically secure and able to safely dissipate any heat produced.
- **Grounding.** Ground the frames and cores of magnets, transformers, and inductors.
- **Rotating Electrical Machinery.** Beware of the hazards of residual voltages that exist until rotating electrical equipment comes to a full stop.

8.10 CONTROL AND INSTRUMENTATION

Proper philosophy is vital to the safe design of most control applications. The following checklist should be used as a guide.

- **Checkout.** Check interlock chains for proper operation after installation, after any modification, and during periodic routine testing.
- **Fail-safe design.** Design all control circuits to be "fail-safe." Starting with a breaker or fuse, the circuit should go through all the interlocks in series to momentary on-off switches that energize and "seal in" a control relay. Any open circuit or short circuit will de-energize the control circuit and must be reset by overt act.
- **Interlock Bypass Safeguards.** Establish a systematic procedure for temporarily bypassing interlocks. Follow-up procedure should be included to ensure removal of the bypass as soon as possible. When many control-circuit points are available at one location, the bypassing should be made through the normally open contacts of relays provided for this purpose. In an emergency, these relays can be opened from a remote control area.
- **Isolation.** Isolate control power from higher power circuits by transformers, contactors, or other means. Control power should be not more than 120 V, ac or dc. All circuits should use the same phase or polarity so that no hazardous additive voltages are present between control circuits or in any interconnect system. Control-circuit currents should not exceed 5 A.
- **Lock-out.** Use a keyed switch in interlock chains to provide positive control of circuit use. To ensure power removal before anyone enters the enclosure, this same key should also be used to gain access to the controlled equipment.

- **Motor Control Circuits** Motor circuits must have a positive disconnect within view of the motor or, if this is not practical, a disconnect that can be locked open by the person working on these motor circuits.
- **Overvoltage Protection.** Control and instrumentation circuits used with high-voltage equipment must have provision for shorting fault-induced high voltages to ground. High-voltage fuses with a high-current, low-voltage spark gap downstream from the high-voltage source are recommended. This also applies to all circuits penetrating high-voltage enclosures.
- **Voltage Divider Protection.** The output of voltage dividers used with high voltages must be protected from overvoltage-to-ground within the high-voltage area by spark gaps, neon bulbs, or other appropriate means.
- **Current Monitors.** Measure currents with a shunt that has one side grounded or with current transformers that must be either loaded or shorted at all times.
- **Instrument Accuracy.** Check instrumentation for function and calibration on a routine basis.

8.11 RESPONSIBLE PARTIES

The Electrical Safety Program is the responsibility of:

- Environment, Health & Safety Division (EH&S).
- Electrical Safety Engineer.
- Facilities Department.
- Engineering Division.
- Electrical Safety Subcommittee.
- Division Directors.
- Supervisors.
- Individual employees.

8.11.1 ELECTRICAL SAFETY SUBCOMMITTEE

The Electrical Safety Subcommittee is a Subcommittee of the LBNL Safety Review Committee. As such, the Electrical Safety Subcommittee may be requested to review questions of safety policy and to make recommendations to the Safety Review Committee, the Director of EH&S, or the Deputy Laboratory Director for Operations , as appropriate. The Subcommittee may be requested to review electrical and electronic equipment and their installations at LBNL from the standpoint of personnel and equipment safety.

8.11.2 DIVISION DIRECTORS

Division Directors, by virtue of the delegation of responsibility for all aspects of occupational health and safety through line management, are responsible to the Laboratory Director for assuring compliance with all electrical safety requirements pertaining to all programs, activities, and facilities within their respective divisions or areas of responsibility.

8.11.3 SUPERVISORS

Each employee functioning in a supervisory capacity has specific safety responsibilities. He or she must:

- Develop an attitude and awareness of safety in those being supervised and ensure that individual safety policies are fully carried out.
- Maintain a safe work environment and take corrective action on any potentially hazardous operation or condition.
- Ensure that supervised personnel are knowledgeable and trained in the tasks they are performing.

8.11.4 EMPLOYEES

Individual employees are responsible for their own and their coworkers' safety. Each must:

- Become acquainted with all potential hazards in the area in which they work.
- Learn and follow the appropriate standards, procedures, and hazard control methods.
- Never undertake a potentially hazardous operation without consulting with an appropriate supervisor. Stop any operation believed to be hazardous.
- Notify a supervisor of any condition or behavior that poses a potential hazard.
- Wear and use appropriate personal protective equipment.
- Immediately report any occupational injury or illness to the Medical Department and the appropriate supervisor.

8.12 TRAINING

- LBNL course *Lock Out /Tagout Training* (EHS-256 or -257) is required for anyone who will perform maintenance on equipment that poses a hazard if accidentally energized.
- LBNL courses *CPR* (EHS-123) and *First Aid* (EHS-116) are required for all persons working in high-hazard areas and for persons serving as a Required Safety Watch.
- LBNL course *Electrical Self-Assessment Training* (EHS-261) is optional.
- Various levels of electrical safety training are offered by the Laboratory on an as-need basis. Training is being developed that will be available to affected employees on a regular basis.

8.13 STANDARDS

- 29 CFR Part 1910, *Occupational Safety and Health Standards,* Department of Labor
- 29 CFR Part 1926, *Safety and Health Regulations for Construction,* Department of Labor
- California Code of Regulations, Title 24, Part 3, *California Electrical Code*
- NFPA 70, *National Electrical Code*, 1993
- NFPA 70E, *Electrical Safety Requirements for Employee Workplaces*
- NFPA 101, *Life Safety Code*

8.14 APPENDICES

Appendix A. Sample Sign-Off Sheet for Working on Energized Electrical Equipment

APPENDIX A

Sign-Off Sheet For Work On Energized Electrical Equipment

Engineering order or work request number: ______________________________

Name and location of equipment: ______________________________

____

Reason for electrical equipment to remain energized: ______________________________

____

Work to be performed on equipment (brief outline of method, including safety items):

____

____

____

____

____

Work scheduled:

	______________ Date	______________ Time
Signed by:	______________ Person-in-Charge	______________ Date
	______________ 1. Qualified person performing work	______________ Date
	______________ 2. Qualified person performing work	______________ Date

Chapter 9

EMERGENCY MANAGEMENT

Revised December 1997

Reviewed by: ______ 12/10/97
Date

Approved by: D. C. McGraw 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 9

EMERGENCY MANAGEMENT

9.1 POLICY

During all emergencies, Lawrence Berkeley National Laboratory (LBNL) policy requires that an organized effort be made to protect personnel from injury and minimize damage to property and the environment. All Laboratory resources can be made available to respond to an emergency.

9.2 SCOPE

This policy applies to:

- All Laboratory employees
- Guests
- Contractors

9.3 MASTER EMERGENCY PLAN

The LBNL Master Emergency Plan, PUB-533, provides a detailed description of the Emergency Management Program and includes information on the emergency response organization. Also covered are drills and exercises, off-site interface, communications, recovery, emergency public information, emergency facilities and equipment, training, and administration of the program.

9.4 EMERGENCY COMMAND CENTER

The primary Emergency Command Center is located in the Fire House (Building 48). The training room (109) contains the necessary supplies and equipment to be quickly converted to direct emergency operations. The alternate Emergency Command Center is located in Rooms 014 and 020, Building 90.

9.5 DRILLS AND EXERCISES

The Laboratory conducts an annual exercise that includes activation of the Emergency Command Center and involvement of selected professional response groups and volunteer emergency teams. Drills at selected buildings are conducted periodically.

9.6 SUPPLIES AND EQUIPMENT

The EH&S Division Emergency Program Manager is responsible for the procurement and maintenance of general emergency supplies such as rescue boxes and disaster first-aid kits. Other special equipment to support the program is provided as necessary.

9.7 COMMUNICATIONS EQUIPMENT

The EH&S Division Emergency Program Manager coordinates with the Communications Engineering Group of the Engineering Division to ensure that the Laboratory maintains an emergency communications capability sufficient to meet the requirements of a response to a major disaster.

9.8 TRAINING

The EH&S Division Emergency Program Manager administers and coordinates the emergency training program. Emergency preparedness training available to all Laboratory employees includes First Aid, CPR, Fire Extinguisher Use, and Earthquake Safety. This training is recorded in the FOCUS training database by the EH&S Division.

All building emergency team personnel must receive training in:

- First aid
- Cardio-pulmonary resuscitation (CPR)
- Fire extinguisher use
- Building emergency team orientation
- Hazard communication

Specialized training for emergency responders is the responsibility of the pertinent group. Professional response groups and emergency auxiliary teams must be trained in their respective emergency response roles.

9.9 BUILDING EMERGENCY TEAMS

The EH&S Division Emergency Program Manager provides support and coordinates activities of the building emergency teams located in each building throughout the Laboratory. Support includes providing supplies and equipment and coordinating training, drills, and exercises.

9.10 REPORTING AN EMERGENCY

To report all types of emergencies (medical, fire, vehicle accident, flooding, explosion, hazardous materials spills, natural gas leaks, and radioactive spills or releases):

- FROM AN LBNL PHONE (486 prefix), dial 7911.
- FROM A 642- OR 643- PREFIX (on campus), dial 9-911.

The 7911 number is answered by the LBNL Fire Department dispatcher and is monitored by the LBNL Security dispatch center at Blackberry Gate. The 9-911 number is answered by the UC Berkeley Police dispatcher. Both lines are monitored 24 hours.

When reporting an emergency, it is important to identify yourself and be as specific as possible. Report the following:

- Your name, phone number calling from, and location, including room and building number or nearest building if outside.
- The nature and severity of the emergency, for example, gas leak, personnel/personal injury, or spill of hazardous chemicals. In the latter case, give the name of the chemical and how much.
- Other potential dangers such as the presence of flammable liquids or gases, pressure vessels, exposure of other persons, structure damage, or suspicious object.

The following sections describe the actions to be taken for specific emergencies. Refer to the Building Emergency Plan for more details and the specific locations of emergency equipment in your building.

9.11 FIRE

Call extension 7911 or activate the fire alarms by using a fire pull box. Evacuate the building in accordance with the Building Emergency Plan. Use a fire extinguisher only if you have been trained in fire extinguisher use and only if you have a clear escape route. After evacuation, remain in the assembly area until reentry is authorized by the Building Manager or the Fire Department.

9.12 SERIOUS INJURY OR ILLNESS

Report the emergency in accordance with the instructions under the *Reporting an Emergency* section of this chapter. If you are not near a phone or cannot leave the injured, you may activate the nearest fire call box to summon help. Administer first aid or CPR only if you are trained to do so. Refrain from moving the victim unless he or she would suffer further injury by remaining in the area.

9.13 HAZARDOUS MATERIAL SPILL OR RELEASE

Remember **SIN**:

S **Safety** first; don't become a casualty; err on the side of caution.

I **Isolate** the area and deny entry.

N **Notify** the Fire Department by calling 7911.

9.14 EARTHQUAKE

If you are inside, "duck, cover, and hold" by getting under a desk or table and holding on until the shaking stops. Stay clear of windows, bookcases or any apparatus that may fall. After the shaking stops, gather your personal belongings such as brief cases, umbrellas, or purses and evacuate the building in accordance with the Building Emergency Plan. Do not use the elevator.

If you are outside, stay away from buildings and overhead power lines. Be aware of falling rocks or landslides. Move to the assembly area for the building after the shaking stops.

If you are in a motor vehicle, stop in a safe open area away from buildings, trees, and overhead power lines. Do not park near the edge of a hill because the roadway may shift and cause the vehicle to slide down the hill. Remain in the vehicle and allow emergency vehicles to pass.

Do not attempt to leave the Laboratory immediately following the earthquake. Roads and access routes must be kept clear for emergency vehicles. Landslides may block the roads. Information about the status of roads and buildings will be broadcast to Building Managers over the Building Manager radio network.

9.15 WILDLAND FIRE

Wildland fires on or near the Laboratory site will be announced over the public address system. Follow the instructions. You may be asked to relocate to another area of the Laboratory or be given instructions to leave the site either by vehicle or by walking. Remain calm and follow instructions.

9.16 BOMB THREAT

To report a bomb threat, follow the above procedures to report emergencies (see Section 9.10) and the steps listed in your Building Emergency Plan. The back page of the LBNL directory also describes the building evacuation procedures to be used in the event of a bomb threat.

Building evacuation procedures in the event of a bomb threat:

- An announcement will be made specifying the building/area to be evacuated. The announcement will be repeated once.
- Evacuate the building; leave immediately. The time interval between a bomb threat and the actual explosion can be a matter of minutes. Learn evacuation routes and emergency plans for your area.
- Use the stairways; do not use the elevator. Once outside, continue to your designated assembly area, staying clear of the building being evacuated.
- Do not reenter. Wait outside until the building has been cleared. Serious injuries can result should you reenter at the time of the explosion.
- Never touch, handle, or move a suspicious object. Ticking sounds may not always be heard. Some bombs are devised to detonate if moved just slightly.
- Do not drive a car. Roads must be kept clear for emergency vehicle use.

9.17 EMERGENCY INFORMATION TELEPHONE NUMBER

If a disaster occurs during other than normal working hours, you may dial the Laboratory's emergency status information number to listen to a recorded message, which will provide you with information regarding the Laboratory's status.

To obtain emergency status information dial **1-800-445-5830.**

9.18 RESPONSIBLE PARTIES

Specific responsibilities are assigned to the:

- LBNL Director
- Emergency Response Organization
- Policy Group
- Emergency Preparedness Subcommittee of the Safety Review Committee, EH&S Division, Emergency Program Manager (formerly the Emergency Services Group)
- Supervisors
- Employees-at-large

9.18.1 LBNL DIRECTOR

During emergencies requiring activation of the LBNL Emergency Command Center, the Director has overall responsibility for emergency response and policy decisions. If the Director is not on-site, the sequence of delegated authority is:

- Deputy Director for Operations
- Deputy Director
- Division Director, Environment, Health & Safety
- Associate Laboratory Director, Computing Sciences
- Division Director, Accelerator and Fusion Research
- Division Director, Life Sciences
- Division Director, Chemical Sciences

To assist the Director during operational emergencies are:

- The **Emergency Response Organization**, consisting of the Command Center team and first responder groups. Typically, the Laboratory Deputy Director for Operations is the Incident Commander in charge of the Emergency Response Organization.
- The **Policy Group**, the members of which include the Deputy Directors and Associate Laboratory Director. Typically, the Deputy Director chairs the Policy Group.

LBNL's emergency management organization is consistent with the Incident Command System and the State Emergency Management System (SEMS) used by federal, state, and local jurisdictions to manage emergency response to disasters.

Upon notification of a major emergency, the Emergency Response Organization and the Policy Group report to the Emergency Command Center in the Fire House, Building 48.

9.18.2 EMERGENCY PREPAREDNESS SUBCOMMITTEE

The Emergency Preparedness Subcommittee of the Safety Review Committee may be requested to review the Emergency Preparedness Program and make recommendations regarding emergency preparedness matters.

9.18.3 EH&S DIVISION EMERGENCY PROGRAM MANAGER

The Emergency Program Manager has Laboratory-wide responsibility for developing and implementing the Laboratory's Emergency Preparedness policy.

Functions of the Emergency Program Manager are:

- Developing and updating the Laboratory's *Master Emergency Plan*, LBNL Pub-533.
- Developing and updating Building Emergency Plans.
- Planning and conducting emergency drills and exercises.
- Coordinating volunteer emergency teams (Building Emergency, Auxiliary Ambulance and Fire, Amateur Radio Operators, Auxiliary Medical, and Facility Inspection).

- Maintaining the LBNL Emergency Command Center.
- Maintaining and managing emergency supplies, including disaster rescue boxes, first aid kits, and emergency food.
- Providing emergency preparedness training (First Aid, CPR, Fire Extinguisher Use, Building Emergency Team, and Earthquake Safety).
- Coordinating emergency preparedness functions with state and local jurisdictions and agencies.

9.18.4 SUPERVISORS

All supervisors are responsible for:

- Ensuring that their staff is familiar with the emergency plan for the building and preventing their employees from reentering an evacuated area until it is safe.
- Assisting the Incident Commander during an emergency.
- Understanding shutdown procedures for all equipment used by their staff and knowing the location and use of all safety equipment in their area.

9.18.5 EMPLOYEES-AT-LARGE INVOLVED IN AN EMERGENCY

All employees not in emergency response groups but involved in a major emergency are responsible for:

- Reporting the emergency promptly by phone, stating their name and telephone number, types of injuries, location, and nature of the emergency.
- Showing the ranking emergency-response officer where the incident occurred, summarizing the hazards associated with the area, and providing any other information that will help avoid injuries.
- Removing the injured persons, if there is threat of further injury or further exposure to hazardous conditions.
- Administering first aid or trying to control the incident, only if they can do so safely. They must have been trained in first aid or the appropriate emergency response.
- Leaving the immediate vicinity. If leaving an injured person, employees must report to a Building Emergency Team member or professional responder.

9.18.6 EMPLOYEES-AT-LARGE NOT INVOLVED IN AN EMERGENCY

All employees not involved in an emergency are responsible for:

- Staying away from the scene, evacuating immediately by the nearest safe exit when a fire alarm sounds, and refraining from reentering an evacuated area until notified by the Incident Commander or the Building Manager.

- Following instructions given over the public address system or directly by the Incident Commander or the Building Manager.

9.19 GLOSSARY

First responder groups, also called **professional response groups**, are the designated group(s) of personnel responsible for coping with and minimizing or mitigating the effects of any emergency. The first responder groups are fire, police, EH&S, and Facilities. The Lab also mobilizes volunteer emergency teams to support first responder groups. The various teams augment response, but are not expected to enter a hazardous zone. Individuals not trained in accordance with 29 CFR 1910.120 are prohibited from entering an area considered to be hazardous.

The **Incident Command System** is the emergency management system used by the Laboratory's professional response groups when they respond to emergencies.

The **Incident Commander** is the person in charge during an emergency. The Incident Commander is normally on the scene during major emergencies until command of the incident is transferred to the Incident Commander in the Emergency Command Center.

A **major emergency** may include the following:

- Mass casualties
- Multiple-alarm fire
- Urban wildland fire
- Bomb threat
- Civil disturbance
- Radioactive or chemical spill
- Power outage
- Utility failure
- Earthquake
- Landslide

The **Primary Emergency Command Center** is located in the Fire Station, Building 48, and is activated during a major emergency requiring significant commitment of resources during response and recovery. The **Alternate Emergency Command Center** is located in Rooms 014 and 020, Building 90.

9.20 STANDARDS

- 29 CFR 1910, *Occupational Safety and Health Standards for General Industry*
- NFPA 1600, *Disaster Management*
- 40 CFR 68, *Chemical Accident Prevention Provisions*
- 40 CFR 355, Emergency Planning and Notification (SARA III)
- DOE Order 151.1, Chapter VIII, paragraph 4a and 4d; Chapter I, paragraph 3

9.21 RELATED PUB-3000 CHAPTERS

- *General Policy and Responsibilities* (Chapter 1)
- *EH&S Charter* (Chapter 2)
- *EH&S Training* (Chapter 24)
- *Seismic Safety* (Chapter 23)

9.22 REFERENCES

- *Implementation Procedures for the LBNL Building Manager Program,* Procedure No. ALDO 1.00, Revision 1.0, Effective Date 4/19/93
- *LBNL Master Emergency Plan,* PUB-533, Lawrence Berkeley Laboratory, September 1993
- Policy and Procedure Memo, Volume XVIV, No. 3, December 9, 1992, *LBNL Building Management*
- Policy and Procedure Memo, Volume XXIII, No. 11, May 21, 1997, *LBNL Emergency Command Center Operations*

Chapter 10

CONSTRUCTION SAFETY

Revised December 1997

Reviewed by: Loretta Valentine 12/9/97
Date

Approved by: D. C. McGraw 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 10

CONSTRUCTION SAFETY

10.1 POLICY

This policy and these procedures promote and establish requirements for the protection of life and property, compliance with applicable construction safety standards, and the maintenance of a safe working environment and environmental protection during all construction activities at Lawrence Berkeley National Laboratory.

10.2 SUBCONTRACT EMPLOYEE SAFETY

LBNL is a prime contractor to DOE, sometimes contract work is performed by non-Laboratory personnel. They are referred to as "Construction Subcontractors".

The safety rights and obligations of contract employees are the same as those of Laboratory employees. Those supervisors assigned to direct the work of contract employees must provide instruction, safety equipment, and conditions equivalent to those provided to Laboratory employees. This is to ensure that Laboratory property is protected from damage and that all personnel, whether payroll or non-payroll, are protected from work injury and illness.

The safety and health of construction subcontractor employees is the responsibility of the construction subcontractor. The Laboratory is required to inform construction subcontractors of any serious concealed hazards or peculiar risks that relate to the scope of the construction subcontract in the subcontract bid documents. Should new or previously unidentified serious concealed hazards or peculiar risks be discovered, the Laboratory must immediately disclose this information to the affected construction subcontractor(s).

10.3 SCOPE

The provisions of this policy apply to all construction-related activities at LBNL originating from:

- Construction subcontracts
- Architectural/engineering subcontracts and personal services or consultant agreements
- Purchase orders and blanket orders
- Job orders for in-house work

10.4 LBNL SUPPORT ORGANIZATIONS

- Facilities
- Fire
- Environment, Health and Safety Division
- Environment Department
- Waste Management Group
- Engineering

10.5 CONTRACTOR PROGRAMS

10.5.1 SUBCONTRACTOR SAFETY AND HEALTH PROGRAM AND SITE-SPECIFIC SAFETY PLAN

For all subcontracted construction jobs with a contract amount over $50,000, and for specific smaller jobs, a Subcontractor Safety and Health Program and a Site-Specific Safety Plan are required. The subcontractor must submit this program and plan according to the requirements outlined in the Laboratory's construction specifications. The program and plan must be submitted by the subcontractor to the Project Manager at least 15 working days prior to the start of construction. It is then reviewed and signed off by the General Sciences/Operations Group. Any comments requiring additional submittals or resubmittals must be reviewed and signed off by the General Sciences/Operations Group before on-site work begins. DOE Order 5480.9A must be utilized in preparing the safety and health program specifications in the subcontract documents.

Facilities Maintenance and Operations is not required to prepare a safety program for each construction activity; however, all work must comply with federal and State of California OSHA safety and health regulations and requirements.

10.5.2 SUBCONTRACTOR SAFETY CHECKLIST

For jobs performed by construction subcontractors but not requiring a Subcontractor Safety and Health Program and a Site-Specific Safety Plan, a Construction Subcontractor Prejob Checklist (CSPC) is required. Before on-site work begins, the CSPC must be completed and signed by the subcontractor then reviewed and signed off as satisfactory by the General Sciences/Operations Group.

10.5.3 SUBCONTRACTOR HAZARD COMMUNICATION PROGRAM

The subcontractor must submit a Project Hazard Communication Program according to the requirements outlined in the Laboratory's construction specifications. 29 CFR 1926.59 must be utilized in preparing the specifications.

Facilities Maintenance and Operations is not required to prepare a hazard communication program for each construction activity; however, all construction-related chemical hazards must comply with Federal OSHA 29 CFR 1910.1200 and 29 CFR 1926.59.

10.5.4 SUBCONTRACTOR SAFETY PROGRAM COMPLIANCE

Throughout all phases of construction, the subcontractor must assure the Construction Safety Engineer that all construction activities are conducted in accordance with the safety program and that appropriate measures are taken to minimize the possibility of:

- Personal injury.
- Damage to property on and adjacent to the construction site.
- Adverse effects to the environment.
- Program interruption or delay resulting from accident or fires.

Facilities Maintenance and Operations will take appropriate measures to minimize the concerns identified above.

10.6 PROGRAM OUTLINE

10.6.1 SUBCONTRACTOR PROJECT SAFETY AND HAZARD COMMUNICATION PROGRAMS

The subcontractor must submit the written Project Safety and Hazard Communication Programs to the Project Manager, who will submit the plans to the Construction Safety Engineer for review. The programs must be deemed acceptable before on-site activities begin.

10.6.2 PRE-START MEETING

Potential safety problems must be discussed at the construction pre-start meeting with the subcontractor. The Purchasing Department or the Project Manager will coordinate the scheduling of the pre-start meeting. The Project Manager must notify the Construction Safety Engineer and Construction Inspector of the subcontractor's actual on-site start date.

Facilities Maintenance and Operations work by in-house crafts or a labor-only subcontractor will not normally require a pre-start safety meeting. Fire and Construction Safety Engineers, however, will be notified of all new construction activities.

10.6.3 FIRE PERMIT

The subcontractor must notify the Construction Inspector of work operations requiring a burn permit at least one work day before the scheduled start of open flame operations. The Construction Inspector will contact the Laboratory's Fire Department for a burn permit. The Fire Department's representative will meet with the subcontractor's superintendent at the location requiring the permit and instruct the superintendent about precautions, including the placement of fire extinguishers. The Fire Department's first points of contact are the Construction Inspector and the Project Manager. In case of immediate fire safety hazard, the Fire Department will contact the person creating the hazard.

Facilities Maintenance and Operations will submit burn requests to the Fire Department.

10.7 EXCAVATIONS, TRENCHING, AND SHORING

Trench excavations 1.5 m (5 ft) or more deep, and all excavations that are dug in unstable earth, require protection, unless no one will be working in the trench or excavation.

If a job requires shoring, job orders, purchase orders, and subcontracts must specify that the required shoring is in compliance with 29 CFR 1926, Subpart P, *Excavation*. Contact Facilities or EH&S for details.

Only a civil engineer registered by the State of California may request a deviation from the above requirements. The engineer must submit detailed data to Facilities and EH&S for alternative effective shoring and sloping systems, including:

- Soil evaluations
- Slope stability
- An estimate of the forces to be resisted
- Plans
- Specifications for the proposed materials and methods

When sheet piling is to be used, full loading due to ground water table must be assumed, unless prevented by weep holes and drains or other means. Additional stringers, uprights, and bracing must be provided for temporary removal of individual supports.

Excavated material must be located at least 0.6 m (2 ft) back from the edge of the excavation.

Sloping may be used on the sides or walls of an excavation, in lieu of a shoring system, if this provides equivalent protection. The degree of sloping is dependent on the type of soil and the depth of excavation. Sloping requirements are described in 29 CFR 1926, Subpart P, Appendix B.

Excavation work must be done under immediate supervision at all times. The supervisor must have the authority and qualifications to modify the shoring system or work methods as necessary to provide the required safety.

A ladder projecting 0.9 m (36 in.) above ground surface must be provided for access and exit. The travel distance to the ladder must not exceed 7.6 m (25 ft).

10.8 INSPECTIONS

10.8.1 PURPOSE, SCHEDULING, AND SCOPE OF INSPECTIONS

To ensure compliance with applicable construction safety and health codes, standards, and regulations, the Laboratory will conduct construction site fire, safety, and health inspections concurrent with construction activity. Factors used to determine the frequency and scope of on-site safety and health inspections include:

- The number and type of hazards involved (e.g., confined spaces, trenching and excavating, work at elevations).
- The total level of risk to the workforce, property, and environment.
- The presence of qualified subcontractor safety and health personnel.
- The duration of the project.
- The time elapsed since the last fire, safety, or health inspection.
- The availability of independent sources of inspection.
- Previous experience with the subcontractor.

Inspections may be made at any time.

Facilities Maintenance and Operations work is subject to construction site fire, safety, and health inspections.

10.8.2 FIRE, SAFETY, AND HEALTH INSPECTORS; SITE COORDINATION

Construction site fire, safety, and health inspections will be made by the authorized Laboratory representative (e.g., Construction Safety Engineer, industrial hygienist, or fire inspector). When possible, these inspections will be coordinated with the Construction Inspector. When the Construction Inspector is not available, the inspection will proceed without delay.

10.9 SAFETY VIOLATIONS

LBNL construction site personnel must report unsafe conditions immediately to the Project Manager, or Construction Safety Engineer. The Project Manager, or Construction Safety Engineer will notify the subcontractor promptly regarding subcontractor environment, health, and safety problems. Discrepancies or problems, other than work stoppages, must be recorded in writing by the Construction Safety Engineer and addressed to the Project Manager. Correction of the deficiency is the responsibility of the subcontractor. The Construction Safety Engineer will monitor the correction of the subcontractor's safety deficiencies.

Facilities Maintenance and Operations will be advised by the construction safety specialist regarding safety problems.

10.10 STOP WORK ORDERS

10.10.1 OVERVIEW

A stop work order shall be given when imminent danger is identified or where significant damage to equipment or property or environmental degradation could occur if the operation continued. When a stop work order is issued, only those areas of a construction project immediately involved in the identified hazardous situation are to be included in the order. The Project Manager is responsible for directing the subcontractor to stop an operation. In imminent danger situations, EH&S personnel or building managers can temporarily stop the subcontractor's work, but the Project Manager must be notified immediately. Subcontractors shall not resume work until authorized by the Project Manager.

10.10.2 WORK-STOPPAGE MEMORANDUM

All work stoppages must be submitted in writing to the subcontractor and must reference the appropriate OSHA regulation and subcontract provision to stop work. A work-stoppage memorandum must be issued by the Project Manager after each instance of stopping work. Copies go to the Construction Inspector, contract administrator, and EH&S Division Head.

10.10.3 CONFLICT RESOLUTION

Differences of opinion between the Construction Safety Engineer and the Construction Inspector, or Project Manager, regarding a stop work order must be immediately referred to their respective functional supervisors for resolution. The Construction Safety Engineer's recommendations must be followed until the functional supervisors agree on a decision.

Facilities Maintenance and Operations construction activities are subject to work stoppages should an imminent danger exist. After each instance of stopping work, the Project Manager or Project Superintendent and the Maintenance and Operations Managers must be notified immediately.

10.11 ACCIDENTS

In the event of a serious accident at a construction site, LBNL Emergency Services must be notified. All work must stop in the area of the accident to preserve the accident scene until EH&S has conducted an initial investigation and collected information from witnesses. A determination must be made whether or not work may resume. The person stopping work must immediately notify the Construction Inspector and the Project Manager and one of them, in turn, must immediately notify the Environment, Health and Safety Division Office. Then a determination will be made as to the next step.

10.12 CONSTRUCTION SITE ACCESS CONTROLS

Personnel required to enter a construction area will:

- Identify themselves to the Construction Inspector or Project Manager upon arrival and be accompanied by that person while on the jobsite, unless otherwise directed.
- Obey all safety regulations, wear appropriate protective equipment, and follow special instructions given by the Construction Inspector.
- Communicate with subcontractor representatives only when authorized by the Construction Inspector or Project Manager.
- Notify the Construction Inspector or Project Manager when the visit is completed.

Facilities Maintenance and Operations construction site visitors will coordinate their visits with the job superintendent.

10.13 SPECIAL INSTRUCTIONS: RADIATION AREAS

Subcontract personnel who plan to work in areas where they may be exposed to ionizing radiation from LBNL operations must receive a personal dosimeter and radiation safety training from EH&S before beginning work. Each dosimeter issued to subcontractor personnel must be returned at the designated times and at the conclusion of the job. Training will be handled on a case-by-case basis for each contract. The length of this training will range from 15 minutes to 1 hour, depending on the facility in which work is to be done.

The EH&S Division must be notified of the above situation before work begins so that they can determine whether to issue dosimeters and what radiation training will be required.

10.14 GLOSSARY

Construction is any combination of engineering, procurement, erection, installation, assembly, demolition, or fabrication used to create a new facility or to alter, add to, rehabilitate, dismantle, or remove an existing facility. It also includes the alteration and repair (including dredging, excavating, and painting) of buildings, structures, or other real property, as well as any construction and excavation activities conducted as part of environmental remediation efforts. This does not involve the manufacture, production, finishing, construction, alteration, repair, processing, or assembling of personal property. This definition will be used to determine the applicability of DOE Orders in lieu of the Davis–Bacon Act definition, which is used to determine wage rates. Accordingly, projects defined as maintenance projects under the Davis–Bacon Act definition may be defined as construction projects under this definition.

The **Construction Inspector** is the Laboratory Facilities Department's representative for monitoring quality control, subcontractor construction work, and subcontractor compliance with the terms and conditions of the subcontract documents.

The **Subcontract Administrator** is the Laboratory Purchasing Department's representative for business matters. This person ensures subcontractor compliance with the administrative, business, and contractual requirements of the construction subcontract.

The **Project Manager** is the Laboratory Facilities Engineering management representative for quality assurance. This person ensures subcontractor compliance with subcontract documents, including performance, schedule, budget, and safety. The Project Manager may perform the duties of the Construction Manager.

The **Construction Safety Engineer** is the Laboratory Environment, Health and Safety Division's representative responsible for safety and health oversight of construction activities. This person monitors subcontractor compliance with the applicable safety and health codes, standards, and regulations.

A **Subcontractor** is a person or firm that has sole contractual responsibility for execution of the construction work and compliance with all safety and health codes, standards, and regulations. The subcontractor must take all reasonable and necessary precautions in the performance of the work to protect the safety and health of its employees, the employees of its lower-tier subcontractors, LBNL employees, and members of the public. It must comply with all applicable safety and health regulations and requirements listed in the construction documents. The subcontractor is responsible for the safety and health performance of its lower-tier subcontractors.

Facilities Maintenance and Operations Personnel provide direct and indirect support to the Laboratory by carrying out plant operating and maintenance services. They also supervise small purchase order construction subcontracts and in-house construction activities. When engaging in construction activities, their work must comply with all applicable safety and health codes, standards, regulations, and requirements.

An **imminent danger** is any condition or practice that could reasonably be expected to cause death or serious physical harm (permanent or prolonged impairment of the body or temporary disablement requiring hospitalization) to employees or the public unless immediate actions are taken.

10.15 STANDARDS

- 29 CFR 1926, Occupational Safety and Health Standards for Construction
- 29 CFR 1910, Occupational Safety and Health Standards for General Industry
- California Code of Regulations (CCR), Title 8, Construction Safety Orders

10.16 RELATED PUB-3000 CHAPTERS

- *Fire Prevention and Protection* (Chapter 12)

- *Occupational Safety* (Chapter 5)—Section I, *Accident Investigation and Reporting*
- *Radiation Protection* (Chapter 21)

10.17 REFERENCES

See also the requirements listed under Worker Protection issues, such as Fire Protection, Hazardous Materials Handling, Material Handling, Industrial Hygiene, and Electrical Safety. These requirements also apply to design and construction.

Chapter 11

ENVIRONMENTAL PROTECTION GROUP

Revised December 1997

Reviewed by: Ron Pauer 12/12/97
Date

Approved by: David McGraw 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 11

ENVIRONMENTAL PROTECTION GROUP

11.1 POLICY

The environmental protection policy of Berkeley Lab is to conduct its operations in a manner that preserves the quality of the environment. Protection of the environment and the public are responsibilities of paramount importance and concern at Berkeley Lab. The Laboratory's operations comply with both the spirit and the letter of environmental laws and regulations. Berkeley Lab is committed to good environmental management of all its potential risks, minimizing risks to the environment and public health, and anticipating and addressing potential environmental problems before they pose a threat to the quality of the environment or the public welfare.

11.2 SCOPE

The Berkeley Lab environmental protection programs are designed for the protection of air, water, soil, and other environmental media. The programs are managed by the Environmental Protection Group (EPG). These programs include:

- Air emissions
- Environmental radiological dose assessment
- Environmental monitoring
- Environmental releases
- Hazardous wastewater treatment units
- Petroleum products storage
- Sanitary sewer discharges
- Storm water discharges
- Underground storage tanks

11.3 PROGRAM DESCRIPTIONS

11.3.1 AIR EMISSIONS

Operations at Berkeley Lab that emit hazardous or regulated air pollutants are subject to the rules and regulations administered by the Bay Area Air Quality Management District (BAAQMD). BAAQMD rules and regulations require any person who wishes to build, erect, alter, replace, operate, or use any article, machine, equipment, or other device that might cause the emission of air pollutants to first obtain a permit from BAAQMD. At Berkeley Lab, operating permits have been issued for equipment associated with pollutant abatement, furnaces and ovens, gasoline dispensing, machining materials, semiconductor research, surface cleaning, surface coating, and surface preparation operations.

After a potential source of air emissions is identified and it has been determined that a permit is required, an application is prepared by EPG with the assistance of the source operator. The application typically consists of a combination of forms, text, diagrams, and maps. If an action involves construction or installation of new equipment, an Authority to Construct is first issued by BAAQMD after approval of the application. When construction is completed and operations are ready to begin, an inspector from BAAQMD checks the equipment. If the equipment is satisfactory, a Permit to Operate is issued, which is valid for one year.

Advanced planning is essential in obtaining either a new or modified operating permit from BAAQMD since it may take up to four months to get initial approval to install the system or conduct the operations. One month may be spent assessing permit requirements, preparing the permit application, and paying the necessary fees. BAAQMD is allowed up to one month to determine if Berkeley Lab included enough information on the application. Then BAAQMD has an additional two months to review the application for approval or denial before issuing the Authority to Construct. Getting to this point is the key step in obtaining an operating permit. The Authority to Construct is valid for two years, and may be renewed if requested. At any time during this two-year period, when the new or modified source is ready for operation, Berkeley Lab must give BAAQMD notice of startup. BAAQMD has an additional two months to take final action on approving or denying the operating permit, based on the earlier review of the Authority to Construct and the results for the startup period. The entire permit review process may take even longer if BAAQMD requests additional information at any stage of the process or if a risk assessment is required because of hazardous air pollutants emitted by the source.

Annually, BAAQMD will send permit renewal forms to EPG to update information on each source. New permits are issued after the forms are submitted, the District completes its inspection, and renewal fees are paid. BAAQMD conducts an annual inspection of permitted sources, and reviews registered, but permit-exempt sources on a less frequent schedule.

The air emission source operator plays an important role in this program by:

- Identifying and notifying EPG of unpermitted existing, new, and planned emission sources.
- Notifying EPG of any upcoming equipment or process modifications, location changes, or changes in chemical usage that may affect permit status.
- Complying with permit conditions and operating standards.
- Submitting related information in a timely manner to EPG for use in evaluating sources, preparing permit/exemption request applications, renewing permits, and responding to violation notices.
- Maintaining complete and accurate records required by regulations and/or the Permit to Operate.
- *Being available during both BAAQMD inspections, or DOE and EPG audits, and providing any information requested by EPG personnel.*

For complete descriptions of the air emission source permitting process, refer to the Berkeley Lab Air Quality Program Manual.

11.3.2 ENVIRONMENTAL RADIOLOGICAL DOSE ASSESSMENT

Dose assessment for radiological air emissions conforms to the standard prescribed in the National Emission Standards for Hazardous Air Pollutants (NESHAPs) for radionuclide emissions, promulgated as a result of the Clean Air Act (40 CFR 61, Subpart H). NESHAPs compliance is enforced by the United States Environmental Protection Agency (EPA), Region 9, and inspections are periodically conducted by EPA personnel.

NESHAPs requires that DOE facilities limit dosage exposure in offsite individuals to less than 10 mrem per year from all exposure pathways resulting from airborne releases of radionuclides. Exposures to doses of a hypothetical maximally-exposed member of the public are determined, as well as the sum of all exposures to the population within a 80-km (50-mile) radius of Berkeley Lab. The dose assessments are performed using computer models which have been approved by the EPA.

Berkeley Lab employees play an important role in this process by providing accurate and up-to-date information on their radionuclide use. The dose assessment results are reported in the Site Environmental Report and the Annual NESHAPs Report. These reports are distributed to DOE and regulatory agencies.

11.3.3 ENVIRONMENTAL MONITORING

Federal, state, and local regulations and DOE Orders contain requirements and guidance for environmental monitoring. Environmental monitoring is used to demonstrate compliance with legal and regulatory requirements imposed by federal, state, and local agencies; confirm adherence to DOE environmental protection policies; and support environmental management decisions. The Berkeley Lab environmental monitoring program consists of three major activities: (1) measurement and monitoring of effluents from Laboratory operations; (2) surveillance, i.e., measurement, monitoring, and calculation, of the effects of those operations on the environment and public health; and (3) meteorological monitoring.

Berkeley Lab monitors effluent streams that have the potential for discharging toxic or radioactive materials into the environment. At present, the two sanitary sewer outfalls and approximately 30 ventilation stacks are routinely monitored. The number of stacks monitored varies because of the dynamic nature of research activities. In addition, wastewater discharges from two metal finishing operations and from groundwater treatment activities are sampled periodically prior to discharge.

Environmental surveillance includes sample collection and analysis from storm water run-off; groundwater discharges from Berkeley Lab sub-surface drainage systems; rain, creek and lake water; ambient air; soil and sediment; and vegetation.

During the last few years, Berkeley Lab has initiated an extensive meteorological monitoring program. The program is designed to characterize and quantify airflow patterns for the environmental dose assessment program and to assess the potential consequences from spills and releases. This information is used in environmental reports and permits.

The program is described in detail in the Berkeley Lab publication, *Environmental Monitoring Plan*.

11.3.4 ENVIRONMENTAL RELEASES

Various DOE Orders and federal, state, and local laws and regulations require Berkeley Lab to report any significant spills or releases of hazardous materials, pollutants, or chemical agents to the environment. To implement these requirements, the following procedure has been developed:

- The line organization is responsible for immediately reporting environmental releases and spills of any magnitude. For emergency cases, the initial report should be made to the Fire Department by dialing ext. 7911. For environmental spill or releases that do not require emergency action, the Environmental Protection Group (EPG) should be contacted directly at extension 7614. See also Chapter 9, "Reporting an Emergency" and "Hazardous Material Spill or Release."
- The EPG will investigate all reports of environmental spills or unplanned releases to determine the appropriate reporting level for each instance. Notification may be sent to DOE and various federal, state, and local agencies.

For complete descriptions of emergency procedures, refer to the *Berkeley Lab Master Emergency Plan*, PUB-533.

11.3.5 ENVIRONMENTAL RESTORATION PROGRAM

The Berkeley Lab Hazardous Waste Handling Facility operates under a Resource Conservation and Recovery Act (RCRA), Part B Hazardous Waste Facility Permit issued by the California Environmental Protection Agency (CAL-EPA) Department of Toxic Substances Control (DTSC). Section 30004(u) of RCRA as amended by Hazardous and Solid Waste Amendments (HSWA) and Title 40 of the Code of Federal Regulations (CFR) §264, requires that permits issued after November 8, 1984 address corrective action of all releases of hazardous wastes including hazardous constituents from any Solid Waste Management Unit (SWMU). The LBNL Part B Permit, which was issued on May 4, 1993, requires that LBNL investigate and address all release of hazardous waste that may have occurred at the facility.

Additionally, a new Hazardous Waste Handling Facility (HWHF) has been constructed. Therefore the closure of the old HWHF is required by the Berkeley Lab Part B Permit.

Investigations of potential environmental contamination, including soil, surface water, and groundwater contamination, and closure of the old HWHF is conducted at LBNL under the Environmental Restoration Program (ERP). The ERP is part of a nationwide effort by the United States Department of Energy (DOE) to identify and clean up contaminated areas at its facilities.

11.3.6 HAZARDOUS WASTEWATER TREATMENT UNITS

Berkeley Lab operates six hazardous wastewater treatment units, or fixed treatment units (FTU). These are:

- Building 2— acid wastewater
- Building 25— acid wastewater with metals
- Building 70A— acid wastewater
- Building 76— oily wastewater
- Building 77— acid wastewater with metals (2 units)

The wastewater is treated to meet East Bay Municipal Utility District's discharge limits and then is discharged to the sanitary sewer.

State law requires all facilities treating hazardous waste to obtain authorization from the California Environmental Protection Agency's Department of Toxic Substances Control. This Department has created a tiered permitting program, based on environmental risk, as the permitting process to gain authorization to operate. The FTUs located at Buildings 25 and 77 have received authorization to operate under the Permit-by-Rule tier. The FTUs located at Buildings 2, 70A and 76 are permitted to operate under the Conditional Authorization tier.

EPG has prepared and maintains permit documentation including notifications and plans required by the tiered permit program. It has also provided oversight of construction upgrades to these units to verify that the engineering standards have been met. An annual renewal is prepared and submitted to DTSC.

Permit-by-Rule and Conditional Authorization FTUs have the following operation requirements for which the operators of these units are responsible:

- Preparing Activity Hazard Documents.
- Recording dates, amounts, and types of waste treated and submit an annual report of wastewater treated to EPG.
- Preparing inspection logs that document maintenance activities.
- Complying with hazardous waste generator operating standards.
- Ensuring that operators have received OSHA 24-hour training for hazardous waste workers.
- Maintaining worker training files.
- Informing EPG of any new process waste streams or new treatment processes.

When a new fixed treatment unit is planned, the Department of Toxic Substances Control (DTSC), the City of Berkeley, and the East Bay Municipal Utility District (EBMUD) must be notified 60 days before commencing the first treatment of waste. The permit submission requires the signature of the Deputy Laboratory Director. The permit submission shall include:

1. A completed Facility Specific Notification form.
2. A completed Unit Specific Notification form.
3. A description of the treatment process.
4. Drawings of the treatment system which include tanks, containers, secondary containment, and leak detection (as-built drawings preferred).
5. Tank and containment system certification obtained from an independent, qualified, professional engineer, registered in California.
6. A certification specifying the local agencies that have been notified.

Planning should take into account the 60-day lag time that DTSC requires to process the permit. In practice, a permit can not be submitted until construction has been completed, the system leak tested, and the treatment unit certified by an independent, qualified, professional engineer. In addition, planning should allow two to four months for the preparation of the permit. Preparation time will vary depending on the complexity of the treatment unit and whether the independent engineer identifies that upgrades are needed.

When there is a change to an existing treatment unit, a permit amendment must be submitted to DTSC, City of Berkeley, and EBMUD. The permit amendment submission may include all the items listed for a new permit and requires the signature of the Deputy Laboratory Director. Planning should allow two to four months for the preparation of the permit amendment. Once proof of receipt of the permit amendment has been received from DTSC, treatment of the waste may begin.

11.3.7 PETROLEUM PRODUCTS STORAGE

Petroleum product storage requirements are prescribed by federal regulations, which are driven by the Clean Water Act; hazardous material storage requirements, which are determined by DOE Order; and best management practice. Petroleum products stored in 55-gallon drums or tanks are governed by these requirements. The principal requirements include:

- The material must be stored in tanks or containers of approved design and construction.
- The tanks or drums must have approved double containment capable of holding the entire contents of the largest single tank plus sufficient freeboard to allow for precipitation. (Berkeley Lab uses a 25-year, 24-hour, storm event of 4.78 inches as sufficient freeboard.)
- Berkeley Lab Facilities Department has a formal rainwater disposal procedure for inspecting and testing accumulated rainwater prior to discharge.
- The storage facility must be covered by routine maintenance and inspection programs.
- Users of bulk storage facilities must receive annual training.

The details of the petroleum storage requirements are described in the Berkeley Lab *Spill Prevention, Control and Countermeasures Plan* .

11.3.8 SANITARY SEWER DISCHARGES

Discharges to the sanitary sewer system are subject to increasingly complex and restrictive standards. Berkeley Lab's use of the sanitary sewer system is guided by restrictions imposed by the East Bay Municipal Utility District (EBMUD), a publicly owned treatment work (POTW). The POTW accepts only specific wastes at specific concentrations.

Berkeley Lab has four wastewater discharge permits. They are for:

1. Sitewide activities.
2. Wastewater pretreatment units at the Building 25 photo fabrication facility.
3. Wastewater pretreatment units at the Building 77 ultra high vacuum cleaning facility.
4. Groundwater treatment units at various locations.

These wastewater discharge permits specify different discharge limits at the site boundary and at the treatment units. Table 1 shows the substances for which Berkeley Lab has discharge limits for all permits.

Table 1. Sanitary Sewer Discharge Limits

Parameter	Site Limit (daily maximum)	Wastewater Treatment Unit Limit (daily maximum)	Wastewater Treatment Unit Limit (monthly maximum)	Treated Groundwater Limit (daily maximum)
Arsenic	2 mg/L	2 mg/L	—	—
Cadmium	1 mg/L	0.69 mg/L	0.26 mg/L	—
Chlorinated Hydrocarbons (Total Identifiable)	0.5 mg/L	—	—	—
Methylene Chloride	0.01 mg/L	—	—	—
Chromium	2 mg/L	2.77 mg/L	1.71 mg/L	—
Copper	5 mg/L	3.38 mg/L	2.07 mg/L	—
Cyanide	5 mg/L	1.2 mg/L	0.65 mg/L	—
Iron	100 mg/L	100 mg/L	—	—
Lead	2 mg/L	0.69 mg/L	0.43 mg/L	—
Mercury	0.05 mg/L	0.05 mg/L	—	—
Methylene Chloride	0.01 mg/L	—	—	—
Nickel	5 mg/L	3.98 mg/L	2.38 mg/L	—
Oil and Grease	100 mg/L	100 mg/L	—	—
Phenolic compounds	100 mg/L	100 mg/L	—	—
Silver	1 mg/L	0.43 mg/L	0.24 mg/L	—
Zinc	5 mg/L	2.61 mg/L	1.48 mg/L	—
pH (not less than)	5.5 S.U.	5.5 S.U.	—	—
Temperature	150 F	150 F	—	—
Total Toxic Organics	—	2.13 mg/L	—	—
Carbon Tetrachloride	—	—	—	0.005 mg/L
Chloroform	—	—	—	0.014 mg/L
1,1-dichloroethane	—	—	—	0.005 mg/L
1,1-dichloroethene	—	—	—	0.005 mg/L
Cis-1,2-dichloroethene	—	—	—	0.005 mg/L
Trichloroethene	—	—	—	0.005 mg/L
1,1,1-trichloroethane	—	—	—	0.005 mg/L
1,1,2-trichlorofluoroethane	—	—	—	0.005 mg/L
Tetrachloroethene	—	—	—	0.005 mg/L
Polychlorinated biphenyls (PCBs)	—	—	—	0.0002 mg/L

EBMUD requires Berkeley Lab to apply annually for the wastewater discharge permits that allow the Laboratory to discharge wastewater from the site, the two wastewater pretreatment units, and the groundwater treatment units to the EBMUD facility. The terms of that permit require that Berkeley Lab abide by all applicable provisions of the EBMUD Ordinance or any other federal, state, and local regulations. Limits for radionuclide discharges are established based on the limits specified in Title 17 of the California Code of Regulations (17 CCR, Section 30253). Because of these requirements, no discharge may be made to the sanitary sewer system until the composition and concentration of the discharge is known. In some cases, sampling and analysis must be performed in order to determine if a discharge can be released to the sewer. The EPG will assist employees in making this determination. Approval for release to the sewer can be issued only after all required analyses have been conducted and properly evaluated. All sinks should be labeled to warn against disposal of hazardous substances down the drain.

11.3.9 STORM WATER DISCHARGES

In accordance with EPA regulations, Berkeley Lab has notified the State Water Resources Control Board (SWRCB) that it will comply with the National Pollutant Discharge Elimination System's General Permit for discharges of storm water associated with industrial activity. This permit requires Berkeley Lab to implement the best available technology that is economically achievable and the best conventional pollution control technology to reduce or eliminate storm water pollution. As a result, Berkeley Lab must:

- Maintain an effective and appropriate storm water drainage system.
- Assure that no water other than storm water enters the storm water drainage system other than SWRCB-approved non-storm water discharges from activities such as irrigation, fire sprinkler testing, and air conditioner condensate.
- Collect, monitor, and properly dispose of all non-storm water.
- Identify all operations that could cause contamination of storm waters and take appropriate corrective measures.

To implement these requirements Berkeley Lab has identified and eliminated all unauthorized connections to the storm drains. In addition, outdoor chemical storage areas and transformer pads have been equipped with secondary containment basins. Storm water is monitored during storms to determine whether the practices employed to reduce and control pollutants are effective.

As a practical matter, employees must adhere to the above requirements for any outdoor operations involving water, oil, or chemicals. Indoor operations must be designed to preclude escape of contaminants to the exterior, and spills must be reported promptly to allow immediate containment and clean-up.

This program is described in detail in the Berkeley Lab publications, *Storm Water Pollution Prevention Plan* and the *Storm Water Monitoring Plan*.

11.3.10 UNDERGROUND STORAGE TANKS

Underground storage tanks (USTs) and systems are stringently regulated by federal and state laws. Regulatory elements address the following aspects of UST system management:

- Registration and operating permits
- Construction standards—double containment and overfill protection
- Monitoring and leak detection
- Integrity testing
- Release recording and reporting
- Closure—temporary and permanent
- Cleanup of contaminated sites

The City of Berkeley enforces the UST regulatory program, consolidating federal, state, and local UST requirements. Berkeley also coordinates UST requirements with applicable fire code provisions. In addition, Berkeley Lab's UST program must also conform to DOE policies.

The EPG provides UST compliance support, maintains a documented program including a UST Monitoring and Emergency Response Field Manual, and provides UST compliance training, as required by law. The Facilities Department plays a major role in implementing plans and procedures to ensure compliance with UST and City of Berkeley regulations. Please refer to the UST Manual for more details about the Program.

Berkeley Lab currently has nine operating UST systems. Seven of them store diesel fuel for emergency generators, and two are used for unleaded and diesel fuel storage at the Building 76 motor pool.

11.4 SUPPORT ORGANIZATIONS

- EH&S Field Support Department
- Facilities Department

11.5 RESPONSIBLE PARTIES

11.5.1 PRINCIPAL INVESTIGATORS AND SUPERVISORS

- Ensure that environmental laws and regulations are followed.
- Request assistance from the Environmental Protection Group for advice on what environmental requirements apply to their operations and what would be an appropriate compliance strategy.

- Provide training for employees in operational requirements pertaining to environmental protection, and maintain records of such training.
- Ensure that activities are performed within acceptable operating standards and that any required records are current.
- Notify the EH&S Division immediately of any unplanned environmental releases or spills.

11.5.2 EMPLOYEES

- Are fully aware of the environmental impact of their own activities, and comply with all requirements that govern those activities.
- Adhere to all environmental requirements contained in Activity Hazard Documents and operating procedures.
- Perform activities within acceptable operating standards and maintain current records whenever required.
- Participate in energy conservation, recycling, and pollution prevention programs.
- Take immediate action to stop unplanned releases to the environment and report all instances of unplanned environmental releases to the EH&S Division.
- Complete all required training provided by supervisors and the EH&S Division.

11.5.3 ENVIRONMENTAL PROTECTION GROUP (EPG)

- Develops Laboratory policies and procedures that will assure operations are conducted in an environmentally safe manner and in full compliance with all applicable environmental laws and regulations and DOE Orders.
- Prepares environmental compliance plans and reports as mandated by laws and regulations and DOE Orders.
- Assesses current and planned Berkeley Lab programs and assists in defining environmental protection compliance upgrades and corrective actions.
- Identifies significant institutional environmental compliance issues and develops cost effective mechanisms for resolving them.
- Performs environmental dose assessments to document that radiation doses to the public are maintained well below the applicable standards and regulations.
- Prepares budget requests for and manages environmental protection upgrades and corrective actions for institutional projects.
- Provides training, makes presentations, and participates in discussions regarding environmental protection matters with Berkeley Lab employees, regulatory agencies, concerned public citizens, community organizations and the media.
- Manages the preparation of environmental operating permit applications.

- Curtails or suspends any operations that pose an immediate danger to members of the public or the environment.
- Monitors laboratory emissions and discharges to the environment to verify compliance with applicable regulations and permits.
- Investigates reports of unplanned environmental releases, and notifies federal, state, and local authorities in a timely manner, as required.
- Coordinates and represents Berkeley Lab activities during environmental audits and inspections by regulatory agencies and DOE.

11.6 GLOSSARY

Acutely hazardous wastes are any wastes defined as acutely hazardous by 22 CCR, Division 4.5, Chapter 11, Article 4.

Bay Area Air Quality Management District (BAAQMD) is the local agency responsible for regulating stationary sources of regulated or hazardous air pollutants in the San Francisco Bay Area.

Department of Toxic Substances Control (DTSC) s a Department within the California Environmental Protection Agency that regulates hazardous waste management and remedial actions.

East Bay Municipal Utility District (EBMUD) is the local municipal wastewater treatment facility which accepts and regulates sanitary sewer discharges from Berkeley Lab.

Effluent is any treated or untreated air emission or liquid discharge at Berkeley Lab or from a Laboratory facility.

Environmental monitoring is the collection and analysis of environmental samples or direct measurements of environmental media. Environmental monitoring consists of three major activities: effluent monitoring, environmental surveillance, and meteorological monitoring.

Environmental surveillance is the collection and analysis of samples, or direct measurements of air, water, soil, foodstuff, biota and other media from Berkeley Lab and its environs for the purpose of determining compliance with applicable standards and permit requirements, assessing radiation exposures of members of the public, and assessing the effects, if any, on the local environment.

Environmental occurrence is any sudden or sustained deviation from a regulated or planned performance at an operation that has environmental protection and compliance significance.

Extremely hazardous waste is any hazardous waste or mixture of hazardous wastes that, if human exposure should occur, may result in death, disabling personal injury, or serious illness because of its quantity, concentration, or chemical characteristics (22 CCR Section 66261.110).

Hazardous air pollutant is any pollutant that is listed in Section 112(b) of the Clean Air Act.

Hazardous wastes are wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity and toxicity. In addition, EPA has listed specific wastes as hazardous that do not necessarily exhibit these characteristics.

Public Owned Treatment Works (POTW) is a general term used for sewage treatment plants. The East Bay Municipal Utility District plant is the POTW that accepts sewage from Berkeley Lab.

Radionuclide is a natural or manmade atom which spontaneously undergoes radioactive decay.

Regulated air pollutants are pollutants for which standards have been promulgated under Section 111 of the Clean Air Act and include the classes of substances defined as nitrogen oxides, volatile organic compounds, or ozone-depleting substances.

State Water Resources Control Board (SWRCB) is the agency responsible for promulgating the California General Permit for Storm Water Discharge associated with industrial activities. At Berkeley Lab, this permit is administered and enforced by the San Francisco Regional Water Quality Control Board, with assistance from the City of Berkeley.

Underground storage tank (UST) is a stationary device designed to contain an accumulation of hazardous material or waste. A tank is constructed primarily of non-earthen material, but the entire surface area of the tank is totally below the surface of, and covered by, the ground.

United States Environmental Protection Agency is a Federal agency responsible for enforcing environmental laws. In California, some of this responsibility is typically delegated to state and local regulatory agencies.

11.7 STANDARDS

11.7.1 FEDERAL

- Office of Management & Budget (OMB) Circular A-106 Pollution Abatement
- 40 CFR, Part 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities*
- 40 CFR, Part 112, *Oil Pollution Prevention*
- 40 CFR, Part 122, *Federal Storm Water Discharge Requirements*
- 40 CFR, Part 136, *Guidelines Establishing Test Procedures for the Analysis of Pollutants (under the Clean Water Act)*
- 40 CFR, Part 141, *Safe Drinking Water Act*
- 40 CFR, Parts 260-272, *Resource Conservation and Recovery Act (Hazardous Waste Regulations)*

- 40 CFR, Part 403, *Federal Pretreatment Regulations*
- 40 CFR, Part 433, *Metal Finishing Point Source Category*
- Clean Air Act (42 U.S. C. Section 7401 *et seq.*)
- Clean Water Act (33 U.S.C. Section 1151 *et seq.*)
- Comprehensive Environmental Response, Compensation and Liability Act (42 U.S.C. Section 1601 *et seq.*)
- Resource Conservation & Recovery Act (42 U.S.C. Section 6901 *et seq.*)
- Toxic Substance & Control Act (15 U.S.C. Section 2601 *et seq.*)

11.7.2 STATE

- CCR, Title 17, Section 30287 & 30288, *Disposal by Release into Sanitary Sewers (Radionuclides)*
- CCR, Title 22, Division 4.5, *Environmental Health Standards for the Management of Hazardous Waste*, Sections 66001-67800.5
- CCR, Title 23, Division 3, Chapter 16, *Underground Storage Tank Regulations*
- Air Toxics "Hot Spots" Information and Assessment Act (California Health and Safety Code Section 44300 *et seq.*)
- California Clean Air Act (California Health and Safety Code Section 39000 *et seq.*)
- Hazardous Waste Control Law (California Health and Safety Code Section 25100 *et seq.*)
- Hazardous Waste Source Reduction and Management Review Act (California Health and Safety Code Section *et seq.*)
- Petroleum Storage Act (California Health and Safety Code Section 25270 *et seq.*)
- Petroleum Underground Storage Tank Cleanup (California Health and Safety Code Section 25299.10 *et seq.*)
- Porter-Cologne Water Quality Control Act (Water Code Section 13000 *et seq.*)
- Safe Drinking Water and Toxic Enforcement Act (California Health and Safety Code Section 25249.5 *et seq.*)
- Toxic Air Contaminants Law (California Health and Safety Code Section 44300 *et seq.*)
- Underground Storage of Hazardous Substances (California Health and Safety Code Section 25280 *et seq.*)

11.7.3 LOCAL

- Bay Area Air Quality Management District Rules and Regulations
- City of Berkeley Toxics Management Program
- San Francisco Bay Basin Plan and Amendments, Regional Water Quality Control Board

- East Bay Municipal Utility District Waste Water Control Ordinance No. 311
- City of Berkeley Storm Water Pollution Reduction Ordinance No. 6216
- DOE Order 5000.3A, Occurrence Reporting and Processing of Operations Information
- DOE Order 5400.1, *General Environmental Protection Program*, Chapter IV, paragraphs 1.a, 3, 4, 5 (not including 5.a.2.d), 6, and 10.c
- DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, Chapter II, paragraphs 1 (not including 1.a.3.c and 1.c), 2, 5, 6 (not including 6.a), 7, and 8.a and Chapter IV
- DOE Order 5700.6B, *Quality Assurance*

11.8 RELATED PUB-3000 CHAPTERS

- *Emergency Management* (Chapter 9)
- *Fire Prevention and Protection* (Chapter 12)
- *Hazardous Waste Disposal* (Chapter 20)

11.9 REFERENCES

- *Accidental Spill Prevention and Containment Plan*, Environmental Protection Group, Berkeley Lab
- *Air Emission Permits to Operate*, Bay Area Air Quality Management District
- *Air Quality Program Manual*, Environmental Protection Group, Berkeley Lab
- *Environmental Monitoring Plan*, Environmental Protection Group, Berkeley Lab
- *General Permit for Discharges of Storm Water Associated with Industrial Activity*, State Water Resources Control Board
- *Berkeley Lab Master Emergency Plan*, Berkeley Lab, PUB-533
- *PCB Management Plan, Environmental Protection Group*, Berkeley Lab
- *Spill Prevention, Control and Countermeasures Plan*, Environmental Protection Group, Berkeley Lab
- *Storm Water Monitoring Plan*, Environmental Protection Group, Berkeley Lab
- *Storm Water Pollution Prevention Plan*, Environmental Protection Group, Berkeley Lab
- *UST Monitoring and Emergency Response Manual*, Environmental Protection Group, Berkeley Lab
- *Wastewater Discharge Permits*, East Bay Municipal Utility District

All of the above references can be found in the Environment Protection Group offices, located in building 75B.

Chapter 12

FIRE PREVENTION AND PROTECTION

Revised December 1997

Reviewed by: Anthony a. [illegible] 12/9/97
Date

Approved by: [illegible] 12/15/97
EH&S Division Director Date

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Chapter 12

FIRE PREVENTION AND PROTECTION

12.1 POLICY

The fire prevention and protection policy at LBNL is to ensure that fires create no threat to the public nor hazards to employees. Property damage from fire must be held to a minimum, as must the impact of fire and related perils on the LBNL mission and programs.

This policy requires adherence to and compliance with all applicable laws, orders, regulations, codes, standards, guides, policies, and good practices pertaining to fire prevention and protection.

12.2 EMERGENCY PROCEDURES FOR FIRES AND OTHER FIRE-RELATED EMERGENCIES

1. Evacuate the immediate area in which there is a fire or a threat of fire and close the door.

2. Call the Fire Department:

   On site (including offsite leased bldgs. 1, 3, 901, 934, 936, 938 and 940):

   - Ext. 7911 (from an LBNL phone—486 or 495 prefix)

   - 486-6015 (from a cellular phone or a Pacific Bell phone)

On campus:

- Ext. 9-911 (on UC Campus—642 or 643 prefix).

The 7911 number is answered by the Berkeley Lab Fire Department dispatcher and is monitored by the onsite security department. The 9-911 number is answered by the UC Berkeley Police dispatcher, and information is then relayed to the responsible Fire Department, either the Berkeley Lab or City of Berkeley.

When reporting an emergency, it is important to identify yourself and be as detailed as possible. Report the following:

- Your name and specific location of the emergency, including room and building number, or nearest building, if possible, and phone number calling from.
- The nature and severity of the emergency, for example, structure fire, fire in lab hood, gas leak, explosion, or spill of hazardous materials.

3. Activate the nearest fire alarm to evacuate the occupants of the building.
4. Do not attempt to extinguish a fire involving a building's structure or a building containing explosives, radioactive materials, or highly toxic materials.
5. Do not attempt to extinguish a fire unless you have been trained in the use of fire extinguishers and have a clear escape route.

REPORT FIRES, SMOKE, OR ANY POTENTIAL FIRE HAZARDS TO THE FIRE DEPARTMENT.

IN AN EMERGENCY, CALL:

ON SITE (INCLUDING OFFSITE LEASED BLDGS. 1, 3, 901, 934, 936, 938, AND 940):

- **EXT. 7911 (FROM AN LBNL PHONE—486 OR 495 PREFIX)**
- **486-6015 (FROM A CELLULAR PHONE OR A NON-LAB PHONE)**

ON CAMPUS:

- **EXT. 9-911 (ON UC CAMPUS—642 OR 643 PREFIX)**

12.3 EMERGENCY PROCEDURES FOR HAZARDOUS MATERIAL SPILLS

Think safety first. Isolate the area and deny entry. Call for help.

To report a hazardous material release or spill, call the Berkeley Lab Fire Department, ext. 7911 (onsite) or ext. 9-911 (on campus). The Fire Department will respond in accordance with *EH&S Emergency Organization and HazMat Procedures 1.01* to manage and control the emergency situation. Refer to the LBNL *Chemical Hygiene and Safety Plan*, PUB-5341, for additional information regarding spill response.

The person reporting the spill should provide the fire dispatcher with the name of chemical(s) involved, quantity, state (gas, liquid, solid), possible contamination, spill locations, other active hazards, and injury information.

12.4 MEDICAL EMERGENCIES

1. Apply first aid at once if victim is not breathing, circulation has stopped, or heavy bleeding is occurring.
2. **DO NOT LEAVE THE SCENE TO REPORT THE INJURY. CALL FOR HELP. YOU MUST RESTORE BREATHING AND CIRCULATION AND STOP ANY BLEEDING.**
3. Instruct a bystander to call the Fire Department, ext. 7911 (on site) or 486-6015 if a cellular or non-Lab phone is used or ext. 9-911 (on campus), to summon medical aid.

12.5 FIRE PROTECTION EQUIPMENT

Portable and fixed fire protection equipment is provided for operating areas.

Portable equipment consists of fire extinguishers, which are available for employees to use before the Fire Department arrives (provided the employee has been trained in fire extinguisher operation). A schedule of training is available through EH&S.

Fire extinguishers are divided into four classes:

- Class A—Used for fires in ordinary combustible materials, such as wood, cloth, paper, rubber, and plastic.
- Class B—Used for fires in flammable and combustible liquids and flammable gases.
- Class C—Used for fires that involve energized electrical equipment.
- Class D—Used for fires in combustible metals, such as magnesium, titanium, lithium, potassium, and sodium.

Fire extinguishers are inspected monthly by Fire Department personnel. Any used or damaged extinguishers should be reported to the Fire Department, ext. 6015.

Fixed equipment includes smoke and heat detectors and alarms, automatic fire sprinklers, fire doors and dampers, attached fire hoses, and fire hydrants. Fixed equipment is described in the following sections.

12.6 FIRE DETECTION SYSTEMS

Several types of automatic fire detectors are used at LBNL. All on-site fire detection systems transmit an alarm to the Berkeley Lab Fire Dispatch Center when activated. Signals from fire alarm systems installed in the off-site buildings will be transmitted to fire/burglar alarm monitoring services available locally under contract with the building owner or LBNL. The fire/burglar alarm monitoring services will contact local police and fire department.

12.7 EVACUATION ALARMS

All buildings at LBNL are equipped with evacuation alarm bells. These are activated by either an automatic detector or a manual pull box. In some cases, automatic detectors also activate automatic extinguishing systems. The Fire Department will dispatch firefighters to the scene when an alarm is activated.

Evacuation procedures for each building and operating area, as well as personnel emergency actions for each building are published in the respective Building Emergency Plan.

12.8 AUTOMATIC SPRINKLERS

Many buildings at LBNL have automatic sprinkler systems. The sprinkler heads contain a fusible element that, upon melting, opens the head to start water flow. This flow in the piping activates an alarm at the Berkeley Lab Fire Dispatch Center.

For automatic sprinkler heads installed below 7'-0" above the finished floor or subjected to mechanical abuse, sprinkler guards shall be installed to prevent such damage.

Heat inadvertently applied to a sprinkler head can activate the sprinkler without the presence of fire.

KEEP NORMAL HEAT SOURCES AWAY FROM SPRINKLER HEADS.

To avoid reducing water flow or altering a spray pattern, do not place material or furniture near sprinkler heads.

ALLOW AT LEAST 46 CM (18 INCHES) CLEARANCE BELOW SPRINKLER HEADS.

MAINTAIN ACCESS FOR THE FIRE DEPARTMENT TO REACH SPRINKLER SYSTEM CONTROL VALVES.

MAINTAIN A MINIMUM CLEARANCE OF 91 CM (3 FEET) AT ALL TIMES AROUND THE VALVES.

12.9 FIRE DOORS AND DAMPERS

Self-closing and automatic fire doors and dampers are located at strategic points. A damper is a door in an air-handling system that closes to prevent smoke from being spread throughout the system.

Automatic fire doors close and latch to block the spread of smoke and fire when automatic detectors are activated.

Maintain fire doors in good repair at all times. Never block or otherwise prevent fire doors from functioning.

Self-closing fire doors are designed and installed to reclose automatically after being opened.

NEVER BLOCK, WEDGE, OR TIE OPEN SELF-CLOSING FIRE DOORS.

IF THE DOORS MUST REMAIN OPEN, REPLACE THE SELF-CLOSING MECHANISM WITH AN APPROVED AUTOMATIC SMOKE-ACTIVATED RELEASE HOLD-OPEN DEVICE.

CONTACT THE WORK REQUEST CENTER IN THE FACILITIES DEPARTMENT, EXT. 6274, FOR ASSISTANCE WITH THIS CONVERSION.

12.10 FIRE HYDRANTS

The Berkeley Lab Fire Department maintains on-site fire hydrants for emergency use. These must be accessible and in good working order at all times. To use a fire hydrant on a temporary basis, obtain authorization in writing from the Fire Marshal, ext. 6360, or the Fire Protection Engineer, ext. 6095.

Employees or contractors who have temporary authorization to use a fire hydrant must:

- Use only valve outlets provided by the Plumbing Shop.

- Use only the hydrant spanner provided by the Fire Department.
- Supervise the connections while in use, except at construction sites.
- Close hydrant valve one-eighth of a turn after fully opening it. The hydrant valve must be closed SLOWLY to prevent damage to the water main as a result of the water hammer effect.
- Replace outlet caps after using the hydrant and tighten these caps by hand.

12.11 PERMITS

The Berkeley Lab Fire Department's program to reduce fire hazards includes a permit system. Fire detection system may have to be impaired temporarily while this activity is being carried out. Permits are required for the following tasks:

- Welding (arc, oxyacetylene, or heliarc)
- Soldering
- Using a torch
- Using tar pots
- Having an open fire
- Spray painting

To obtain a permit or additional information prior to start of work, call the Berkeley Lab Fire Department, ext. 6015.

12.12 COMBUSTIBLES

Combustible materials are divided into four types, described in the following paragraphs.

12.12.1 CLASS A COMBUSTIBLES

Class A combustibles include common combustible materials (e.g., wood, paper, cloth, rubber, and plastics) that can act as fuel and are found in nonspecialized operating areas (e.g., offices).

To handle Class A combustibles safely:

- Dispose of waste daily.
- Keep all trash in metal or metal-lined receptacles with tight-fitting covers. Metal wastebaskets that are emptied every day do not need to be covered.
- Use ash trays to extinguish smoking materials. Make sure that the contents of ash trays are extinguished, and empty the contents into a safe receptacle.
- Keep work areas clean and free of fuel paths that could allow a fire to spread.

- Keep combustibles away from accidental ignition sources (e.g., hot plates, soldering irons, and other heat- or spark-producing devices).
- Store paper stock in metal cabinets.
- Store rags in metal bins with self-closing lids.
- Do not order excessive amounts of combustibles. An excess could increase fuel loads, cause housekeeping problems and, if not stored properly, could become a fire hazard.
- Make frequent inspections to anticipate fires before they start.

The following fire extinguishing agents are approved for Class A combustibles:

- Water
- Multi-purpose dry chemical (ABC)
- Halon 1211

Halons have been identified as ozone-depleting substances and as such have been targeted for removal. Federal regulations require that DOE and contract facilities phase out halon (and other chlorofluorocarbons) at prescribed time periods. The Berkeley Lab Fire Department has developed a Halon Phase-Out Plan and will be implementing it in accordance with the new regulations.

12.12.2 CLASS B COMBUSTIBLES

Class B combustibles include flammable and combustible liquids (e.g., oils, greases, tars, oil-based paints, and lacquers), flammable gases, and flammable aerosols such as those found in spray cans. (See the *Pressure Safety and Cryogenics* chapter of this manual and the *Chemical Hygiene and Safety Plan*, PUB-5341.)

DO NOT USE WATER TO EXTINGUISH CLASS B FIRES CAUSED BY FLAMMABLE LIQUIDS. WATER CAN CAUSE BURNING LIQUID TO SPREAD, WORSENING THE FIRE.

TO EXTINGUISH A FIRE CAUSED BY FLAMMABLE LIQUIDS, EXCLUDE THE AIR AROUND THE BURNING LIQUID.

The following fire extinguishing agents are approved for Class B combustibles:

- Carbon dioxide
- Multi-purpose dry chemical (ABC)
- Halon 1301
- Halon 1211

CONTROL FIRES INVOLVING FLAMMABLE GASES ESCAPING FROM A TANK BY CLOSING THE VALVE TO ELIMINATE THE SOURCE OF THE FUEL.

Technically, flammable and combustible liquids do not burn. They can, however, generate sufficient quantities of vapors to form ignitable vapor-air mixtures.

The flashpoint of a liquid is defined as the minimum temperature at which the liquid gives off sufficient vapor to form an ignitable mixture with the air near its surface or within the vessel used.

Generally, the lower the flashpoint of a liquid, the greater the risk of fire and explosion. Many flammable and combustible liquids also pose health hazards, as discussed in the *Chemical Hygiene and Safety Plan*, PUB-5341.

Make sure that Class B combustibles are properly identified, labeled, handled, and stored. Contact EH&S Fire Protection Staff, ext. 6095 or 6370, for assistance.

- Use only approved containers, tanks, equipment, and apparatus for storage, handling, and use of Class B combustibles.
- Store quantities greater than 38 liters (10 gallons) of flammable liquids in approved storage cabinets or special rooms approved for such storage.
- Label the contents of all containers accurately and conspicuously.

To handle Class B combustibles safely:

- Use only approved pumps, taking suction from the top, to dispense liquids from tanks, drums, barrels, or similar containers; or use approved self-closing valves or faucets.
- Class I flammable liquids (liquids having flash points below 73°F or boiling point below 100°F) shall not be dispensed into containers unless the nozzle and container are electrically interconnected by contact or by means of a bonding wire. Either the tank or the container shall be grounded. This is to avoid building up of static electricity. (See NFPA 77, Recommended Practice on Static Electricity for additional guidance) *Containers of glass or other non-conducting materials of 19 liters (5 gal) or less can be filled without special precautions.*
- Store, handle, and use Class B combustibles only in approved locations where vapors are prevented from reaching ignition sources (e.g., heating or electrical equipment, open flames, or mechanical or electrical sparks).
- Do not use a flammable liquid as a cleaning agent inside a building. The only exception is in a closed machine approved for cleaning with flammable liquids. Using flammable solvents can also pose inhalation hazards if not adequately controlled and ventilated.
- Do not use, handle, or store Class B combustibles near exits, stairways, or any other areas normally used as exits.

- Do not weld, cut, grind, or use unsafe electrical appliances or equipment near Class B combustibles.
- Do not generate heat, allow an open flame, or smoke near Class B combustibles.
- Know the location of and how to use the nearest portable fire extinguisher rated for Class B fire.

THE FIRE DEPARTMENT OFFERS A COURSE ON FIRE EXTINGUISHER USE (EH&S-130).

FOR INFORMATION, CALL EXT. 6554.

FOR ENROLLMENT, CALL EH&S TRAINING COORDINATOR, EXT. 6571

EMPLOYEES TRAINED IN FIRE EXTINGUISHER USE MAY USE FIRE EXTINGUISHERS WHILE WAITING FOR THE FIRE DEPARTMENT TO ARRIVE. REFER TO THE SECTION OF THIS CHAPTER ON "EMERGENCY PROCEDURES FOR FIRES."

12.12.3 CLASS C COMBUSTIBLES

Class C combustibles are energized electrical equipment which, when de-energized, would be classified as Class A or B combustibles.

The following fire extinguishing agents are approved for Class C combustibles:

- Carbon dioxide
- Multi-purpose dry chemical (ABC)
- Halon 1301
- Halon 1211

12.12.4 CLASS D COMBUSTIBLES

Class D combustibles are combustible metals that present special fire safety and extinguishing problems. For guidance on safe handling of combustible metals and selection of the proper extinguishing agent, contact the Berkeley Lab Fire Department, ext. 6015.

12.13 PORTABLE HEATING DEVICES

Portable heating devices include coffee pots, hot plates, and portable electric heaters. Portable heating devices may only be used when there is no chance of injury or fire occurring from their use. This applies both to LBNL and personally owned devices. When plugged in, these devices should not be left unattended.

Portable heating devices must not be used in the following locations:

- Where flammable or explosive vapors or dusts may be present.
- Where smoking, eating, or drinking are prohibited due to the possible presence of toxic or radioactive materials.
- Where an area is designated as unsafe for such devices.

To handle portable heating devices safely:

- Confirm that appliances are listed either by Underwriters Laboratories, Inc., or by Factory Mutual Research Corporation
- Do not place appliances on unstable surfaces or adjacent to readily combustible materials. Maintain a clearance of at least 46 cm (18 inches) between appliances and combustible material.
- Connect appliances directly to proper electrical outlets using the original manufacturer's cord. Do not use extension cords in lieu of permanent wiring.
- Do not leave an appliance unattended during off hours unless the appliance is controlled by a timer installed by an LBNL electrician. The timer must de-energize the appliance during off hours and energize it no more than 30 minutes prior to the beginning of the workday.
- For 24-hour operation (e.g. during construction or maintenance shutdown), obtain a permit by calling the Berkeley Lab Fire Department, ext. 6015, for the proposed operation. Post the permit conspicuously near the appliance.

12.14 MECHANICAL EQUIPMENT AND FAN ROOMS

Mechanical equipment rooms house boilers, blowers, compressors, filters, and other electrical equipment. These rooms must be separated from other areas of a building by fire-resistant walls and doors.

NEVER LEAVE FIRE DOORS OPEN IN A MECHANICAL EQUIPMENT ROOM.

Fan rooms house ventilation equipment (e.g., dampers and automatic shutdown equipment). This equipment is often interlocked with a building's smoke and fire detectors.

NEVER DISABLE FIRE DAMPERS OR OTHER AUTOMATIC SHUTDOWN EQUIPMENT WITHOUT THE APPROVAL OF THE FIRE MARSHAL.

NEVER USE MECHANICAL EQUIPMENT ROOMS OR FAN ROOMS FOR STORAGE.

12.15 CONSTRUCTION AREAS

Ensure that construction areas under the control of LBNL or outside contractors are safe from the threat of fire. Maintain access for Laboratory emergency response personnel to reach construction areas and access to fire hydrants at all times.

12.16 EMERGENCY LIGHTING

The Life Safety Code of the National Fire Protection Association (NFPA 101) requires emergency lighting within facilities at the following areas:

- Exit corridors in any office-type building two or more stories above the level of exit discharge.
- All exit aisles, corridors, and passageways of research and industrial facilities (e.g., laboratories, accelerators, and shops).
- Elevators, for a period of at least 4 hours (see the CCR Title 8, California Construction Safety Orders and the California Building Code).

Emergency lighting that is not required by the code may be installed in areas where egress would be hazardous during a power failure.

Two types of emergency light fixtures satisfy the code specifications:

- Battery powered
- Generator powered

Use only rechargeable batteries in battery-operated emergency lights. The battery rating must be sufficient to provide illumination for 1.5 hours if normal lighting fails. When emergency lighting is provided by a generator, the delay must not be greater than 10 seconds.

12.17 EXIT SIGNS

The California Fire Code, California Building Code, and the Life Safety Code of the National Fire Protection Association (NFPA 101) require that approved exit signs be provided in specific locations in buildings to designate the means of egress from the buildings. The codes specify the minimum size, graphics, power supply, visibility, and conditions for installation of exit signs.

Exit signs:

- Must not be installed without the approval of the Fire Marshal or Fire Protection Engineer or his or her authorized representative.
- Must be installed at all required exit doorways and where necessary to indicate clearly the direction of egress. Access to exits must be marked by an exit sign when the exit or exit pathway is not immediately visible to the occupants.
- Must be installed where two or more exits are required from a room or area, except when main exterior doors are obvious and clearly identifiable as an exit (e.g., glass doors).
- Must be illuminated. (Report burned-out lights to the Facilities Department's Work Request Center, ext. 6274.)

Doors, passages, or stairways that are not exits, but could be mistaken as such, must be identified by a posted sign on the door stating: *NOT AN EXIT*.

12.18 PATH MARKINGS

Path markings (e.g., arrows or stripping) on floors or walls may be necessary to identify exit routes clearly in certain facilities. Path markings should be luminous or phosphorescent to be identifiable in case of power failure.

12.19 EXIT CORRIDORS

NFPA 101 requires that buildings designed for human occupancy maintain unobstructed exits to facilitate prompt evacuation of building occupants and access for emergency personnel.

NEVER USE EXIT CORRIDORS FOR:

- **PERMANENT STORAGE**
- **TEMPORARY STORAGE OF FURNITURE, EQUIPMENT, OR SUPPLIES**
- **STORAGE OF COMBUSTIBLES, INCLUDING RECYCLABLE WASTE OR PAPER**

12.20 LOCKERS AND CABINETS

In the past, installing metal lockers and cabinets in exit corridors was permitted as long as the lockers and cabinets complied with specific location rules, design characteristics, and storage limitations. These storage practices are no longer considered safe and are in violation of fire and life safety codes. The Facilities and Fire Departments are implementing a phased plan to remove existing storage cabinets from exit corridors. To adhere to the new regulations, use the following guidelines:

- Do not install storage cabinets in exit corridors.
- Remove any cabinet that does not have 45-degree angle fairing at its top and sides.
- Remove cabinets that have not been properly maintained (e.g., doors that do not automatically return to the closed position or cabinets that are not anchored to the wall).
- Do not store chemicals, liquids, or combustible materials in cabinets.

12.21 SMOKING

Smoking is forbidden in all LBNL buildings. Certain outdoor areas are also designated as *no smoking* areas. Areas in which smoking is prohibited are identified by white rectangular signs that state in red letters on a white background: *NO SMOKING.*

12.22 NEW EXPERIMENTS AND RESEARCH ACTIVITIES

New experiments and research activities are reviewed by the Fire Protection Staff as part of an Activity Hazard Document (AHD) review. This review ensures that the risks are reduced to an acceptable level and that the required engineering and administrative controls are in place.

In order to identify the necessary safeguards for the experiment or process, the Fire Protection Staff will conduct a review of currently accessible chemical inventory data for information on hazardous material use and storage.

12.23 RESPONSIBLE PARTIES

The following parties are responsible for implementing the LBNL fire prevention and protection policy:

12.23.1 LBNL MANAGEMENT

- Sets LBNL fire prevention and protection policy consistent with applicable codes, regulations, and DOE orders.
- Provides and maintains the necessary fire protection program/services to maintain adequate level of fire and life safety as well as property protection.
- Minimizes the potential for the occurrence of fire or related perils.
- Ensures the safety of LBNL employees in the event of fire.
- Ensures that a fire does not cause an unacceptable on-site or off-site release of hazardous material that will threaten the public's health and safety or the environment.

- Ensures that vital DOE programs will not suffer unacceptable delays as a result of fire or related perils.
- Ensures that property damage resulting from fire and related perils does not exceed levels established by DOE.
- Ensures that experiments, research projects, and activities involving materials hazardous to life or property are reviewed by the appropriate EH&S authorities, including the Fire Department, prior to design and initiation.

12.23.2 FIRE SAFETY SUBCOMMITTEE

- Subcommittee appointed by the Safety Review Committee to address specific health and safety matters related to Fire Safety.
- May be requested to review interpretation and implementation of fire codes, regulations, and policy in research laboratories.

12.23.3 FIRE MARSHAL

- Enforces, interprets, applies, and implements the LBNL fire prevention and protection policy.
- Has the authority to suspend unsafe operations or activities.
- Ensures Lab-wide compliance with fire prevention and protection requirements.
- Delegates to members of the Fire Department responsibility and authority for enforcement of the LBNL fire prevention and protection policy.
- Along with his or her authorized representatives, functions as the authority having jurisdiction (AHJ) in the enforcement and application of the LBNL fire prevention and protection policy.

12.13.4 FIRE DEPARTMENT

- Prevents and controls fires.
- Provides emergency response services to protect people and property from fires, explosions, and other hazardous events.
- Investigates the cause, origin, and circumstances of fires and explosions.
- Responds to all calls received by the Berkeley Lab Fire Dispatch Center.
- Provides first-response rescue and transportation services in medical emergencies.
- Conducts Fire Safety Inspections.
- Inspects fire extinguishers.
- Develops and maintains up-to-date Pre-fire Plans to effectively prepare and respond to building emergencies.

- Trains employees in fire safety, fire extinguisher operation, and use of self-contained breathing apparatus.

12.23.5 FIRE PROTECTION ENGINEER

- Responsible for the overall Fire Protection Program.
- Reviews Facilities Department projects to ensure LBNL's compliance with fire- and life-safety requirements for the storage, handling, and use of explosives and flammable, combustible, toxic, corrosive, and other hazardous materials.
- Provides guidance for fire safety in the design, processes, and equipment used in experiments and research projects.
- Conducts fire risk surveys and fire hazard analyses, and makes recommendations based on findings.
- Inspects and supervises the testing, repair, and maintenance of automatic fire protection and alarm systems.
- Manages fire extinguisher and fixed fire suppression systems maintenance and testing program.
- Supports Fire Marshal in ensuring Lab-wide compliance with fire prevention and protection policy.

12.23.6 FACILITIES DEPARTMENT

- Ensures compliance with all fire safety, inspection, and protection requirements for planning, designing, constructing, and installing buildings, structures, systems, and utilities.
- Ensures that all architectural and engineering projects are reviewed by the appropriate EH&S authorities, including the Fire Department.
- Inspects, tests, and maintains the water supply, fire alarms, and fixed fire extinguishing systems.

12.23.7 SUPERVISORS

- Notify the Fire Department when changes in operation increase the risk of fire or other related perils.
- Ensure that their employees receive appropriate fire safety training to work safely and protect LBNL assets.

12.23.8 EMPLOYEES

- Complete all requisite training before working without supervision.
- Conduct operations with minimum risk of fire.
- Report fires, smoke, and potential fire hazards to the Fire Department immediately.

12.24 GLOSSARY

Authority Having Jurisdiction (AHJ) determines the interpretation and application of fire prevention and protection requirements.

Fixed equipment includes detectors and alarms, automatic fire sprinklers, fire doors and dampers, attached fire hoses, and fire hydrants.

NFPA is the National Fire Protection Association.

Portable equipment consists of fire extinguishers.

12.25 STANDARDS

- CAC, Title 24, Part 2, California Building Code
- CAC, Title 24, Part 9, California Fire Code
- California Health & Safety Code
- NFPA 101, Life Safety Code
- NFPA 1, Fire Protection Code
- CCR Title 8, California Construction Safety Orders
- Title 19, California Code of Regulations
- 29 CFR 1910, *General Industry Safety Orders*
- 29 CFR 1926, *OSHA Construction Industry Standards*
- DOE Orders 420.1, *Facility Safety*
- DOE Orders 440.1, *Worker Protection Management for DOE Federal and Contractor Employees*

12.26 RELATED PUB-3000 CHAPTERS

- *EH&S Training* (Chapter 24)
- *Emergency Management* (Chapter 9)
- *Hazardous Waste Disposal* (Chapter 20)
- *Industrial Hygiene* (Chapter 4)
- *Pressure Safety and Cryogenics* (Chapter 7)

12.27 REFERENCES

- *American Petroleum Institute Guidelines*, latest edition

- *Chemical Hygiene and Safety Plan*, PUB-5341, Lawrence Berkeley Laboratory, August 1992
- *EH&S Emergency Organization and HazMat Procedures 1.01*, Lawrence Berkeley Laboratory, September 1, 1993
- Factory Mutual Loss Prevention Data Sheets, latest editions
- National Fire Protection Association Handbooks, latest editions
- *Master Emergency Plan*, PUB-533, Lawrence Berkeley Laboratory, July 1993
- *Society of Fire Protection Engineers (SFPE) Handbook*, latest edition

Chapter 13

GASES

Revised December 1997

Reviewed by: Bruce King 12/10/97
Date

Approved by: [signature] 12/15/97
EH&S Division Director Date

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Chapter 13

GASES

13.1 POLICY

Berkeley Lab will take precautions to prevent injuries, property damage, and disruption to operations caused by leaks of compressed gas and over-pressurizations. Types of injuries and accidents that will be controlled include:

- Injuries caused by flying objects accelerated by an explosion or pressure release
- Fires and injuries caused by flammable gas ignition
- Injuries caused by inhalation of toxic or asphyxiating gases

This policy requires the use of industry standard gas systems, engineering controls, and administrative controls, as well as training. Higher-hazard gas systems require redundant levels of engineering controls.

13.2 SCOPE

This policy applies to the storage, use, and handling of gases in pressurized portable containers and gas systems. The primary focus of this chapter is on single gas uses and systems. Additional requirements apply to:

- Use of multiple gases in a single control area or building
- Pressure and cryogenic systems, covered in Chapter 7
- Large compressed gas facilities, storage areas, or use areas
- Transportation of compressed gases on or across Berkeley Lab public roads

13.3 DIRECTORY

Topic	Source
General Compressed Gas Requirements	See the *General Compressed Gas Systems* section of this chapter.
Hazardous Gas Requirements	See the *General, Flammable, Health Hazard, and Pyrophoric Gases* sections of this chapter. Contact the EH&S Hazardous Gas Safety Coordinator, ext. 5255.
Pressure Safety	See Chapter 7, *Pressure Safety and Cryogenics.* Contact the EH&S Pressure Safety Coordinator, ext. 6428 for general concerns. Contact Mechanical Engineering, ext. 5689, for pressure safety evaluations and Safety Notes.
Activity Hazard Document (AHD)	See the *General (Documentation)* section of this chapter and Chapter 6, *ES&H Documentation and Approvals*. Contact the EH&S AHD Coordinator, ext. 4171, for safety review of AHDs.
Fire, Life-safety, and Code Requirements	Contact EH&S Fire Prevention, ext. 6095.
Hardware for Gas Systems	See this chapter and Chapter 7, *Pressure Safety and Cryogenics.* Contact the Maintenance & Operations Regulator Shop, ext. 7669, for regulators, components, and gas system installations.
New Installation of Facilities	Contact the Facilities Work Request Center, ext. 6274.
Maintenance of Facilities	Contact the Facilities Work Request Center, ext. 6274.
Purchasing Gases	Lower hazard industrial and high purity gases (e.g., nitrogen, oxygen, hydrogen): Fax order form to Bay Air Gas (phone 658-5010, Fax 652-6513). Higher hazard and speciality gases: Use the Berkeley Lab requisition form and ordering system and send to Purchasing (Gas Buyer, ext. 5460). Contact the EH&S Hazardous Gas Safety Coordinator, ext. 5255, for pre-purchase approval of health and pyrophoric hazard gases. Contact the gas supplier sub-contractor coordinator, ext. 4216, for questions regarding the gas supply sub-contracts.
Delivery and Pickup of Gas Cylinders	See the *General (Gas Cylinders)* and *Health Hazard Gases (Gas Delivery and Return)* sections of this chapter. Lower hazard industrial and high purity gases (e.g., nitrogen, oxygen, hydrogen): A routine transportation schedule is maintained by Bay Air Gas. Higher hazard and speciality gases: Contact Facilities Transportation, ext. 5404, for cylinder delivery and pickup.

13.4 GENERAL COMPRESSED GAS SYSTEMS

13.4.1 GAS LEAK EMERGENCIES

Hazardous gas leaks that pose a fire, explosion, or health hazard must be reported to the Berkeley Lab Fire Department (ext. 7-911 on site, or ext. 9-911 on Campus) after the area has been evacuated.

Ignition sources in the vicinity of leaking flammable gas should be turned off if an immediate hazard does not exist. A leaking hazardous gas cylinder must not be moved or transported. Room ventilation systems and exhausted enclosures required by this policy should control the hazard until the Fire Department can initiate action. The Berkeley Lab Fire Department is equipped and trained to contain a leaking gas cylinder in a pressure-rated overpack.

13.4.2 DOCUMENTATION

Process Safety Documentation

An Activity Hazard Document (AHD) shall be developed and approved for all hazardous gas uses that could cause significant injury, property damage, or off-site consequences (see Chapter 6 for AHD administrative requirements). Examples of gas uses that typically require AHDs include:

- NFPA Classes 3 and 4 Health Hazard gases, and Class 2 gases with poor warning properties (see the *Health Hazard Gases* section of this chapter)
- Flammable gas in quantities greater than 11 m^3 (400 CF)
- Pyrophoric gases
- Gases in situations that may cause oxygen deficiency in a room

Gas Quantity and Location Control

Total quantities of hazardous gases at specific locations must be controlled. Gas quantity limitations (i.e., exempt amounts) are specified in Tables 3D and 3E of the California Building Code. Gas in quantities up to these exempt amounts may be stored, dispensed, handled, or used within each control area or building (i.e., in the absence of defined control areas). Quantities greater than the exempt amounts require building construction modifications. Contact the Fire Department for specific requirements.

To control quantities of hazardous gases at specific locations, a list of hazardous gases should be maintained at each location. This list will itemize gas quantities and identify storage locations. The Berkeley Lab chemical inventory system can help with this task. The list should be included in the AHD, when appropriate. Typical information on the list includes each gas name and hazard category(ies), number of cylinders, cylinder size(s), total cylinder volume(s) at standard temperature and pressure (STP) in cubic meters (m^3) and cubic feet (CF), and maximum allowable quantities by hazard category(ies). When incompatibility separations are required, storage locations for each gas shall be noted.

13.4.3 TRAINING

Personnel who operate or work on compressed gas and pressure systems must complete the Berkeley Lab *Pressure Safety Orientation* (EHS 231). Additional requirements apply to personnel who design or assemble pressure systems (see Chapter 7, *Pressure Safety and Cryogenics*).

Personnel who handle or use hazardous gases must complete the *Chemical Hygiene and Safety Course* (EHS 348). These personnel must also receive specific training on the hazard and safety procedures for each hazardous gas-use operation, including a review of any AHD. This training is the responsibility of the supervisor.

13.4.4 GAS CYLINDER STORAGE AND USE LOCATIONS

Exits and Lighting

Storage and use of gas cylinders in exit corridors are prohibited. Hazardous gases must be located away from exit routes and doors, unless located in gas cabinets. Adequate natural or artificial lighting must be provided.

Area Signs

Entrances to all areas where hazardous gases are used or stored must be posted with visible and durable gas hazard identification signs. Hazardous gas exterior storage and use areas shall have signs that prohibit smoking within 8 m (25 ft).

Exterior Locations

Exterior storage and use areas must be covered with a noncombustible canopy. These areas must be protected from vehicle damage. Cylinders must not be placed on unpaved ground or on surfaces where water can accumulate.

Combustible Materials Separation

Cylinder storage and use locations must be kept clear of all weeds, grass, brush, and trash, as well as any other combustible materials, for a minimum distance of 5 m (15 ft) from all cylinders. Exception: an approved noncombustible barrier, cabinet, or hood may be used instead (see the *Hazardous Materials Separation* section, below).

Hazardous Materials Separation

Hazardous gases must be separated from incompatible hazardous materials by distance, barriers, cabinets, or lab hoods, as noted in Table 13.1. See Appendix B for hazard categories of specific health hazard gases. When a gas is classified in more than one category, all compatibilities shall be considered and the most stringent separation used. Non-hazardous gases (e.g., inerts) may be stored in any hazard category. When gas cylinders must be separated into hazard categories, each category area will be posted with a hazard category sign.

Table 13.1. Gas Cylinder Separation by Hazard

Gas Hazard Category	Non-Flammable	Corrosive	Oxidizing	Flammable	Pyrophoric
Toxic	—[a]	—	6 m (20 ft)[b]	6 m (20 ft)[b]	6 m (20 ft)[b]
Pyrophoric	—	—	6 m (20 ft)[b]	6 m (20 ft)[b]	
Flammable	—	—	6 m (20 ft)[b]		
Oxidizing	—	—			
Corrosive	—				

Footnotes:

[a] A dash (—) indicates that cylinders with these hazard ratings may be stored adjacent to each other.

[b] Exception 1: Containers of hazardous solids or liquids with a capacity less than 2.3 kg (5 lb) or 1.9 L (0.5 gal) when stored in quantities not exceeding exempt amounts specified in Article 80 of the UFC.

Exception 2: Distances can be reduced without limit when hazardous materials are: (1) separated by a one-half-hour-rated noncombustible barrier (e.g., 2.5 mm or 12 gauge steel) that extends not less than 50 cm (18 in) above and to the sides of the gas cylinder; or (2) stored in separate approved hazardous materials storage cabinets, gas cabinets, or lab hoods.

Safety Shower and Eyewash

An approved safety shower and eyewash will be maintained within 30 m (100 ft) or 10 seconds (whichever is less) of locations where corrosive, eye-irritating, or skin/eye-toxic gases are stored or used.

13.4.5 GAS CYLINDERS

Cylinder Transportation

Only standard DOT cylinders will be used for transporting compressed gas.

Personnel who are trained to use compressed gases may use standard cylinder carts to transport cylinders within buildings and between adjoining buildings. Carts are preferred, but cylinders weighing 11 kg (25 lb) or less may be hand-carried. Valve protection caps and plugs must be in place during movement of cylinders. Lecture bottles and other cylinders without protective caps must be transported in standard shipping crates, or an equivalent container.

Gas cylinders must be transported between nonadjoining buildings by a person properly trained, licensed, and equipped to transport gas cylinders. Proper transportation is provided by Berkeley Lab Facilities Transportation or approved Berkeley Lab gas supply sub-contractors.

Cylinder Position

Gas cylinders must be stored in a "valve end up" upright position, which includes conditions where the cylinder is inclined as much as 45 degrees from the vertical. Exceptions include cylinders designed for use in a horizontal position, and cylinders with non-liquified compressed gas that have a water volume less than 5L (0.18 CF or 1.3 gal).

Cylinder Securing

Gas cylinders must be secured to prevent falling due to accidental contact, vibration, or earthquakes. Cylinders must be secured in one of the following ways:

- By a noncombustible, two-point restraint system (e.g., chains) that secures the cylinder at the top and bottom one-third portions. Exception: cylinders less than 1 m (3 ft) tall require only one restraining point.
- By a noncombustible rack, framework, cabinet, approved strapping device, secured cylinder cart, or other assembly that prevents the cylinder from falling.

Cylinder Valves, Caps, and Plugs

Gas cylinders designed to have valve-protection caps and valve-outlet caps and plugs must have these devices in place. Exception: when the cylinder is in use or being serviced.

Gas cylinder valves must have a handwheel, spindle key, or other approved control handle on the valve stem while the cylinder is in use. Cylinder valves should be opened slowly. Cylinder valves seat in both the closed and open position and are likely to leak unless left in the fully-open or fully-closed position.

Unauthorized Cylinder Modification or Use

All labels, markings, and tags provided on the gas cylinder by the manufacturer must be maintained in good condition. Gas cylinder parts must not be modified, tampered with, obstructed, removed, repaired, or painted by the gas user.

"Empty" Cylinders

Gas cylinders should be left with residual pressure (i.e., typically 200 kPa or 30 psi) to prevent contamination of cylinder contents. Cylinders considered to be empty should be handled with the same precautions as cylinders filled with gas because so-called "empty" cylinders still contain residual gas and pressure. Empty gas cylinders must be labeled "Empty."

Cylinder Changing

Two people must be present during hazardous gas purge and cylinder change procedures. Reconnected gas fittings must be checked for leaks using a leak detection fluid or other approved method.

Cylinder Temperature Control

Gas cylinders should be stored in the shade and must not be exposed to temperatures exceeding 50 C (125 F).

13.4.6 GAS FLOW SYSTEM

Pressure Safety

Compressed gas systems must be designed and installed in accordance with the requirements of Chapter 7, *Pressure Safety and Cryogenics*, except for the following:

- Inert gas systems to 1 MPa gauge (150 psig) with a total stored energy of not more than 100 kJ (75,000 ft-lb).
- Compressed gas cylinder manifolds assembled by the Facilities Department Regulator Shop.
- Simple flow system with a standard pressure regulator, with pressure relief devices set to no more than 1 MPa gauge (150 psig), and with no components rated for a working pressure less than 1 MPa gauge.

Under no circumstances may any gas be used without a standard pressure regulator that is rated for the service.

All pressurized hazardous gas system connections shall be leak-checked on new gas systems and after reconnection of any fitting.

Pipes and Components

Gas pipes, valves, fittings, regulators, and related components must be constructed of materials compatible with the gases to be contained and must be rated for the service.

In general, gas systems must be constructed of approved metallic tubing with compression fittings, or better. Where nonmetallic tubing is approved, additional controls may be required. Stainless steel components are preferred. Additional requirements apply to systems covered in Chapter 7.

Pipe Labels

Each gas line outside of the source gas cabinet or lab hood that contains compressed gas must be labeled at least every 6 m (20 ft), at every change in direction, at critical shutoff valves, and as needed to provide clear identification. Labels shall be durable and display the gas name and direction of gas flow. Exception: piping that may contain more than one type of gas at various times must have signs or labels posted at the manifold, along the piping, and at points of use, as needed, for clear identification and warning.

Regulators

Gas system pressure shall be reduced through a regulator mounted to the cylinder valve outlet or to a manifold installed by the Regulator Shop. Exception: an excess flow valve may be installed between the cylinder valve and regulator. A regulator of the approved type and design for the specific gas and cylinder combination must be used.

Regulators should be inspected by the Berkeley Lab Regulator Shop before installation to ensure that the regulator is the correct one for the particular application and is in safe working condition. Only the Regulator Shop is authorized to alter or repair regulators at Berkeley Lab. Oxygen regulators must be labeled for oxygen service, and used regulators reapplied to oxygen service must be degreased in the Regulator Shop.

Back-Flow Prevention

Check valves or other back-flow prevention devices must be provided when the back-flow of materials could create a hazardous condition.

Shutoff Valves

Required emergency shutoff valves must be easily accessible, the valve location identified by means of a sign, and the valve labeled with the gas name or function. Exception: gas cylinder valves do not need to be identified.

An emergency gas shutoff valve must be located at the process equipment utilizing hazardous gas when this equipment is in a different room from the source gas cylinder.

Accidental Flow Control

Excess flow valves (EFVs) or restrictive flow orifices (RFOs) are recommended and may be required by this policy or EH&S to control accidental gas leaks or flows that could cause a fire, explosion, or health risk. Systems with such devices require a Safety Note and must be constructed in accordance with the requirements of Chapter 7, *Pressure Safety and Cryogenics*.

13.4.7 PURGE GAS

When an inert gas source is used to purge hazardous gas from gas lines where different hazard categories of gas are in use at the same time, a separate purge supply shall be used for each category of hazardous gas. It is also preferable to have a separate purge cylinder for each hazardous gas cylinder that is in use. Back-flow prevention devices must be installed between the purge gas supply and the hazardous gas system.

13.4.8 VACUUM PUMPS

The type of vacuum pump oil to be used with gases and chemicals must be analyzed for its compatibility with those gases and chemicals. Hydrocarbon oil should not be used with an oxidizer (i.e., oxygen in concentrations greater than or equal to 25%) or with pyrophoric gases. Inert oils should be used instead. Pumps must have a pressure relief or shutdown device that prevents the pump from bursting if a line becomes plugged. Oil drip pans should be provided under all pump and oil filter assemblies.

13.4.9 VENTILATION

General Ventilation Requirements

Exhaust ventilation systems for hazardous gas areas and hazardous gas uses must be installed in accordance with the California Fire and Mechanical Codes and must operate continuously

General area mechanical ventilation for hazardous gas stored and used indoors must be 0.005 m^3/s per square meter (one cfm per square foot) of floor area or greater.

Exhausted Enclosures

- **General Enclosure Requirements**

A gas cabinet or lab hood must be used when exhausted enclosures are required for the storage or use of a hazardous gas cylinder. Exception: exhausted process equipment enclosures that meet the same general performance criteria as gas cabinets or lab hoods, as approved by the EH&S Field Support Department.

Each lab hood or gas cabinet that contains one or more hazardous gas cylinders must be posted with a sign that identifies the name of the gases and their hazard categories.

Exhausted enclosures for hazardous gases shall be constructed of noncombustible materials. Exception: unless approved by Industrial Hygiene based on low gas quantities or concentrations.

- **Gas Cabinets**

Gas cabinets must meet current industry and regulatory specifications, which typically include the following:

- Constructed of not less than 12 gauge (2.5 mm or 0.097 in) steel and coated to prevent corrosion.
- Provided with a self-closing and self-latching cylinder access door.
- Provided with a noncombustible safety window (6.4-mm or 0.25-in wire-reinforced safety glass or equal) that allows viewing of equipment controls.

- Provided with self-closing access port(s) or windows of sufficient size that allow hand access to equipment controls.
- Provided with make-up air inlets that allow air circulation throughout the cabinet when the access port(s) or windows are closed.
- Provided with an approved fire sprinkler.
- Provided with exhaust ventilation that ensures:
  - The cabinet is at negative pressure in relation to the surrounding area.
  - An average velocity of air flow at the face of open access ports or windows of 1 to 1.5 m/s (200 to 300 fpm) with a minimum of 0.75 m/s (150 fpm) at any measurement point.

Exhaust Duct Systems and Connections

Exhaust systems must be constructed to current building code, fire code, and ACGIH Industrial Ventilation Manual requirements. For example:

- Exhaust ducts for hazardous gases must be constructed of noncombustible materials, constructed of compatible materials (or have interior coatings), and sealed and seismically braced.
- Exhaust ducts must maintain negative pressure and required flow rates.

The following purge and exhaust systems ancillary to the use of hazardous gas must be connected to the exhaust duct system in an approved manner:

- All lines or ducts carrying purged hazardous gas emissions (e.g., pipe vents) or exhausted hazardous gas emissions (e.g., vacuum pump lines).
- Exhausted enclosures, gas cabinets, and lab hoods.

Ventilation Monitoring

All exhausted enclosures must have a ventilation monitor that measures duct or enclosure exhaust performance and displays a quantitative readout easily visible to the gas user (e.g., magnehelic or better).

When ventilation monitoring is required, the monitor must have local audible and visual alarms that activate when the exhaust flow decreases to 70 to 80% of the required air flow.

13.4.10 GAS DETECTION

General Detection Requirements

Gas detection controls must be used when significant toxic, flammable, or oxygen-deficiency leak risks cannot be adequately controlled by other means or when required by codes.

Gas detection controls must not be used in place of proper primary controls (e.g., approved gas lines) and secondary controls (e.g., ventilation and ventilation monitoring). Ventilation monitoring interlocked to automatic gas shutdown at the gas source may also be required.

Requirements for flammable and health hazard gas detection procedures are presented in the *Flammable Gases* and *Health Hazard Gases* sections of this chapter. Requirements for oxygen-deficiency detection procedures are presented below. When gas detection procedures are required, Appendix A is used to determine gas detector system maintenance, audit, responsibility, selection, and installation requirements.

Oxygen-Deficiency Detection

Oxygen-deficiency detection controls may be needed to detect a lack of breathable air in a space that could be occupied by someone. This situation may be the result of inadequate ventilation or displacement of air by a gas or process by-product. Guidelines for oxygen-deficiency detection shall be developed on a case-specific and hazard basis through Activity Hazard Document and EH&S Field Support reviews. Oxygen-deficiency detection controls are generally not recommended when engineering controls (e.g., ventilation) can be used to control the hazard.

Work spaces that may be oxygen deficient and have limited personnel access and egress meet the definition of a "confined space" and must meet all the requirements of the Berkeley Lab Confined Space Program (see Chapter 4, *Industrial Hygiene*). Portable oxygen detectors, in place of fixed-in-place detectors, are usually sufficient for confined spaces.

13.4.11 ELECTRICAL SYSTEMS

Electrical equipment and wiring must be installed in accordance with the National Electrical Code. Gas piping and containers must not be designed or placed where they can become part of the electrical circuit or used for grounding.

Required ventilation and control systems must be connected to a standby or emergency source of power to automatically supply electricity in the event of loss of power from the primary source. Exception: when standby power is not available in the building and the gas quantities are below the amounts exempted by the California Fire Code (CFC). Emergency power is required for CFC highly toxic gases in quantities greater than 1 m^3 (40 F).

When standby or emergency power is not provided for hazardous gas facilities, controls, or systems that provide primary control against the development of a hazardous condition, loss of system power will activate automatic gas shutoff. Example: an exhaust duct blower that provides exhaust ventilation for flammable or health hazard gas process effluents that continue to be generated after power is lost.

13.5 FLAMMABLE GASES

13.5.1 GENERAL

See the *General Compressed Gas Systems* section of this chapter for general requirements for all compressed and hazardous (e.g., flammable) gases.

13.5.2 SCOPE

The requirements of this section apply to the storage and use of compressed and liquified flammable gas in quantities less than or equal to 11 m^3 or 400 CF (e.g., two size 1A hydrogen cylinders containing about 200 CF each) and greater than 0.6 m^3 (20 CF).

The Berkeley Lab EH&S Field Support, Facilities, and Engineering organizations can assist in requirements, designs, and construction for the following gas uses, which are not specifically covered in this section:

- Storage and use of flammable gas in quantities greater than 11 m^3 (400 CF) for compressed gas and 45 kg (100 lb) for liquified gas, as specified by the National Fire Protection Association in:
  - NFPA 50A, *Gaseous Hydrogen Systems at Consumer Sites*
  - NFPA 55, *Storage, Use, and Handling of Compressed and Liquified Gases in Portable Containers*
- Welding and cutting, as specified by the National Fire Protection Association in:
  - NFPA 51, *Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*
  - NFPA 51B, *Cutting and Welding Processes*
  - CFC, Article 49, *Welding and Cutting*
- Dispensing of compressed liquified flammable gas.

13.5.3 PIPES AND COMPONENTS

Piping and related gas-flow components must be of approved and noncombustible design and construction. Stainless steel pipe and fittings are recommended. Exception: approved nonmetallic tubing and fittings may be used in lengths up to 1.5 m (5 ft) when flexibility is required, if approved by the EH&S Field Support Department.

13.5.4 GAS CYLINDER STORAGE AND USE

Interior storage and use rooms must be of noncombustible construction.

Exterior storage and use of cylinders must not be located under a window or within 5 m (20 ft) of smoking, open flames, or other ignition sources. Signs that prohibit smoking within 8 m

(25 ft) must be posted. In addition, exterior locations must have a minimum of 25% of the perimeter open to the atmosphere and without walls.

Cylinders of compressed gas in solution and liquified gas shall be stored upright so that the pressure relief valve is in direct contact with the vapor space of the cylinder.

13.5.5 VENTILATION

Negative-pressure local exhaust or positive-pressure dilution ventilation is required at all potential leak points in the gas system where the ventilation rate is less than six air changes per hour. Six air changes per hour is approximately 0.005 m^3/s per square meter, or one cfm per square foot, of floor area. EH&S Field Support will determine when leak-point ventilation is required.

These leak-point ventilation requirements generally do not apply to process equipment that has undergone adequate product safety evaluation and is specifically designed to handle small quantities of flammable gas.

13.5.6 GAS DETECTION

Flammable gas detection procedures may be required for systems that use heavier-than-air gases, where there is a significant chance that a flammable gas leak could be accidentally ignited in air.

EH&S Field Support will determine when this third level of hazard control is warranted. When detection procedures for flammable gas are required, consult Appendix A to determine gas detector system maintenance, audit, responsibility, selection, and installation requirements.

13.6 PYROPHORIC GASES

13.6.1 GENERAL

See the *General Compressed Gas Systems* section of this chapter for general requirements for all compressed and hazardous (e.g., pyrophoric) gases.

See the *Health Hazard Gases* section of this chapter for information on gas purchase approval, cylinder delivery, cylinder return, and piping and component construction.

Pyrophoric gases include, for example, diborane, phosphine, and silane. Diborane and phosphine are both pyrophoric and CFC Highly Toxic (NFPA Health Hazard Class 4) gases, and therefore require both pyrophoric and toxic (i.e., health hazard) gas safety controls. Silane is a NFPA Health Hazard Class 2 gas, but its primary hazard is its pyrophoricity.

13.6.2 SCOPE

This section presents general requirements and guidelines for pyrophoric gas use. Additional requirements may apply to the storage and use of pyrophoric gas in quantities greater than 0.3 m^3 (10 CF) for gas not in a gas cabinet and 0.6 m^3 (20 CF) for gas in a gas cabinet.

13.6.3 GAS STORAGE AND USE

Locations, Barriers, and Cabinets

Whenever possible, silane gas cylinders should be stored and used at exterior locations outside of gas cabinets. Whenever silane is being used outside of a gas cabinet, each silane cylinder should be separated from other hazardous gas cylinders by a 6-mm (0.25-in) thick steel barrier. Silane cylinders stored or used at exterior locations should be located in shelters or bunkers, or provided with a chain-link fence to restrict entry and reduce the impact of an explosion at the location perimeter. Interior storage and use of silane must be in gas cabinets.

Pyrophoric gas that also has a NFPA health-hazard classification of 3 or 4 must be stored in and used in a gas cabinet. Class 3 or 4 health hazard gas at Berkeley Lab must be stored and used in an interior area because of code restrictions.

Only single-cylinder gas cabinets shall be used for pyrophoric gases.

Pyrophoric gas cylinders located in gas cabinets must have mechanical ventilation at a minimum rate of 1 m/s (200 fpm) air velocity across the cylinder valve and gas fittings with the cabinet access port(s) closed.

Gas Flow Controls

Pyrophoric gas systems at any pressure require a Safety Note.

Remote manual shutdown devices for pyrophoric gas flow must be provided outside each gas cabinet or near each gas panel. Dispensing areas should have an emergency shutdown mechanism for all gases that can be operated at a minimum distance of 5 m (15 ft) from the dispensing area.

Pyrophoric gas flow, purge, and exhaust systems must have redundant controls that prevent pyrophoric gas from igniting or exploding in an unsafe and uncontrolled manner. These controls may include excess flow valves, flow orifices, mass flow controller sizing, process bypass line elimination or control, vacuum-pump inert-gas purging, dilution of process effluent with inert gas and ventilation, controlled combustion of process effluent, ventilation monitoring, and automatic gas shutdown.

13.7 HEALTH HAZARD GASES

13.7.1 GENERAL

See the *General Compressed Gas Systems* section of this chapter for general requirements for all compressed and hazardous (e.g., health hazard) gases.

13.7.2 GAS HEALTH HAZARD CLASSIFICATION

Health hazard gases, for the purpose of this chapter, include gases that may cause significant acute or chronic toxic health effects in people at lower concentrations. These gases can, for example, poison someone and/or cause corrosion, irritation, and disease in human tissue.

Acute Health Hazards

Table 13.2 presents standard CFC and NFPA acute health hazard gas classifications and shows each category's relationship to lethal concentration values. These gas classifications shall be used to determine which controls in this section are required for each gas use.

Table 13.2. Health Hazard Gas Classifications

Pure Gas LC_{50} (ppm)	zero to 200	greater than 200 to 1000	greater than 1000 to 2000	greater than 2000 to 3000	greater than 3000 to 5000
CFC Toxic Gas Classes[a]	Highly Toxic	Toxic		N/A	
NFPA Health Hazard Classes[b]	4		3		2

Footnotes:

[a] *CFC Highly Toxic and Toxic Gases:* CFC Highly Toxic Gases have a median lethal concentration (one-hour rat LC_{50}) in air of 200 parts per million (ppm) by volume or less of gas. CFC Toxic Gases have a LC_{50} greater than 200 ppm and less than or equal to 2000 ppm.

[b] *NFPA Class 4, 3, and 2 Health Hazard Gases:* NFPA Class 4 gases have a LC_{50} for acute inhalation toxicity that is less than or equal to 1000 ppm. NFPA Class 3 gases have a LC_{50} greater than 1000 ppm, but less than or equal to 3000 ppm. NFPA Class 2 gases have a LC_{50} greater than 3000 ppm, but less than or equal to 5000 ppm.

Chronic Health Hazards

In contrast to acute health hazard gases, chronic health hazard gases can be pure or mixed chemicals under pressure in gas cylinders that have significant longer-term health hazards. Examples include OSHA Select Carcinogens (see *Chemical Hygiene and Safety Plan*, PUB-5341). Gases that are only chronic health hazards will be assigned a health hazard classification and set of engineering controls by EH&S Field Support based on the specific gas and use.

Specific Gas Information

See Appendix B for a list of specific health hazard gases and their corresponding CFC and NFPA classifications. EH&S Field Support will assign health hazard classifications and engineering controls to previously unclassified gases, dilute gases, and gas mixtures.

13.7.3 SMALL GAS CONCENTRATIONS AND QUANTITIES

The required controls in this *Health Hazard Gases* section only apply to concentrations and quantities of gas that are sufficient to cause a gas-leak health hazard. A hazard exists at all potential leak points where a worst-case gas release will result in a small cloud of gas that is at or above the Ceiling Limit or STEL (or the TWA if no Ceiling Limit or STEL is available).

A leak health hazard exists if the concentration of gas inside the gas source (e.g., cylinder or gas line) is at or above the Ceiling Limit or STEL (or the TWA, if no Ceiling Limit or STEL is available). Exception: when a documented (e.g., in the AHD) gas release hazard evaluation shows that a leak hazard does not exist. EH&S Field Support will approve all leak hazard evaluations and establish evaluation criteria, as needed.

13.7.4 GAS PURCHASE APPROVAL

Purchase requisitions for NFPA Health Hazard Classes 3 and 4 gases (and Class 2 gases with poor physiological warning properties), and pyrophoric gases must be approved by EH&S Field Support. The gas purchase requisition will be sent to EH&S Field Support for approval before purchase. Berkeley Lab Purchasing will not process the requisition until EH&S Field Support approval is obtained.

13.7.5 GAS DELIVERY AND RETURN

Facilities Transportation must handle all gases that require pre-purchase approval, as follows:

- Gases must be kept in exhausted enclosures until they can be delivered directly to the gas user.
- Delivery and pickup of gases will be scheduled directly with and handled directly by a person designated by the gas user. The designated person will also sign the Hazardous Shipping Form provided by Facilities Transportation
- Gas cylinder valves will be checked for leaks before delivery and at time of pickup from the gas user.

13.7.6 GAS FLOW SYSTEM

All gas flow systems at any pressure that handle NFPA Health Classes 2, 3, and 4 gases require a Safety Note and must be designed and constructed in accordance with the requirements of Chapter 7, *Pressure and Cryogenics.*

13.7.7 VENTILATION

Area Ventilation

Area ventilation must be 0.005 m^3/s per square meter (one cfm per square foot) of floor area or greater and must be maintained at negative pressure relative to adjacent corridors and non-laboratory or non-gas-use areas.

General Local Exhaust Requirements

NFPA Classes 3 and 4 gases (and NFPA Class 2 gases with no physiological warning properties): gas cylinders must be kept in laboratory hoods or gas cabinets.

CFC Highly Toxic and Toxic gases (recommended for other NFPA Class 3 gases): all potential gas leak points must be contained within exhausted enclosures.

NFPA Class 3 gases that are not CFC Toxic gases (and NFPA Class 2 gases with no physiological warning properties): all unapproved components in the gas system must be enclosed and exhausted.

Process Equipment Enclosures

When process equipment enclosures are exhausted, ventilation face velocities at all enclosure holes, cracks, and access ports that may need to be opened in a gas emergency must be 0.5 m/s (100 fpm) or greater. Where emergency access is needed, small (not large) access doors must be used to reduce exhaust requirements.

Purge Vents and Exhaust Lines

All lines or ducts carrying purged or exhausted emissions of health hazard gases must be connected to an approved exhaust system.

Corrosive Gas Venting: significant emissions from corrosive gas venting may require the use of an emissions control device (e.g., scrubber) to prevent duct corrosion before the purged gas can be vented into the exhaust duct system.

Ventilation Monitoring and Interlocks

CFC Highly Toxic and Toxic gases: a ventilation monitor with audible and visual alarms is required on the lab hood or gas cabinet where the gas cylinder is kept.

Ventilation monitoring interlocked with automatic gas shutdown may be used in addition to or in place of audible and visual ventilation monitor alarms. In addition, automatic gas shutdown is required based on the gas's physiological warning properties, as shown in Table 13.3. Ventilation monitoring interlocked with automatic gas shutdown is also recommended for CFC Highly Toxic gases.

13.7.8 ACCIDENT RELEASE EVALUATION AND CONTROL

When required by EH&S Field Support, the Activity Hazard Document (AHD) or Safety Note must include an evaluation of the consequences of a worst-case gas release of the largest CFC Highly Toxic or Toxic gas cylinder into the exhaust system. The following release times will be assumed for a worst-case gas release if no flow control devices are provided: 5 minutes for nonliquified gases and 30 minutes for liquified gases. If calculations show that IDLH concentrations are exceeded at the exhaust stack discharge, restrictive flow orifices or excess flow valves should be provided in the cylinder valve or as close to the cylinder valve as possible.

When quantities of CFC Highly Toxic gas exceed 1 m^3 (40 CF), gas release controls must be implemented to reduce the exhaust stack discharge concentration to one-half of the IDLH at the point of discharge into the atmosphere.

13.7.9 GAS DETECTION

The following criteria shall be used to determine the need for health hazard gas detection: gas concentration, quantity, and physiological warning properties. Health hazard gas detection is only required when the gas posing a health hazard has poor physiological warning properties. Poor warning conditions exist when the concentration and warning properties of the gas are at or above the Ceiling Limit or STEL (or the TWA if no Ceiling Limit or STEL is available) as determined by Industrial Hygiene. See Table 13.3 for health hazard gases that require gas detection, ventilation, and gas shutdown controls. Exception: if the aggregate quantity of the health hazard gas in the control area is less than or equal to 1 m^3 (40 CF), ventilation monitoring and gas source shutdown may be used in place of gas detection.

When gas detection methods are required, use Appendix A to determine gas detector system maintenance, audit, responsibility, selection, and installation requirements.

Table 13.3. Health Hazard Gas Controls

For Ventilation Power and Monitoring, Gas Shutdown, and Gas Detection Requirements

DIRECTIONS: First, determine the physiological warning property rating for the gas to be used.
Then, determine the required gas controls based on the quantity of gas.
See footnotes for additional explanations, abbreviation definitions, and exceptions.

REQUIRED CONTROLS

Physiological Warning Property Rating	**Control Area Gas Quantity At STP**				
	Any Amount	Less than or equal to 1 m^3 (40 CF)		Greater than 1 m^3 (40 CF)	
	Ventilation On Backup Power & Monitored	Ventilation Monitor & Gas Shutdown	Gas Detection & Gas Shutdown	Ventilation Monitor & Gas Shutdown (E1)	Gas Detection & Gas Shutdown
(G) Good	Required	—	—	—	—
(A) Adequate	Required	—	—	Recommended	—
(M) Marginal	Required	Recommended	—	Recommended	—
(P) Poor	Required	Recommended	—	Required	Required (E2)

PHYSIOLOGICAL WARNING PROPERTY RATINGS

For Select Health Hazard Gases

1,3-butadiene (G*)
ammonia (G*)
arsenic pentafluoride (U*)
arsine (P*)
boron trichloride (A*)
boron trifluoride (P*)
bromine pentafluoride (P)
bromine trifluoride (P)
carbon monoxide (P*)
carbonyl fluoride (U*)
carbonyl sulfide (U)
chlorine (A*)
chlorine trifluoride (M*)
cyanogen (P)
cyanogen chloride (P)
diborane (P*)
dichlorosilane (A*)
fluorine (M*)
germane (U*)
hydrogen bromide (A*)
hydrogen chloride (A*)
hydrogen cyanide (P*)
hydrogen fluoride (A*)
hydrogen selenide (P*)
hydrogen sulfide (M*)
iodine pentafluoride (U)
methyl bromide (P*)
methyl chloride (M)
methyl silane (U)
nickel carbonyl (P)
nitric oxide (G*)
nitrogen dioxide (A*)
nitrogen trifluoride (P*)
nitrosyl chloride (A)
oxygen difluoride (P)
phosgene (P*)
phosphine (P*)
phosphorous pentafluoride (A*)
phosphorous trichloride (P*)
phosphorous trifluoride (P*)
selenium hexafluoride (P)
silane (M*)
silicon tetrachloride (A*)
silicon tetrafluoride (A*)
stibine (P*)
sulfur dioxide (G*)
sulfur tetrafluoride (P*)
sulfuryl fluoride (P)
tellurium hexafluoride (P)
tungsten hexafluoride (A*)
vinyl chloride (P*)

Footnotes:

- *(A) Adequate:* Warning properties are fairly well understood and occur at or below the lowest PEL or TLV. Data uncertainties may exist.
- *(E1) Exception 1:* A ventilation monitor must be installed, but may not need to be interlocked to gas shutdown if procedures for the operation require: (1) an operator to be present at all times while the gas cylinder valve is open, and (2) the gas cylinder valve to be closed if the ventilation alarm is activated. Exceptions must be approved by Industrial Hygiene.
- *(E2) Exception 2:* If no gas detection system is available, control measures that provide an equal level of safety must be used.
- *(G) Good:* Warning properties are well understood and occur at or below the lowest PEL or TLV.
- *(M) Marginal:* Warning properties are marginally adequate and are most likely to occur at or below the STEL (or TWA, if no STEL or C is available). Data uncertainties may exist.
- *(P) Poor:* Warning properties occur at or above the STEL or C (or TWA, if no STEL or C is available). Many data uncertainties may exist. Gas may have high hazard toxicity properties.
- *(U) Undetermined:* Information on warning properties is lacking. EH&S will evaluate on a case-by-case basis.
- *(*) Available gas detection system(s) have been identified.*
- *(—) No general requirement.*

13.8 RESPONSIBLE PARTIES

13.8.1 PRINCIPAL INVESTIGATOR/SUPERVISOR

The principal investigator or gas-use supervisor has primary responsibility for gas-use safety and implementation of all provisions of this chapter, including:

- Activity Hazard Documents
- Safety Notes
- Training
- Equipment and controls implementation, maintenance, and inspections
- Request of gas pre-purchase approval, when required
- Self-assessment inspections

13.8.2 EH&S – FIELD SUPPORT DEPARTMENT

Provides an EH&S hazard evaluation and Code-compliance coordination role related to fire, life-safety, pressure, health, and oxygen-deficiency gas hazards, which includes:

- Assisting the gas user in the evaluation of hazards and the determination of appropriate controls.
- Evaluating and approving purchases of gases that require pre-purchase approval.
- Reviewing new gas-use controls and designs (i.e., as part of AHD reviews), facilities projects, and required pre-gas purchases.
- Determining health hazard classifications, required engineering controls, and/or physiological warning property ratings to previously unclassified health hazard gases, dilute gases, and gas mixtures.
- Periodically auditing gas uses as one component of the EH&S Integrated Functional Appraisal Program.
- Administering and maintaining the Hazardous Gas, Pressure Safety, and Fire Protection programs. Pressure safety responsibilities are described in Chapter 7, *Pressure Safety and Cryogenics.*

13.8.3 EH&S – FIRE DEPARTMENT

- Monitoring and responding to alarms transmitted via the fire alarm system or emergency telephone number system.
- Evaluating and issuing permits for welding, cutting, and other hot work operations.

13.8.4 MECHANICAL ENGINEERING

- Pressure-safety responsibilities are described in Chapter 7.

13.8.5 FACILITIES DEPARTMENT – MAINTENANCE & OPERATIONS

- Assists in the selection, installation, and startup of maintainable and reliable facilities safety systems that support gas-use operations.
- Through the Regulator Shop, assembles gas systems and provides, inspects, repairs and/or rebuilds many commonly-used gas system components when requested.
- Manages gas detector maintenance services for detector users who request service. Maintains an updated inventory of all gas detectors.

13.8.6 FACILITIES DEPARTMENT – TECHNICAL SERVICES

Manages a gas supplier sub-contract for lower hazard industrial and high purity gases. The gas sub-contractor:

- Receives gas orders from Berkeley Lab gas users, provides gases from gas suppliers, delivers gas cylinders to gas requestors, picks up cylinders from gas requestors, and returns cylinders to gas suppliers.
- Screens gas purchase requests and ensures that requests that require pre-purchase approval are not ordered.

Provides the following services related to higher hazard and speciality gases:

- Screens gas purchase requests and ensures that requests that require pre-purchase approval are approved by EH&S Field Support.
- Receives gas cylinders from gas suppliers, delivers gas cylinders to gas requestors, picks up cylinders from gas requestors, and returns cylinders to gas suppliers.
- Delivers and picks up gases that require pre-purchase approval directly from a person designated by the gas requestor.

13.9 GLOSSARY

CFC stands for the California Fire Code.

A **control area** is a space bounded by not less than a one-hour fire-resistive occupancy separation within which exempt amounts of hazardous materials may be stored, dispensed, handled, or used, as defined in the California Fire Code (CFC)).

A **corrosive gas** is a gas that can cause visible destruction of, or irreversible alterations in, living tissue (e.g., skin, eyes, or respiratory system) by chemical action.

DOT is the U.S. Department of Transportation.

An **exhausted enclosure** is a gas cabinet, lab hood, or enclosed compartment that is connected to an approved negative-pressure exhaust duct system.

A **flammable gas** is a gas that can be ignited in air.

A **compressed gas** is a material that is shipped in a compressed gas cylinder and acts as a gas upon release at normal temperature and pressure or is used or handled as a gas.

A **gas cabinet** is an exhausted enclosure used to store or use gas cylinders that meets the requirements specified in this chapter.

A **hazardous gas** is a gas that is included in one or more of the following hazard categories: corrosive, flammable, health hazard, oxidizer, pyrophoric, reactive, or toxic.

A **hazardous gas detection system** is a fixed system used to detect the presence of hazardous gas at potentially unsafe levels.

A **health hazard gas** is described in the *Health Hazard Gases* section of this chapter.

IDLH stands for "immediately dangerous to life and health." IDLH is a maximum concentration of airborne contaminant to which a person could be exposed for 30 minutes without experiencing escaping-impairing symptoms or irreversible health effects.

A **liquified gas** is a liquid contained in a compressed gas cylinder that has a vapor pressure exceeding 276 kPa at 38 C (40 psi at 100 F).

Lower explosive limit (LEL) is the lowest concentration of a substance in air that will produce a flash of fire when an ignition source is present.

NFPA stands for the National Fire Protection Association.

Oxidizing gas is gas that initiates or promotes combustion in materials, either by catching fire itself or by causing a fire through the release of oxygen or other gases.

Oxygen deficiency is a condition that occurs when a breathable atmosphere contains less than 19.5% oxygen. Note: normal air contains 20.9% oxygen.

Permissible Exposure Limit (PEL) and **Threshold Limit Value (TLV)** are employee airborne exposure limits established for particular chemicals by the Federal Occupational Safety and Health Administration (Fed/OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH), respectively. DOE requires that employee exposures must not exceed PELs or TLVs. **Time-Weighted Average (TWA), Short-Term Exposure Limit (STEL)**, and **Ceiling (C)** standards are summarized as follows:

Organizations & Standards	Work Exposure Duration
Fed/OSHA PEL-TWA and ACGIH TLV-TWA	8-hour shift and 40-hour week
Fed/OSHA PEL-STEL and ACGIH TLV-STEL	15 minutes
Fed/OSHA PEL-C and ACGIH TLV-C	Any point in time

Pyrophoric gases are gases that may spontaneously ignite in air at or below 54 C (130 F). Specific gases may not ignite in all circumstances or may explosively decompose.

A **Safety Note** is a document used to record engineering calculations or tests on specific equipment. A Safety Note may also specify operational requirements addressed in an Activity Hazard Document or in operating instructions. See Chapter 7, *Pressure Safety and Cryogenics*, for details.

STP stands for standard temperature and pressure.

Threshold Limit Value (TLV) is defined under **Permissible Exposure Limit**, above.

13.10 STANDARDS

- CFC Title 24, Part 9, California Fire Code, Article 49, *Welding and Cutting*
- CFC Title 24, Part 9, California Fire Code, Article 51, *Semiconductor Fabrication Facilities Using Hazardous Production Materials*
- CFC Title 24, Part 9, California Fire Code, Article 74, *Compressed Gases*
- CFC Title 24, Part 9, California Fire Code, Article 80, *Hazardous Materials*
- CFC Title 24, Part 9, California Fire Code, Article 82, *Liquified Petroleum Gas*
- 29 CFR 1910.101, *Occupational Safety and Health Standards for General Industry, Compressed Gases*
- 29 CFR 1910.102, *Occupational Safety and Health Standards for General Industry, Acetylene*
- 29 CFR 1910.103, *Occupational Safety and Health Standards for General Industry, Hydrogen*
- 29 CFR 1910.105, *Occupational Safety and Health Standards for General Industry, Nitrous Oxide*
- 29 CFR 1910.110, *Occupational Safety and Health Standards for General Industry, Storage and Handling of Liquified Petroleum Gases*
- 29 CFR 1910.111, *Occupational Safety and Health Standards for General Industry, Storage and Handling of Anhydrous Ammonia*
- 29 CFR 1910.1000, *Occupational Safety and Health Standards for General Industry, Permissible Exposure Limits*
- 29 CFR 1910.1200, *Occupational Safety and Health Standards for General Industry, Hazard Communication*
- 29 CFR 1910.1450, *Occupational Safety and Health Standards for General Industry, Laboratory Standards*
- 49 CFR *Transportation*, Parts 100-199
- DOE Order *430.1, Life Cycle Asset Management*

- DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards, sections specified in Work Smart Standards set*
- DOE Order 5480.19, *Conduct of Operations*

13.11 RELATED PUB-3000 CHAPTERS

- *EH&S Training* (Chapter 24)
- *Fire Prevention and Protection* (Chapter 12)
- *General Policy and Responsibilities* (Chapter 1)
- *Industrial Hygiene* (Chapter 4)
- *Pressure Safety and Cryogenics* (Chapter 7)
- *Seismic Safety* (Chapter 23)

13.12 REFERENCES

- American National Standards Institute (ANSI), ANSI/AIHA Z9.5-1992, *American National Standard for Laboratory Ventilation*
- *Chemical Hygiene and Safety Plan*, PUB-5341, Lawrence Berkeley Laboratory, August 1992
- *Compressed and Liquified Gases in Portable Containers*, National Fire Protection Association, NFPA 55
- *Cutting and Welding Processes*, National Fire Protection Association, NFPA 51B
- Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting and Allied Processes, National Fire Protection Association, NFPA 51
- DOE *Pressure Safety Draft Manual*, Version 2, November 1992
- *Industrial Ventilation, a Manual of Recommended Practice*, American Conference of Governmental Industrial Hygienists, 1995
- *Fire Protection for Laboratories Using Chemicals*, National Fire Protection Association, NFPA 45
- *Gaseous Hydrogen Systems at Consumer Sites*, National Fire Protection Association, NFPA 50A
- *Identification of the Fire Hazards of Materials*, National Fire Protection Association, NFPA 704
- *Installation, Maintenance, and Use of Protective Signaling Systems*, National Fire Protection Association, NFPA 72
- Odor Thresholds for Chemicals with Established Occupational Health Standards, American Industrial Hygiene Association, 1989
- *Pocket Guide to Chemical Hazards*, DHHS (NIOSH), Pub. No. 90-117, National Institute of Occupational Safety and Health
- PUB-3122 Maintenance Program Guidelines for Programmatic Equipment

- *Tentative Standard for the Classification of Toxic Gas Mixtures*, Compressed Gas Association, CGA P-20T-1991
- *Threshold Limit Values for Chemical Substances and Physical Agents*, American Conference of Governmental Industrial Hygienists

13.13 APPENDICES

- Appendix A: Gas Detection System Requirements
- Appendix B: Specific Health Hazard Gas Classifications

APPENDIX A

GAS DETECTION SYSTEM REQUIREMENTS

This Appendix contains requirements for maintenance, selection, and installation of gas detection systems. Explanations for when gas detection is required are presented in the *General Compressed Gas Systems, Flammable Gases*, and *Health Hazard Gases* sections of this chapter.

DETECTION SYSTEM MAINTENANCE

GENERAL MAINTENANCE REQUIREMENTS

- The principal investigator or gas use supervisor is primarily responsible for the management of gas detection system maintenance related to his or her project or operation.
- Maintenance must at a minimum follow manufacturer's recommendations for maintenance, including frequency of maintenance, and PUB-3122 Maintenance Program Guidelines for Programmatic Equipment. Testing of the detection system's ability to detect and transmit a signal to the Fire Department must follow NFPA guidelines, or must occur on at least a quarterly basis. The Facilities Department will provide technical guidance, if requested.

MAINTENANCE PERSONNEL

- The principal investigator may assign maintenance tasks to qualified subordinates, the Facilities Department, or contractors.
- Personnel conducting detector maintenance must be adequately trained, having detector manufacturer recommended training, or an equivalent, and be certified as "qualified" maintenance personnel.

MAINTENANCE DOCUMENTATION

A formal system of documentation will be maintained for each gas detection system, and will include:

- Manufacturer's operation and service manuals
- Preventive maintenance procedures, post-maintenance testing, schedules, and records of results
- Procedures and records for verifying proper connection of detector alarms and interlocks
- Records of all repairs, calibrations, non-routine maintenance, and system failures

- Names and qualifications of maintenance personnel
- Calibration source documentation

A one-year summary (e.g., log) of function checks and maintenance actions performed must be visibly maintained on the detector system. Minimum summary information must include date, person's name, and action taken.

DETECTION SYSTEM SELECTION

LISTING

Systems must be listed by Underwriters Laboratory, Factory Mutual, or Canadian Safety Association, and the California State Fire Marshall's office, or equivalent. The Fire Department may approve unlisted equipment if listed equipment is not available or is inferior.

PERFORMANCE

Gas detector sensitivity must be below the lowest PEL or TLV for health hazard gases and/or at or below 10-15% of the lower explosive limit (LEL) level for flammable gases.

HARDWARE

System hardware must include:

- Separate relays for "warning" (low concentration gas detection), "alarm" (high concentration gas detection), and "trouble" (malfunction) conditions, and normally-open and normally-closed dry contact relay output capability for specified but adjustable levels of gas detection.
- Capability system that is installed as fixed-in-place, with hard-wired and plumbed connections.
- Control protection from direct unauthorized personnel access.

DETECTION SYSTEM INSTALLATIONS

DESIGN

Detection system installations will be designed and documented (i.e., plans and as-built drawings) by the Facilities Department. A Facilities Department licensed professional engineer and EH&S Fire Protection Engineer will approve all designs prior to contract award or installation. In addition, an EH&S Industrial Hygienist will approve all toxic and oxygen-deficiency detection system designs.

SAMPLE POINT LOCATIONS

Gas detector sample points must be placed immediately adjacent to potential leak points or in the flow path of exhausted enclosures.

ALARM LOCATIONS

All gas detection systems must have:

- Audible and visual alarms in the following locations: gas supply location, gas use or operator room, and outside the gas use room (e.g., corridor).
- An alarm status and gas concentration readout panel must be located outside the gas use room.
- Local audible and visual alarms must be specific and distinct from fire alarm bells and have signs to indicate the alarm's meaning and required personnel action.

ALARM MONITORING

Gas detection systems required by this policy must have alarm connections to the Berkeley Lab Fire Department Alarm Room, which continuously monitors alarm status. Alarm connections must be made through the building and Berkeley Lab fire alarm system, must transmit "alarm" and "trouble" signals as separate zones, and must be made in accordance with NFPA 72.

ALARM CONDITIONS & ACTIONS

- Alarm conditions must consist of "trouble," "warning," and "alarm."
- Toxic gas "warning" and "alarm" level setpoints must normally be set at less-than-PEL/TLV and equal-to-PEL/TLV concentrations, respectively.
- Flammable gas warning and alarm level setpoints must normally be set at 10-15% LEL and 20% LEL, respectively.
- Low level "warnings" must activate local alarms and personnel response only.
- High level "alarms" must activate local area evacuation, automatic gas shutdown at the gas source, and Fire Department notification.

POWER & CONTROL

- The detection and alarm systems will be connected to emergency power. In the event of a power failure, the detection system must continue to operate without interruption (e.g., must have an uninterruptable power supply) or gas systems must be automatically shut down at the gas source.
- Power connections, control switches, and adjustments that affect the system's safety control must be protected from direct access (e.g., must be hard-wired or covered and locked).

RESPONSIBLE PARTIES

PRINCIPAL INVESTIGATOR/SUPERVISOR

- Ensures that gas users are adequately protected by verifying that appropriate detector systems are selected and installed.
- Ensures implementation of detector maintenance and calibration in an approved manner.
- Ensures records of gas detection system maintenance are maintained and archived.
- Provides records of new or removed gas detection systems to Maintenance.
- Ensures documented self-assessments of gas detection system functions and maintenance are conducted.

FACILITIES DEPARTMENT – MAINTENANCE

- Manages gas detector maintenance services for detector users who request service. Provides service on a charge-back basis through Maintenance, outside contractors, or other means.
- Maintains and archives records of gas detection system maintenance for activities that are managed by Maintenance. In addition, provides maintenance status reports to the principal investigator.
- Administers detector maintenance contracts, if requested.
- Maintains an updated inventory of all gas detectors and provides copies of same to EH&S.
- Installs and maintains fire alarm systems used to monitor gas detection systems.
- Assists in the selection, installation, and startup of maintainable and reliable detector systems.

FACILITIES DEPARTMENT – ENGINEERING

- Assists in gas detector system and hardware selection.
- Develops and approves detector, alarm, and interlock system design packages.
- Reviews and approves detection system construction, installation, and startup.

EH&S FIELD SUPPORT DEPARTMENT

Provides an EH&S coordination role in the following areas:

- Assists in detector, alarm, and interlock system conceptual design and selection. Approves design and installation. Witnesses acceptance tests of detection systems.
- Specifies alarm setpoint concentrations.
- Determines toxic gas physiological warning property ratings.

- Periodically audits installation and maintenance of gas detectors as one component of the EH&S Integrated Functional Appraisal Program.

EH&S FIRE DEPARTMENT

- Monitors and responds to alarms transmitted via the fire alarm system or emergency telephone number system.

APPENDIX B

SPECIFIC HEALTH HAZARD GAS CLASSIFICATIONS

Gas Name (Symbol)	NFPA Health Class	UFC Hazard Classes
ammonia (NH_3)	3	C, F(LG)
arsenic pentafluoride (AsF_5)	4	T(H), C, CAR, WR(1)
arsine (AsH_3)	4	T(H), F, F(LG)
benzene in air	—	CAR, F @1.4%, Liquid
boron trichloride (BCl_3)	3	T, C, WR(1)
boron trifluoride (BF_3)	3	T, C, WR(1)
bromine pentafluoride	3	T, C, WR(3), O(3)
bromine trifluoride (BrF_3)	4	T(H), C, WR(3), O
1,3-butadiene (C_4H_6)	4	F, CAR, UR(2), I
carbon monoxide (CO)	2	F(G)
carbonyl fluoride (COF_2)	3	T, I, WR(1)
carbonyl sulfide	3	T, C, F(LG), OHH
chlorine (Cl_2)	3	T, C, O(LG)
chlorine trifluoride (ClF_3)	4	T(H),C,O(LG),UR(3D),WR(2)
cyanogen (C_2N_2)	4	T(H), C, F(G)
cyanogen chloride (ClCN)	4	T(H), I, UR(2), WR(1)
diborane (H_6B_2)	4	T(H), P, I, UR(3D), WR(1)
dichlorosilane (SiH_2Cl_2)	3	C, F(LG), WR(1)
fluorine (F_2)	4	T(H), C, WR(2), O(G)
germanium tetrahydride (GeH_4)	4	T(H), I, F(G), UR(3D)
hydrogen bromide (HBr)	2	I
hydrogen chloride (HCl)	3	C
hydrogen cyanide (HCN)	4	T(H), F(LG), UR(2), WR(1)
hydrogen fluoride (HF)	3	T, C, WR(2)
hydrogen selenide (H_2Se)	4	T(H), F(LG), I
hydrogen sulfide (H_2S)	3	T, I, F(LG)
iodine pentafluoride (IP_5)	NL	
methyl bromide (CH_3Br)	3	T, C, F(LG)
methyl chloride (CH_3Cl)	2	F(LG), WR(1), I
methyl silane	3	
nickel carbonyl $Ni(CO)_4$	4	T(H),I,F,UR(3D),WR(1), Liq
nitric oxide (NO)	3	T, I, O(LG)
nitrogen dioxide (NO_2)	4	T(H), C, O(LG), WR(1)

Continued

Gas Name (Symbol)	NFPA Health Class	UFC Hazard Classes
nitrogen trifluoride (NF_3)	3	I, O(G), OHH
nitrosyl chloride (NOCl)	NL	
oxygen difluoride (OF_2)	NL	
phosgene ($COCl_2$)	4	T, I, WR(1)
phosphine (PH_3)	4	T(H), P
phosphorous pentafluoride (PF_5)	3	T, C, WR(1), WR(1)
phosphorous trichloride (PCl_3)	3	T, P, C, UR(2), WR(2), Liquid
phosphorous trifluoride (PF_3)	3	T, I, WR(1)
selenium hexafluoride	NL	
silane (silicontetrahydride-SiH_4)	2	P, UR(1)
silicon tetrachloride ($SiCl_4$)	3	C, WR(1), Liquid
silicon tetrafluoride (SiF_4)	3	T
stibine (SbH_3)	4	T(H), F(G)
sulfur dioxide (SO_2)	2	I
sulfur tetrafluoride (SF_4)	4	T(H), C, UR(2), WR(1)
sulfuryl fluoride (SO_2F_2)	3	T, I
tellurium hexafluoride (TeF_6)	NL	
tungsten hexafluoride (WF_6)	3	T, C, WR(2)
vinyl chloride (C_2H_3Cl)	4	T, I, F(LG), UR(1), CAR

Abbreviations:

CAR	Carcinogen
C	Corrosive
F	Flammable: Gas (G), Liquified Gas (LG)
I	Irritant
NL	Not Listed
O	Oxidizer: Gas (G); Liquified Gas (LG); Classes (1), (2), (3), and (4)
OHH	Other Health Hazard
T	Toxic: Highly (H)
UR	Unstable Reactive: Classes (1), (2), (3), Detonatable (3D), and (4)
WR	Water Reactive: Classes (1), (2), (3), and (4)

Chapter 14

LESSONS LEARNED

Revised December 1997

Reviewed by: Larry McFee 12/9/97
Date

Approved by: D. L. McGraw 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 14

LESSONS LEARNED

14.1 POLICY

LBNL practices a policy that enhances the Laboratory's safety culture and improves safety performance at all levels. This is accomplished through event analysis, determination of event causes, development of corrective actions, and distribution of *lessons learned*.

14.2 SCOPE

The *lessons learned* process is an integral part of every safety, health, and environment program at LBNL. In every case, it is the intent of the Laboratory to correct on as broad a basis as possible any problems found.

Major LBNL safety programs that contain *lessons learned* elements are included in the *Sources* section of this chapter. In addition, LBNL has developed a Lessons Learned Program. This program formalizes the communication process and ensures consistent distribution of *lessons learned* to the LBNL staff and DOE community.

The Lessons Learned Program ensures that incidents, near misses, and other events at LBNL are identified and translated into corrective actions that improve safety performance and prevent recurrence. The Program addresses safe practices as well as practices leading to events or accidents.

14.3 SOURCES

14.3.1 OVERVIEW

The sources for Lessons Learned include:

- Occurrence Reporting Processing System (ORPS)
- LBNL Self-Assessment Program
- LBNL Accident Investigations
- Division Lessons Learned Program
- LBNL Staff
- DOE Facilities/Headquarters
- Other Professional Materials

14.3.2 ORPS

The Occurrence Reporting Processing System (ORPS) implements DOE Order 232.1, *Occurrence Reporting*, which dictates that divisions analyze occurrence criteria, as developed by the Order and the LBNL document *Occurrence Reporting*, LBID-1694, to determine root causes, corrective actions, and *lessons learned*. The division affected has the opportunity to use *lessons learned* both for internal and Lab-wide changes and observations. Instructions say: "Include any lessons that others might learn from the occurrence that could be of importance to other facility operators or that should be addressed in personnel training or facility procedures."

14.3.3 LBNL SELF-ASSESSMENT

The Laboratory's Operating and Assurance Program (OAP) requires that management and personnel evaluate their performance to identify, correct, and prevent problems, and to ensure achievement of performance objectives. The LBNL Self-Assessment Program implements these requirements through a formalized information-gathering process of appraisals and assessments. The self-assessment process generates *lessons learned* within each division and the Laboratory as a whole. These lessons are reported, by division, in annual self-assessment reports to the Office of Assessment and Assurance (OAA). The OAA provides the Lessons Learned Administrator with these reports annually.

14.3.4 ACCIDENT INVESTIGATION PROGRAM

The Laboratory's Accident Investigation Program has been developed to identify and eliminate accident causes, thereby preventing similar accidents. Accident investigation is a major component of LBNL's safety, health, and environment programs, which aim to provide employees with a safe and healthy work environment. The Accident Investigation Program's primary emphasis is on accident prevention by engineering safe facilities and equipment, developing sound operational procedures, and providing adequate training and protective equipment. *Lessons learned* from the accident investigation process help to define and improve these efforts. The Accident Investigation Program is written to conform with the requirements of DOE Order 225.1 Chapters 1 and 2 , and LBNL's *Health and Safety Manual*, PUB-3000.

14.3.5 DIVISION LESSONS LEARNED PROGRAMS

Many LBNL Divisions have a Lessons Learned Program as part of self-assessment or as part of the Division's Safety Committee Charter. The LBNL Lessons Learned Program offers the Division a Laboratory-wide communication network for dissemination of specific safety lessons.

14.3.6 LBNL STAFF

All staff are encouraged to supply *lessons learned* covering any subject they believe to be important to the Laboratory and the DOE community. (See the LBNL Lessons Learned Input Form in the Appendix.)

14.3.7 DOE FACILITIES/HEADQUARTERS

Information received from DOE (e.g., through the Operating Experience Weekly Summary, Safety Note, Safety Bulletin, or Occupational Safety Observer) and/or other DOE facilities is reviewed for applicability to the LBNL community.

14.3.8 OTHER PROFESSIONAL MATERIALS

Input from professional journals, papers, and other documents is reviewed for applicability to the LBNL community.

14.4 LESSONS LEARNED DELIVERABLES

There are three LBNL-generated *lessons learned* deliverables: (1) *Safety News Bulletin*, (2) *Safety Alert*, and (3) *Lessons Learned Report*.

- **Safety News Bulletin**

The *Safety News Bulletin* is an informational announcement, issued on a need-only basis, that addresses a single subject (e.g., "Relay Socket Design May Cause Breakage," No. 302). The *Bulletin* is distinguished by a colored header.

- **Safety Alert**

The *Safety Alert* is an announcement, issued on a need-only basis, that dictates immediate corrective actions and accountability responsibilities. It is distinguished by a colored header.

- **Lessons Learned Report**

The *Lessons Learned Report* is a blue information sheet covering any subjects of interest to the Laboratory (e.g., Small Spill Requirements, Construction Hazard Safety Tips).

14.5 PROCEDURES

14.5.1 OVERVIEW

The Lessons Learned Administrator (LLA) in Field Support Department(FSD) follows these procedures to implement the Lessons Learned Program:

1. Obtains applicable *lessons learned* data from LBNL programs and external sources.
2. Determines the applicability of each *lessons learned* element (see *Determining Applicability*, below).

3. Distributes *lessons learned* deliverables, including the DOE-printed *lessons learned* materials, *LBNL Lessons Learned Report, LBNL Safety News Bulletin, LBNL Safety Alert*, and occurrence report summaries, to the Laboratory, DOE, and DOE facilities.

4. Tracks *lessons learned* as to what actions has been taken (e.g., safety alert requiring removal of a defective equipment component).

14.5.2 OBTAINING DATA

All LBNL organizations are requested to provide prospective *lessons learned* items to the LLA for review and inclusion in the Lessons Learned Program deliverables. The LBNL Lessons Learned Input Form is used for this process, and is available from the LLA and Division Safety Committees. Specific areas and programs (e.g., OAA, Occurrence Reporting, Division Safety Committees, Facilities) routinely contribute information for inclusion in the *lessons learned* deliverables.

DOE-published documents (e.g., *Weekly Operating Summary, The Safety Observer*) are distributed to divisions and other interested parties. The LLA annually reviews the mailing lists provided by the originator to reduce duplication and to ensure that the publications are distributed to the correct LBNL audience (e.g., Division Directors, Safety Committees, Building Managers).

14.5.3 DETERMINING APPLICABILITY

The LLA and other technical support personnel, with the LLA as lead, review potential *lessons learned* materials and events to determine applicability based on priority criteria, to evaluate technical accuracy, and to determine distribution. Priority criteria include, but are not limited to, probability of recurrence and events posing an obvious and significant hazard to personnel, the environment, or programs.

14.5.4 DISTRIBUTING DELIVERABLES

All LBNL-oriented deliverables (i.e., *Lessons Learned Report, Safety News Bulletin, Safety Alert*) are distributed to Division Directors, Safety Committees, Building Managers, major program heads, and DOE. Special distribution lists per the LBNL *Regulations and Procedures Manual* (RPM), PUB-201, can also be accommodated. The DOE-printed *lessons learned* materials are distributed to Division Directors, Safety Committees, public use areas, and special interest groups.

14.5.5 TRACKING DELIVERABLES

LBNL *Safety News Bulletins* and *Safety Alerts* are numbered for tracking purposes. Appropriate *lessons learned* deliverables are provided to EH&S personnel who perform training for development or upgrade of training programs, should it be necessary.

DIVISION DIRECTORS ARE RESPONSIBLE FOR COMPLETION OF CORRECTIVE ACTIONS WHEN DIRECTED BY THE DELIVERABLE.

14.6 RESPONSIBLE PARTIES

The Lessons Learned Program is the responsibility of the Environment, Health and Safety (EH&S) Division, Occupational Safety Group, Division Directors, and LBNL staff.

14.6.1 EH&S

The EH&S Division manages the Lessons Learned Program.

14.6.2 FIELD SUPPORT DEPARTMENT (FSD)

FSD is responsible for the coordination, analysis, publication, and distribution of the LBNL Lessons Learned Program. FSD analyzes LBNL events by using occurrence reporting, accident investigations, self-assessment, and quality assurance findings, as well as other materials provided by the divisions. This information is the basis for the *lessons learned* deliverables. FSD provides EH&S who perform training with LBNL event materials for review and inclusion in formal training programs, where appropriate.

14.6.3 DIVISION DIRECTORS

Division Directors are responsible for ensuring that *lessons learned* deliverables are available and distributed to their staff and that any necessary follow-up actions are implemented. Division Directors are responsible for seeing that *lessons learned* in their divisions that have a Laboratory impact are brought to the attention of the Occupational Safety Group, using the LBNL Lessons Learned Input Form.

14.6.4 LBNL STAFF

All staff are responsible for safety awareness of the issues presented in the *lessons learned* deliverables. Staff are encouraged to provide input directly to FSD for consideration for the Lessons Learned Program.

14.7 STANDARDS

- DOE Order 232.1, *Occurrence Reporting and Processing of Operations Information*

14.8 RELATED PUB-3000 CHAPTERS

- *Occupational Safety* (Chapter 5)

- *Occurrence Reporting* (Chapter 15)

14.9 REFERENCES

- *Lawrence Berkeley Laboratory Self-Assessment Program Implementation Plan,* Lawrence Berkeley Laboratory, PUB-5344, June 1996
- *LBNL Operating and Assurance Program (Revision 3),* Lawrence Berkeley Laboratory, PUB-3111, February 1996
- *Occurrence Reporting* (controlled document), Lawrence Berkeley Laboratory, LBID-1694, Revision 3, October, 1997

14.10 APPENDICES

Appendix A: LBNL Lessons Learned Input Form

APPENDIX A

LBNL Lessons Learned
Input Form

Mail to:
Lessons Learned Coordinator, MS 90-1140

Date: ______________________________

Originator: __________________________ Phone: _____________ FAX: _____________

Summary of Event or Finding:

Analysis/Recommendation:

Proposed Interest Areas for Distribution:

Contact for Additional Information

Chapter 15

OCCURRENCE REPORTING

Revised December 1997

Reviewed by: Mark J. Turner 12/10/97
Date

Approved by: Dolo McGraw 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 15

OCCURRENCE REPORTING

15.1 POLICY

It is the policy of LBNL to encourage a positive attitude toward reporting occurrences. It is also the policy of LBNL to ensure that occurrences are consistently reported to make certain that DOE is kept fully and currently informed of all events that could: (1) affect the health and safety of the public and workers, (2) adversely impact the intended purpose of DOE facilities, (3) have a noticeable adverse effect on the environment, (4) adversely affect the credibility of DOE facilities, (5) adversely affect national security or the security interests of DOE. It is further the policy of DOE to ensure that there is a system for determining appropriate corrective action and that such action is effectively taken. The mechanism used is the Occurrence Reporting and Processing System (ORPS).

15.2 SCOPE

LBNL, in accordance with DOE Order 232.1A, *Occurrence Reporting and Processing*, has prepared an implementation manual, *Occurrence Reporting*, LBID-1694, that describes in detail the intent of the order and the specific criteria involved in the reporting and investigative process.

Division Directors and designees are responsible for the implementation of the order as described in LBID-1694. The Occurrence Reporting Program is administered by the Environment, Health and Safety Division.

It is the Laboratory's responsibility to determine and document the significance, nature, and extent of an event or condition; its cause(s), including the root cause; and any corrective and preventative actions.

FOR MORE DETAILED INFORMATION ON THIS PROGRAM AND ITS SPECIFIC IMPLEMENTATION PROCEDURES, PLEASE REFER TO THE OCCURRENCE REPORTING *MANUAL*, LBID-1694. TRAINING IS PROVIDED TO THE DIVISIONS BY EH&S ON A QUARTERLY BASIS OR AT THE REQUEST OF THE DIVISION. THE FOLLOWING INFORMATION IS PROVIDED AS AN OVERVIEW OF THIS PROGRAM ONLY.

15.3 REPORTING PROCESS

The Occurrence Report is completed in phases on a rigidly defined and tracked timeline.

15.3.1 VERBAL NOTIFICATION REQUIREMENTS

The Laboratory must determine the occurrence categorization within 2 hours of the discovery of an event or condition that meets the reporting criteria.

- If the occurrence is categorized as an *emergency*, verbal notification to DOE Headquarters must be made within 15 minutes of the categorization.
- If the occurrence is categorized as *unusual*, verbal notification to DOE Headquarters must be made within 2 hours of categorization.
- If the occurrence is categorized as *off-normal*, verbal notification to DOE Headquarters is not required, but a courtesy notice to the Berkeley Site Office will be forwarded as soon as reasonable after categorization.

15.3.2 WRITTEN REPORT REQUIREMENTS

1. A Notification Report is due at the close of business the next day after the occurrence is categorized. It provides initial information about what occurred, when it occurred, who was notified, and the immediate actions taken to mitigate the event/condition.
2. An update report may be submitted when significant, new information becomes available, but is not required before the final report.
3. A Final Report is due within 45 days of categorization. This report must describe the event or condition, its causes (root, direct, and contributing), corrective actions that will prevent recurrence, and lessons learned.

15.4 CATEGORIZATION OF REPORTABLE OCCURRENCES

There are ten groups of occurrences that relate to DOE operations. These groups have been created so that DOE can understand the degree of significance associated with the *emergency, unusual,* and *off-normal* categories. The ten groups are:

1. Facility Condition
2. Environmental
3. Personnel Safety
4. Personnel Radiation Protection
5. Safeguards and Security

6. Transportation
7. Value Basis Reporting
8. Facility Status
9. Nuclear Explosive Safety (not applicable to LBNL)
10. Cross Category Items

Within each of these groups are subgroups that define the condition more specifically. For example, in Group 2, Environmental, the subcategories include: radionuclide releases; release of hazardous substances, regulated pollutants, or oils; hazardous material contamination; ecological resources; and environmental agreement or compliance activities.

15.5 RESPONSIBLE PARTIES

The Occurrence Reporting Program is the responsibility of the Environment, Health and Safety (EH&S) Division, Division Directors, and LBNL staff.

15.5.1 EH&S

The EH&S Division administers the Occurrence Reporting Program. EH&S Division staff provides technical support to the affected division as needed.

15.5.2 DIVISION DIRECTORS

Division Directors and designees are responsible for occurrence categorization, as described in DOE Order 232.1. Division Directors and designees must attend training, EHS-800, in order to meet this responsibility. They must further see that Division-specific protocols are established for the discovery and timely notifications required. Division Directors must approve the *Final Report*, verifying agreement with the causal factors and with the assignment and tracking of corrective action completion.

15.5.3 LBNL STAFF

All employees are responsible for hazard recognition in their areas and for following safe work practices. They are further responsible for reporting unsafe events and conditions to their management, as described by their specific Division's protocol.

15.6 GLOSSARY

Categorization is a process for determining the severity of an event or condition. The specific criteria for each level of severity are described in DOE Order 232.1A and the LBNL implementation manual, *Occurrence Reporting*, LBID 1694.

A **condition** is any as-found state, whether or not resulting from an event that may have adverse safety, health, quality assurance, security, operational, or environmental implications. A condition is programmatic in nature, for example, an error in analysis or calculation. See **event** listed below for comparison of occurrence type.

Emergencies are the most serious occurrences and require an increased alert status for on-site personnel.

An **event** is a real-time incident (e.g., pipe break, valve failure, environmental spill, chemical fire, etc.). See **condition**, above, for comparison of occurrence type.

Facilities are any equipment, structure, system, process, or activity that fulfills a specific purpose. Examples are accelerators, storage areas, environmental restoration activities, or research laboratories.

A **facility manager** is that individual or designee who has direct line responsibility for operation of a facility, including authority to direct physical changes to the facility. At LBNL, for occurrence reporting, this is the Division Director. A facility manager designee serves as the F.M.'s representative for Occurrence Reporting.

A **Notification Report** is the initial documented report of the event or condition that meets the reporting criteria defined in DOE Order 232.1A. The Notification Report consists of questions 1 through 19 plus 25 of the Occurrence Report.

An **Occurrence Report** is a documented evaluation of an event or condition that is prepared in sufficient detail to enable the reader to assess its significance, consequences, or implications, and to evaluate the action being proposed or employed to correct the condition or to avoid recurrence.

Off-normal occurrences are abnormal or unplanned events or conditions that adversely affect the performance or operation of a facility or have the potential to do so (i.e., violation of safety, environmental, or health administrative limits; violation of procedures).

A **reportable occurrence** is an event or condition to be reported in accordance with the criteria defined in DOE Order 232.1A.

An **unusual occurrence** is a nonemergency event or condition that has significant impact or potential for significant impact on safety, environment, health, security, or operations (i.e., involves significant degradation of safety class equipment, violation of technical safety requirements, failure of administrative controls). Unusual occurrences are of a higher level of severity than off-normal occurrences.

15.7 STANDARDS

- DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information

15.8 RELATED PUB-3000 CHAPTERS

- *Lessons Learned* (Chapter 14)

15.9 REFERENCES

- *Occurrence Reporting* (controlled document), Berkeley Lab, LBID-1694, October 1997

Chapter 16

LASERS

Revised December 1997

Reviewed by: Ken Barat, LSC 12/11/97
Date

Approved by: [signature] 12/15/97
EH&S Division Director
Date

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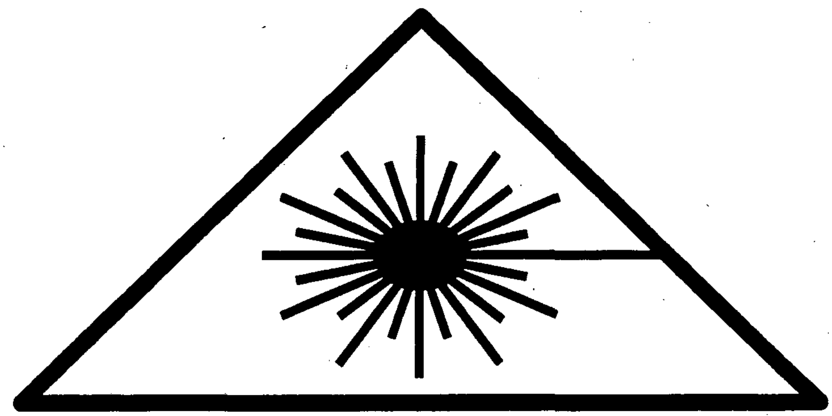
Chapter 16

LASERS



16.1 POLICY

The LBNL policy on laser safety requires that all lasers and laser systems be operated in a manner comparable to the American National Standards Institute (ANSI) Z136.1, Standard for the Safe Use of Lasers, as well as other applicable regulations. These requirements for laser safety are complex and include engineering controls, administrative controls, medical surveillance, and training.

The primary objective of the LBNL laser safety program is to ensure that no laser radiation in excess of the maximum permissible exposure (MPE) limit reaches the human eye or skin. Additionally, the program is designed to ensure that adequate protection against collateral hazards is provided. These collateral hazards include the risk of electrical shock, fire hazard from a beam or from use of dyes and solvents, and chemical exposures from use of chemicals and vaporization of targets.

In order to implement the policy properly while giving the greatest possible latitude to the researcher, all laser operations at LBNL must be reviewed and approved by the LBNL Laser Safety Officer (LSO), also called the Non-Ionizing Radiation Officer (NIRO).

In addition, exposure to ultraviolet (UV) radiation, radio frequency and microwave radiation, and magnetic fields must be kept as low as reasonably achievable. Levels are never to be greater than is permissible under applicable standards.

16.2 COMMON QUESTIONS/SUMMARY OF CHAPTER

Training Requirements	
Class 3b & Class 4 laser users	EH&S 280 Laser Safety Required
Retraining	Three year frequency, user can test out, take special class, or re-take EH&S 280
Class 1-3a laser user	EH&S 280 Laser Safety Recommended
Non-laser user, but work in laser area	EH&S 280 Laser Safety Recommended
	Contact Employee Development & Training (ext. 7366) or EH&S for schedule or check EH&S Web page
Medical Surveillance	
Class 3b & Class 4 laser users	Laser Eye Examination Required within one month of arrival at LBNL
	Suspected injury, required
	Exit examination recommended
Class 1-3a laser users	Contact Bldg. 26, ext. 7378 for appointment (not required)
Classification Meanings	See "Classes of Lasers" in this chapter
Activity Hazard Document (Safety Plan)	
Class 1-3a laser users	Not required
Class 3b & Class 4 laser users	Required
Approval Scheme	Flows from PI (LSO can advise on safety controls) to Division Safety Coordinator to EH&S
	Back to Division for Directors Signature
Control Measures	
Class 3b	See "Class 3 Control Areas" in this chapter
Class 4	See "Class 4 Control Areas" in this chapter
Containment Suggestions	Contact LSO
Interlock	Installation, contact LSO
Laser Supplies	
Warning Signs	From Laser Safety Officer (LSO)
Laser Labels	From LSO
Power Meter	Can be loaned from LSO
Eye Wear Literature	From LSO
Laser Eyewear	Purchased by Researcher from vendor
Curtain Material Data	From LSO, vendor list & options

16.3 CLASSES OF LASERS

To provide a basis for laser safety requirements, all lasers and laser systems and/or devices in the U.S. are classified into one of several classes. Corresponding labels are affixed to the laser or laser system. Understanding the laser classification is a fundamental prerequisite for any discussion of laser safety.

These laser classes are contained both in ANSI Z136.1 and in the Federal Laser Products, Performance Standard, 21 CFR 1040.10 and 1040.11. The first is followed by DOE and OSHA; the second is enforced by the Center for Devices and Radiological Health (CDRH), a part of the Food and Drug Administration (FDA). The classification for most lasers is provided by the manufacturer. For custom-built and modified lasers, the LSO/NIRO can assist with classification.

The following sections describe chiefly continuous-wave lasers. The same hazard levels apply to pulsed lasers; however, the classification criteria are more complex. Details of the classification of pulsed lasers are in the American National Standard for the Safe Use of Lasers, ANSI Z136.1, and Laser Products Performance Standard, 21 CFR 1040.10

CLASS 1 LASERS

Class 1 lasers do not emit harmful levels of radiation and are, therefore, exempt from control measures. As a matter of good practice, unnecessary exposure to Class 1 laser light should be avoided.

CLASS 2 LASERS

Class 2 lasers emit accessible laser light in the visible region and are capable of creating eye damage through chronic exposure. In general, the human eye will blink within 0.25 second when exposed to Class 2 laser light. This blink reflex provides adequate protection. It is possible, however, to overcome the blink reflex and to stare into a Class 2 laser long enough to cause damage to the eye. Class 2 lasers have power levels less than 1 mW. Class 2 lasers are commonly found in alignment applications.

CLASS 2A LASERS

Class 2a lasers are special-purpose lasers not intended for viewing. Their power output is less than 1 mW. This class of lasers causes injury only when viewed directly for more than 1,000 seconds. The 1,000 seconds is spread over an 8 hour day, not continuous exposure. Many bar-code readers fall into this category.

CLASS 3A LASERS

Class 3a lasers and laser systems are normally not hazardous when viewed momentarily with the naked eye, but they pose severe eye hazards when viewed through optical instruments (e.g., microscopes and binoculars). Class 3a lasers have power levels of 1-5 mW.

CLASS 3B LASERS

Class 3b laser light will cause injury upon direct viewing of the beam and specular reflections. The power output of Class 3b lasers is 5-500 mW cw or less than 10 J/cm^2 for a 1/4-s pulsed system. Specific control measures covered in this chapter must be implemented.

CLASS 4 LASERS

Class 4 lasers include all lasers with power levels greater than 500 mW cw or greater than 10 J/cm^2 for a 1/4-s pulsed system. They pose eye hazards, skin hazards, and fire hazards. Viewing of the beam and of specular reflections or exposure to diffuse reflections can cause eye and skin injuries. All of the control measures explained in this document must be implemented.

16.4 BEAM HAZARDS

The most prominent safety concern with lasers is the possibility of eye damage from exposure to the laser beam, as outlined below. The nature of the damage and the threshold level at which each type of injury can occur depends on the beam parameters. These include wavelength, beam divergence, and exposure duration. For pulsed lasers, the parameters include pulse length, pulse repetition frequency, and pulse train characteristics.

16.4.1 RETINA

Laser light in the visible and near infrared (IR) region (400 nm–1400 nm) that enters the eye is focused on the retina. This can result in the following types of damage:

Thermal Burn

Normal focusing by the eye results in an irradiance amplification of roughly 100,000; therefore, a 1 mW/cm^2 beam entering the eye will result in a 100 W/cm^2 exposure at the retina. The most likely effect of intercepting a laser beam with the eye is a thermal burn which destroys the retinal tissue. Since retinal tissue does not regenerate, the damage is permanent. The ANSI MPE values are set below the threshold level for thermal burns.

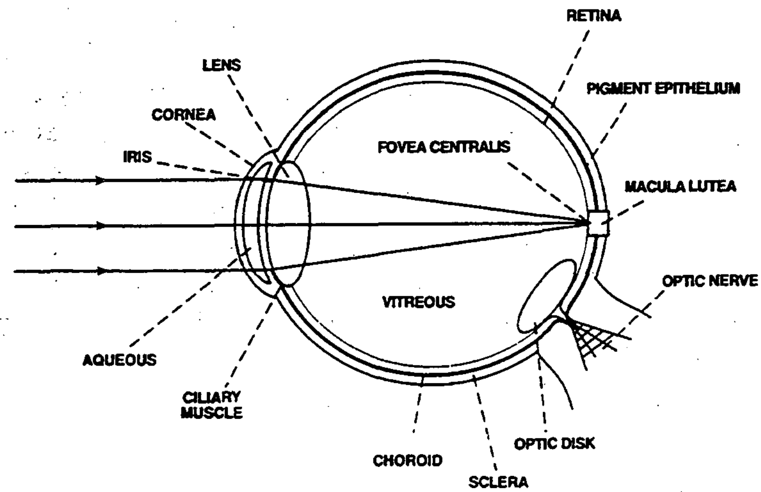


Fig. 16.1. The human eye.

16.4.2 ACOUSTIC DAMAGE

Laser pulses of a duration less than 10 microseconds induce a shock wave in the retinal tissue which causes a rupture of the tissue. This damage is permanent, as with a retinal burn. Acoustic damage is actually more destructive than a thermal burn. Acoustic damage usually affects a greater area of the retina, and the threshold energy for this effect is substantially lower. The ANSI MPE values are reduced for short laser pulses to protect against this effect.

16.4.3 PHOTOCHEMICAL DAMAGE

Light below 400 nm is not focused on the retina. The light can be laser output, ultraviolet (UV) from the pump light, or blue light from a target interaction. The effect is cumulative over a period of days. The ANSI standard is designed to account only for exposure to the laser light. If UV light from a pump light or blue light from a target interaction is emitted, additional precautions must be taken.

16.4.4 OTHER EYE/SKIN HAZARDS

When UV or IR laser light enters the eye, much of the light is absorbed in the lens. Depending on the level of exposure, this may cause immediate thermal burns or the development of cataracts over a period of years.

The cornea and the conjunctiva tissue surrounding the eye can also be damaged by exposure to laser light. Damage to the cornea and conjunctiva tissue usually occurs at greater power levels than damage to the retina; therefore, these issues only become a concern for those wavelengths that do not penetrate to the retina (i.e., UV and IR radiation). Since the amplification by the lens is not involved, the injuries can also be caused by diffuse and noncoherent light.

Skin can suffer thermal burns and photochemical changes from laser exposure. These effects are almost entirely independent of the coherent nature of the laser light, but are aggravated by the high power density of lasers.

<table>
<tr><th colspan="2">Photobiological Spectral Domain</th><th>Eye Effects</th><th>Skin Effects</th></tr>
<tr><td>Ultraviolet C</td><td>(0.200 – 0.280µm)</td><td rowspan="2">—Photokeratitis</td><td>Erythema (sunburn)
Skin Cancer</td></tr>
<tr><td>Ultraviolet B</td><td>(0.280 – 0.315µm)</td><td>Accelerated Skin Aging
Increased Pigmentation</td></tr>
<tr><td>Ultraviolet A</td><td>(0.315 – 0.400 µm)</td><td>Photochemical
UV Cataract</td><td>— Pigment Darkening</td></tr>
<tr><td>Visible</td><td>(0.400 – 0.780 µm)</td><td>Photochemical &
Thermal Retinal
Injury</td><td>— Photosensitive
Reactions</td></tr>
<tr><td>Infrared A</td><td>(0.780 – 1.400 µm)</td><td>Cataract, Retinal
Burns</td><td rowspan="3">— Skin Burn</td></tr>
<tr><td>Infrared B</td><td>(1.400 – 3.000 µm)</td><td>Corneal Burn
Aqueous Flare
IR Cataract</td></tr>
<tr><td>Infrared C</td><td>(3.000 – 1000 µm)</td><td>Corneal Burn Only</td></tr>
</table>

Table 16.1. Summary of basic biological effects of light.

16.5 ASSOCIATED NON-BEAM HAZARDS

While beam hazards are the most prominent laser hazards, other hazards pose equal or possibly greater risk of injury or death. These hazards must be addressed in the Activity Hazard Document (AHD) for the laser operation where they apply.

16.5.1 ELECTRICAL HAZARDS

Most lasers contain high-voltage power supplies and often large capacitors or capacitor banks that store lethal amounts of electrical energy. In general, systems that permit access to components at such lethal levels must be interlocked; however, during maintenance and alignment procedures, such components often become exposed or accessible. This has caused numerous serious and some fatal shocks at other research facilities. See Chapter 8, *Electrical Safety*.

Electrical Safety Guidelines

- No one should work on lasers or power supplies unless qualified and approved to perform the specific tasks.

- Do not wear rings, watches, or other metallic apparel when working with electrical equipment.
- Do not handle electrical equipment when hands or feet are wet or when standing on a wet surface.
- When working with high voltages, regard all floors as conductive and grounded.
- Be familiar with electrocution rescue procedure and emergency first aid.
- Prior to working with electrical equipment, de-energize the power source. Lock and tag out the disconnect switch in accordance with PUB-3000 Chapter 18 Lockout/Tagout.
- Check that each capacitor is discharged, shorted, and grounded prior to working in the area of the capacitors.
- When possible, use shock preventing shields, power supply enclosures, and shielded leads in all experimental or temporary high voltage circuits.

Common Hazards Encountered When Working With Electrical Equipment

- Uncovered electrical terminals
- Improperly insulated electrical terminals
- Hidden power up/on warning lights
- Lack of personnel training in CPR (this and first aid training is offered at the Lab)
- Buddy system not being practiced during maintenance and alignment work
- Non earth-grounded/improperly grounded laser equipment
- Excessive wires and cables on the floor that create fall/trip hazards

16.5.2 LASER DYES

Laser dyes are often toxic and/or carcinogenic chemicals dissolved in flammable solvents. This creates the potential for personnel exposures above permissible limits, fires, and chemical spills. Frequently, the most hazardous aspect of a laser operation is the mixing of chemicals that make up the laser dye. In addition, hazardous-waste-disposal concerns need to be addressed.

16.5.3 COMPRESSED AND TOXIC GASES

Hazardous gases maybe used in laser applications, i.e., excimer lasers (fluorine, hydrogen chloride). The AHD should contain references for the safe handling of compressed gases, such as seminic restraints, use of gas cabinets, proper tubing and fittings, etc. Refer to Pub 3000, Chapter 13.

16.5.4 CRYOGENIC FLUIDS

Cryogenic fluids are used in cooling systems of certain lasers, and can create hazards situations. As these materials evaporate, they can create oxygen deficient atmospheres and an asphyxiation hazard by replacing the oxygen in the air. Adequate ventilation must be provided. Cryogenic fluids are potentially explosive when ice collects in valves or connectors that are not specifically designed for use with cryogenic fluids. Condensation of oxygen in liquid nitrogen presents a serious explosion hazard if the liquid oxygen comes in contact with any organic material. While the quantities of liquid nitrogen that may be used are usually small, protective clothing and face shields must be used to prevent freeze burns to the skin and eyes.

16.5.5 RADIOFREQUENCIES (RF)

Some lasers contain RF excited components as plasma tubes and Q switches. Unshielded and loosely tightened components may allow RF fields to leak from the device and expose staff. RF leakage surveys can be obtained from the LSO/NIRO.

16.5.6 ERGONOMICS

Ergonomic problems can arise from a laser operation by causing awkward unique arm and wrist positions. If such repetitive deviations occur for prolong periods of time, medical problems such as repetitive strain injuries may arise. The LSO/NIRO and EH&S can help the user develop appropriate control measures.

16.5.7 SEISMIC SAFETY

It is lab policy to prevent the loss of life and to minimize the risk of personal injury, program interruption, and property damage due to earthquakes. To support this goal, all laser users need to view their laser setup for compliance with seismic safety guidelines. Examples would be fastening electronic racks to the floor or walls, and racks on casters having at least two locking wheels. When possible, heavy laser equipment should be bolted down. Chapter 23 of PUB-3000 lists seismic restraint recommendations.

16.5.8 FUMES/VAPORS/LASER GENERATED AIR CONTAMINANTS (LGAC), FROM BEAM / TARGET INTERACTION

Air contaminants may be generated when certain Class 3b and Class 4 laser beams interact with matter. When the target irradiance reaches a given threshold of approximately 10 to the 7th W/cm^2 target materials, including plastics, composites, metals, and tissues, may liberate toxic and noxious airborne contaminants. In other words, when laser beams are sufficiently energized to heat up a target, the target may vaporize, creating hazardous fumes or vapors that may need to be captured or exhausted.

When targets are heated to very high temperatures, as in laser welding and cutting, an intense bright light is emitted. This light often contains large amounts of short wavelength or blue light, which may cause conjunctivitis, photochemical damage to the retina, and/or erythema (sunburn-like reactions) in the skin.

16.5.9 PLASMA EMISSIONS

Interactions between very high power laser beams and target materials may in some cases produce plasmas. The plasma generated may contain hazardous "blue light" and UV emissions, which can be an eye and skin hazard.

16.5.10 UV AND VISIBLE RADIATION

UV and visible radiation may be generated by laser discharge tubes and pump lamps. The levels produced may be an eye and skin hazard.

16.5.11 EXPLOSION HAZARDS

High pressure arc lamps, filament lamps, and capacitors may explode if they fail during operation. These components are to be enclosed in a housing which will withstand the maximum explosive forces that may be produced. Laser targets and some optical components also may shatter if heat cannot be dissipated quickly enough. Consequently, care must be used to provide adequate mechanical shielding when exposing brittle materials to high intensity lasers.

16.5.12 IONIZING RADIATION (X-RAYS)

X-rays could be produced from two main sources, high voltage vacuum tubes of laser power supplies such as rectifiers, thyratrons, and electric discharge lasers. Any power supplies which require more than 15 kilovolts may produce enough x-rays to be a health concern.

16.6 VIEWING LASER RADIATION

The figures below illustrate intrabeam viewing of direct (primary) and specularly reflected (secondary) beams.

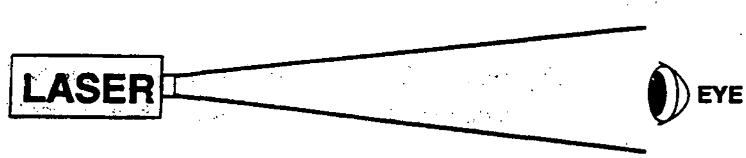


Fig. 16.2. Intrabeam viewing of direct (primary) beam. This type of viewing is most hazardous.

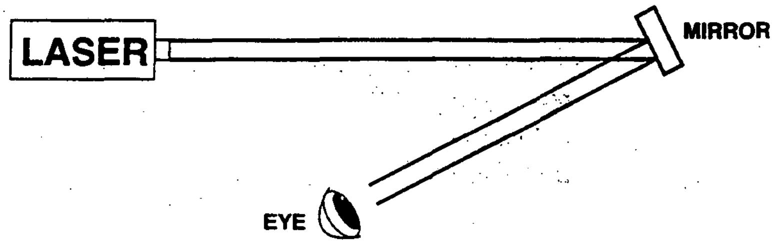


Fig. 16.3. Intrabeam viewing of a specularly reflected (secondary) beam from a flat surface reflector. Specular reflections are most hazardous when the reflecting surface is flat.

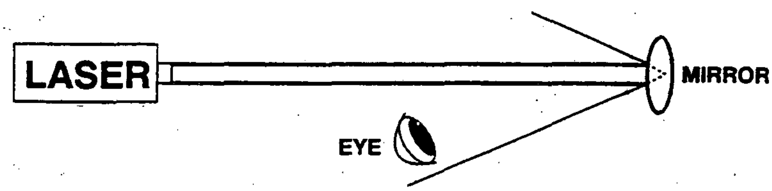


Fig. 16.4. Intrabeam viewing of a specularly reflected (secondary) beam from a curved surface reflector, less hazardous than that of a flat source reflection.

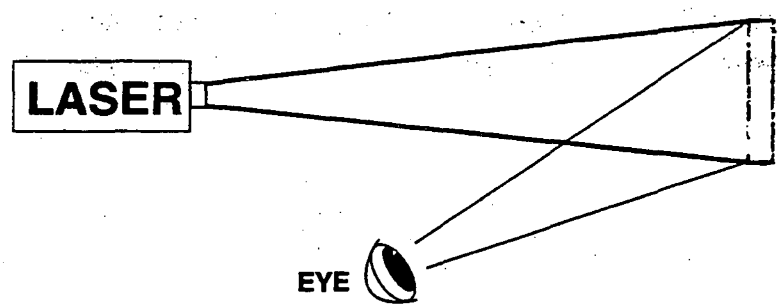


Fig. 16.5. Extended source viewing of a normally diffuse reflection. Diffuse reflections are not normally hazardous, except with very high power Class 4 lasers.

16.7 LASER ACCIDENTS

The laser user can prevent laser accidents. Sixty percent of laser accidents in research settings occur during the alignment process. If individuals suspect they have received a laser hit, they should contact Health Services and contact the laser safety officer. Unfortunately, experience has demonstrated that most laser injuries go unreported for 24–48 hours by the injured person. This is a critical time for treatment of the injury.

Some common unsafe practices that are causes of preventable laser accidents are:

- Not wearing protective eyewear during alignment procedures
- Not wearing protective eyewear in the laser control area
- Misaligned optics and upwardly directed beams
- Equipment malfunction
- Improper methods of handling high voltage
- Available eye protection not used
- Intentional exposure of unprotected personnel
- Lack of protection from nonbeam hazards
- Failure to follow AHD
- Bypassing of interlocks, door and laser housing
- Insertion of reflective materials into beam paths
- Lack of pre-planning
- Turning on power supply accidentally
- Operating unfamiliar equipment
- Wearing the wrong eyewear

Laser alignment guidelines to help prevent accidents:

- No unauthorized personnel will be in the room or area.
- Laser protective eyewear will be worn.
- All laser users must attend the LBNL laser safety class, EH&S 0280.
- The individual who moves or places an optical component on an optical table is responsible for identifying and terminating each and every stray beam coming from that component.
- To reduce accidental reflections, watches and reflective jewelry should be taken off before any alignment activities begin.
- Beam blocks must be secured.
- When the beam is directed out of the horizontal plane, it must be clearly marked.
- A solid stray beam shield must be securely mounted above the area to prevent accidental exposure to the laser beam.
- All laser users must receive an orientation to the laser use area by an authorized laser user of that area.
- Laser users must have had their baseline eye examination prior to performing any alignment procedures.
- The lowest possible/practical power must be used during alignments.

- When possible, a course alignment should be performed with a HeNe alignment laser.
- Have beam paths at a safe height, below eye level when standing or sitting. Not at a level that tempts one to bend down and look at the beam. If necessary, place a step platform around optical table.

16.8 EMBEDDED LASERS

Frequently, lasers are embedded in laser products or systems with a lower hazard rating. For example, laser printers, CD players, and laser scanning confocal microscopes are Class 1 laser products, but they contain Class 3 or Class 4 lasers.

When the laser system is used as intended, the controls for the system's class apply. When the system is opened (e.g., for service or alignment) and the embedded laser beam is accessible, a temporary control area must be established. The controls for the temporary control area must be based on the classification of the embedded laser. Adequate controls are determined by the user and LSO. Confirmation of a system classification is the responsibility of the LSO. An abbreviated AHD may be required, as in the case of such commercially available enclosed laser systems as a Laser Scanning Confocal Microscope.

16.9 REQUIREMENTS FOR LOW-POWER LASERS (CLASS 1, 2, 2a, 3a)

Class 1, 2, and 2a lasers can be used without restriction in the manner intended by the manufacturer and without special training or qualification of operating personnel. Personnel should not be exposed to laser light unnecessarily. When personnel not familiar with the low-hazard nature of laser operations are present, a sign advising of the low-hazard nature of the operation may be appropriate.

Class 3a lasers are governed by the same criteria as Class 1 and Class 2 lasers for normal operations. If the laser light is to be viewed through optical instruments (e.g., binoculars, telescopes, or microscopes), contact the LSO/NIRO for a hazard review. Special control measures may be needed.

16.10 REQUIREMENTS FOR HIGH-POWER LASERS (CLASS 3b AND CLASS 4)

All requirements of the LBNL laser safety program apply to Class 3b and Class 4 lasers, unless documented equivalent procedures and control measures have been approved by the LSO. These requirements are described in the following sections of this document.

16.11 LASER ACQUISITIONS

Laser users are required to notify the LSO/NIRO of any intent to purchase, fabricate, or otherwise acquire a Class 3b or Class 4 laser. The LSO/NIRO will review with the user the hazards of the proposed operation and make recommendations regarding the specific safety requirements that pertain to the proposed use, including requirements for AHDs, laser control areas, training, and eye protection.

To ensure that all lasers are included in this program, the Purchasing Department must notify the LSO/NIRO of purchase orders for lasers as the orders are placed. Arriving Class 3b and Class 4 lasers are held at Receiving until their release is approved by the LSO. This is intended to ensure that such lasers are only installed in areas where the required engineering controls are provided.

16.12 SUBSTITUTION OF ALTERNATE CONTROL MEASURES

The ANSI Z136.1 Laser Standard, the engineering control measures for Class 3b and Class 4 lasers or laser systems, upon documented review by the LSO, may be replaced by administrative or other alternate engineering controls which provide equivalent protection. Approval of these controls are subject to the same review procedure as described (see Chapter 6, Appendix I) on AHD. An example would be a use of curtain maze in place of a entrance interlock.

16.12.1 PROTECTIVE HOUSING

All commercial lasers require a protective housing.

16.12.2 PROTECTIVE HOUSING INTERLOCKS

Commercial Class 3b and Class 4 lasers require protective housing interlock systems that prevent emission of laser radiation when the housing is opened.

16.12.3 KEY SWITCH

All Class 4 lasers must be equipped with a removable master key switch or similar control means, such as computer password control. The laser must not be operable when the key is removed.

16.12.4 REMOTE INTERLOCK CONNECTOR

Commercial Class 4 lasers must be equipped with electrical connections that allow the laser to be controlled by an area interlock system and remote shut-off devices. When the terminals are open-circuited, the laser must not emit any radiation in excess of the MPE.

16.12.5 VIEWING PROTECTION

All viewing portals in the protective housing must be equipped with filters and attenuators to preclude the emission of laser light in excess of the MPE through such portals. It is recommended that the plane of the laser beam be above or below the level of a seated or standing person.

16.12.6 BEAM STOP OR ATTENUATOR

Each Class 4 laser or laser system must be provided with an integral or permanently attached beam stop or attenuator capable of preventing the emission of laser light in excess of the MPE when the beam is not required. An internal shutter can serve this purpose.

16.12.7 COLLECTING OPTICS

All optical instruments intended for viewing a laser or laser system must be equipped with suitable means (e.g., filters, attenuators, or interlocks) to preclude the transmission of laser light in excess of the MPE under all conditions of operation and maintenance.

16.13 LASER CONTROL AREAS

Class 3b and Class 4 lasers may only be operated in laser control areas approved by the LSO. The purpose of laser control areas is to confine laser hazards to well-defined spaces that are under the control of the laser user. This is an attempt to prevent injury to those visiting and working in the control area. Operations must meet or have equivalent operating standards described in this chapter.

16.14 CLASS 3b CONTROL AREAS

All personnel who require routine entry into a Class 3B laser controlled area shall be appropriately trained. They are required to follow all applicable administrative controls.

16.14.1 POSTING

The area must be posted with appropriate warning signs that indicate the nature of the hazard. The wording on the signs will be specified by the LSO.

16.14.2 AUTHORIZATION

Only personnel who have been authorized may operate the laser. Personnel may be authorized upon compliance with the requirements identified in the sections on Training and Medical Surveillance. At a minimum, authorized personnel have met all training and medical surveillance requirements stipulated for the class laser they wish to operate. Line management may stipulate additional authorization requirements. (See the Training and Medical Surveillance section of this chapter.)

16.14.3 BEAM STOP

All laser beams must be terminated within the control area. Beam stops provide protection from misaligned beams, and should be placed in all appropriate and practical locations.

16.14.4 EYE PROTECTION

If there is a possibility of viewing the beam, appropriate eye protection must be provided for all personnel within the laser control area, if such viewing could exceed the MPE, therefore presenting an ocular hazard. The eye protection must have an appropriate optical density and/or reflective properties based on the wavelengths of the beams encountered, the beam intensity, and the expected exposure conditions. At the same time, the need for laser eye protection must be balanced by the need for adequate visible light transmission. It is the responsibility of the user group to obtain appropriate laser protective eyewear from a vendor. To select laser eye protection, contact the LSO/NIRO. Laser eye protection should be inspected periodically to ensure that it is in good condition. The LSO can assist the user in determining the proper parameters of such eyewear, and can provide contact numbers for vendors.

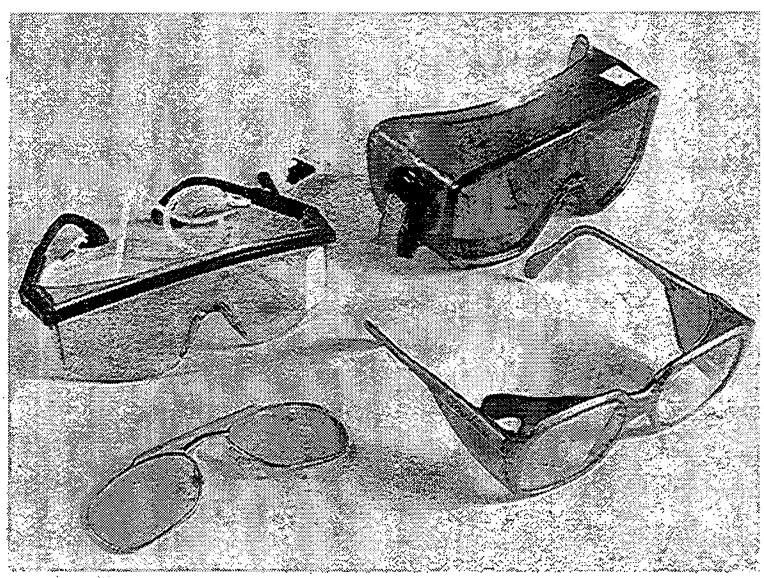


Fig. 16.6. Laser safety glasses.

16.14.5 ROOM ACCESS

Access to the area by spectators or visitors must be limited and controlled by the laser user.

16.14.6 LIGHT CONTAINMENT

Light levels in excess of the MPE must not pass the boundaries of the control area. All windows, doorways, open portals, and other openings through which light might escape from a laser control area must be covered or shielded in such a manner as to preclude the transmission of laser light. Special rules apply for outdoor use and laser control areas that do not provide complete containment. Contact the LSO/NIRO for details.

16.15 CLASS 4 CONTROL AREAS

All personnel who require routine entry into a Class 4 laser controlled area must be appropriately trained. They must be provided with appropriate protective equipment and are required to follow all applicable administrative controls. Class 4 laser control areas must meet all of the requirements that apply to Class 3b control areas and also the following requirements:

16.15.1 CONTROL AREA INTERLOCKS

Class 4 laser control areas must be equipped with interlocks or alternate controls to preclude the entry of unprotected personnel while Class 4 laser radiation is present in the control area. The interlock system may be designed to preclude entry while the laser is operating or to terminate laser operation when the door is opened without deliberate overriding of the interlock by an authorized individual. Administrative or procedural entryway safety controls may be used where interlocks are not feasible or are inappropriate. The following may apply:

All authorized personnel shall be adequately trained. Examples of administrative controls are a door-blocking barrier, screen, curtain, or entry maze. These methods shall be used to block, screen, or attenuate the laser radiation at the entryway. The LSO shall review and approve alternate interlock [access] controls.

16.15.2 RAPID EGRESS

There must be provisions for rapid egress from a laser control area under all normal and emergency conditions. The control area interlock system must not interfere with emergency egress.

16.15.3 REMOTE FIRING

Wherever possible, lasers should be monitored and fired from remote locations.

16.15.4 LASER ACTIVATION SYSTEM

A visible or audible signal must be provided at the entrance to the control area to indicate when the laser is energized and operating.

16.16 TEMPORARY LASER CONTROL AREAS

Temporary laser control areas can be created for the servicing and alignment of embedded lasers, enclosed beams/lasers, and in special cases where permanent laser control areas cannot be provided. They are subject to the normal AHD approval process.

16.17 TRAINING

All employees and guests who use Class 3b or Class 4 lasers must complete the LBNL course, Laser Safety, EH&S 280. In addition, it is highly recommended that anyone who regularly works in a Class 3b or Class 4 laser use area also attend this course. New employees and guests may use lasers under the direct supervision of an authorized LBNL laser user for a maximum of 30 days before completing the Training and Medical Surveillance requirement. The Laser Safety Officer should be notified of these new employee or guest laser users. The Laser Safety course is offered regularly and can also be customized for specific laser user groups. Laser users are also responsible for knowing the safety requirements that apply to their specific laser or laser system and for knowing the contents of the applicable Activity Hazard Document.

16.18 RETRAINING

Laser users must participate in retraining at least once every three years. The retraining requirement may be met through participation in an LBNL approved advanced laser safety course, an examination showing proficiency in laser safety concepts, or through reenrollment in Laser Safety, EH&S-280.

16.19 MEDICAL SURVEILLANCE

All Class 3b and Class 4 laser users who will be at LBNL for more than 1 month must complete a special LBNL laser eye examination. The examination is administered by an optometrist through the on site Health Services Department. The examination includes:

- Medical history
- Visual acuity
- External ocular examination
- Examination by slit lamp
- Ophthalmoscopy
- Manifest reaction, when indicated
- Fundus photographs with dilation

It is strongly recommended that the laser user receive an additional laser eye examination when it has been a year since any previous laser use, and on termination of employment.

Additional laser eye examinations will be performed as follow-up to suspected eye exposure, or at the request of the LSO or user.

16.20 ACTIVITY HAZARD DOCUMENTS (AHD)

All Class 3b and Class 4 laser operations must be covered by an approved AHD. This AHD should cover laser operations (i.e. description of activities, hazard identification and mitigation, routine alignment procedures, schematics of laser set-up) and other relevant hazards in the laboratory. The AHD submittal and approval procedure described in Chapter 6 should be followed. A Laser AHD template is attached to the appendix of this chapter. The use of the template is highly recommended. The template provides a guide for the researcher to identify the characteristics of the laser operation and collateral hazards, and to write up set-up and alignment procedures. For assistance in developing appropriate control measures and completing the AHD, contact the LSO/NIRO.

In the case of laser diode users, and enclosed systems [laser scanning confocual microscopy] an abbreviated AHD can be applied. This abbreviated AHD will follow the standard AHD approval process. This approach can only be used after an experimental review by the LSO/NIRO, who will then determine the required sections of the abbreviated AHD.

All AHDs need to be reviewed annually. If no new hazards have been added to the experiment, the users division can perform the review with notification to the LSO/NIRO. If no new hazards had been added, the existing AHD is considered valid until the division renewal takes place. If new hazards have been added to the experiment, a review by EH&S is necessary to assure all applicable safeguards have been met. AHD review requirements are described in detail in Chapter 6.

A time period exists between the setting up of the laser equipment and the submittal and approval of the AHD. At this time the experimental condition and controls for the AHD are being developed. With the assistance of the user, the LSO will develop a set of documented conditions for the laser user to operate the laser during this time. These conditions will be posted at the laser laboratory and sent to the appropriate division safety coordinator.

16.21 BEAM CONTROL

The laser user is required to keep all laser beams on the optical table or within the experimental envelope at all times. To maintain this control, it is essential to be aware of all beams (including unwanted beams) and to terminate them with beam stops at the end of their useful paths. When a beam traverses to other tables or across aisles, the beam must be enclosed or the access to the aisle must be blocked to prevent personnel exposure to the beam.

16.22 SPECIAL REQUIREMENTS FOR INVISIBLE LASERS

Since IR and UV lasers produce no visible light, this can contribute to their hazard potential. Since IR and UV laser beams are invisible, the use of laser eyewear that will protect against worst case exposures is recommended at all times.

16.22.1 INFRARED LASERS

Infrared laser beams (>0.07 µm) must be terminated by a highly absorbent, non-specular backstop. Note that many surfaces that appear dull are excellent IR reflectors and would not be suitable for this purpose. Beam terminators for Class 4 IR laser beams must be made of fireproof material.

16.22.2 ULTRAVIOLET LASERS

UV radiation causes photochemical reactions in the eyes and the skin, as well as in materials that are found in laboratories. The latter may cause hazardous by-products such as ozone and skin-sensitizing agents. The direct beam and scattered radiation should be shielded to the maximum extent practicable to avoid such problems. The use of long-sleeved coats, gloves, and face protectors is recommended. Some medications can increase one's risk to UV. Contact the LSO/NIRO for a detailed analysis and measurement of scattered UV radiation.

16.23 RESPONSIBLE PARTIES

The individuals and groups listed in the following sections are responsible for implementing the laser safety policy.

16.23.1 LASER USERS

Complete the course, Laser Safety, EH&S-280.

Know and adhere to control requirements in this document and in the pertinent AHD. (See the Appendix, page 16–19, for an example of an AHD.)

Obtain the laser eye examination.

Use laser eye protection.

Immediately report any suspected laser eye exposures to the laser supervisor, Health Services, and the LSO/NIRO.

16.23.2 LASER SUPERVISORS

Ensure that all personnel complete the course, Laser Safety, EH&S-280, and other training required to operate lasers safely.

Ensure that all personnel report to Health Services for laser eye examinations as outlined in the medical surveillance section of this chapter, and after any suspected case of laser eye exposure.

Prepare an AHD for laser operation and ensure that the provisions of the AHD are implemented. (See the Appendix, page 16-25, for an example of an AHD.)

Provide orientation and training for visitors and new employees until they can complete the course, Laser Safety, EH&S-280.

Provide the laser control area, interlock systems, and laser eye protection for laser operations.

Notify LSO/NIRO of proposed laser acquisitions.

Notify LSO/NIRO of proposed changes to the laser control area configuration.

Notify LSO/NIRO of proposed changes in laser use.

Advise the LSO/NIRO of product acceptance testing

16.23.3 EH&S LASER SAFETY OFFICER/NON-IONIZING RADIATION OFFICER

In the ANSI Z 136.1 Laser Standard, the conditions under which the laser is used, the level of safety training of individuals using the laser, and other environmental and personnel factors are important considerations in determining the full extent of safety control measures. Such situations require informed judgment by responsible persons. Major responsibility for such judgments has been assigned to a person with the requisite authority and responsibility, namely the Laser Safety Officer [LSO]. The Laser Safety Officer's duties and responsibilities include, but are not limited to:

Maintaining the LBNL laser safety program.

Reviewing and providing technical advice and safety approval for all laser operations.

Reviewing AHDs listing laser hazards.

Reviewing alternate controls.

Approving Specific Safety plans for Laser diode use when applicable.

Calculating Nominal Hazard Zones upon request.

Calculating laser eye hazards and advising laser users and supervisors on appropriate eye protection.

Maintaining an inventory of all Class 3b and Class 4 lasers at LBNL.

Developing and teaching laser safety training courses for all LBNL laser users.

Investigating all instances of suspected laser eye exposure.

Determining classification and certifying compliance with federal laser product performance standards for custom-built and modified lasers.

16.23.4 PURCHASING

Advises LSO/NIRO of all approved proposed laser purchases.

16.23.5 RECEIVING

Holds all lasers at Receiving until released by the LSO/NIRO.

16.23.6 ELECTRONICS ENGINEERING

Designs and installs interlock systems and access controls for laser control areas.

16.23.7 EH&S HEALTH SERVICES GROUP

Arranges laser eye examinations for all laser users.

Advises laser users and LSO/NIRO of any ocular abnormalities that could be attributed to laser exposure or that could be relevant to laser use.

16.23.8 EH&S PROFESSIONALS

Provide guidance in handling laser associated hazards such as the handling of laser dyes and other toxic materials. Provide evaluation and guidance for ventilation requirements for laser targets and toxic materials. Provide guidance for electrical hazards, seismic, and Lockout/Tagout requirements, etc.

16.24 GLOSSARY

Blink reflex (also known as **aversion response**) is the closure of the eyelid or movement of the head to avoid an exposure to a noxious stimulant or bright light.

A **carcinogen** is an agent potentially capable of causing cancer.

A **continuous wave (cw)** is the output of a laser which is operated in a continuous rather than pulsed mode.

A **controlled area** is an area in which the occupancy and activity of those present is subject to control and supervision for the purpose of protection from radiation hazards.

The **cornea** is the transparent outer coat of the human eye, covering the iris and the crystalline lens. The cornea is the main refracting element of the eye.

Diffuse reflection is the change of the spatial distribution of a beam of radiation when the beam is reflected in many directions by a surface or by a medium.

An **embedded laser** is enclosed in a laser system and has an assigned class number higher than the inherent capability of the laser system. The laser system's lower classification is appropriate because of the engineering features that limit accessible emission.

An **enclosed laser** is contained in a protective housing. Opening or removing the protective housing provides additional access to laser radiation above the applicable MPE. (An embedded laser is a type of enclosed laser.)

Erythema is the medical term for redness of the skin due to congestion of the capillaries.

Infrared radiation (IR) is electromagnetic radiation with wavelengths that lie within the range 0.7 μm to 1 mm.

Intrabeam viewing is the viewing condition in which the source subtends an angle at the eye which is equal to or less than α_{min}, the limiting angular subtense. In simpler terms, the eye views or is exposed to a laser beam directly. This category includes most collimated beams and so-called point sources.

The **iris** is the circular pigmented membrane that lies behind the cornea of the human eye. The iris is perforated by the pupil.

A **joule (J)** is a unit of energy (1 joule = 1 watt per second).

A **laser** is a device that produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to lower energy levels. Laser is an acronym for light amplification by stimulated emission of radiation.

A **macula** is the small, uniquely pigmented and specialized area of the retina.

Maximum permissible exposure (MPE) is the level of laser radiation to which a person may be exposed without hazardous effect on or adverse biological changes in the eye or skin.

The **ocular fundus** is the back of the eye. The ocular fundus may be seen through the pupil by use of an ophthalmoscope.

Optical density (D_λ) is the logarithm to the base ten of the reciprocal of the transmittance: $OD = \log_{10}(E_i/E_t)$, where OD = optical density, E_i = incident beam irradiance (W/cm^2) *worst case exposure,* and E_t = transmitted beam irradiance (MPE limit in W/cm^2).

Power is the rate at which energy is emitted, transferred, or received.

Protective housing is an enclosure that surrounds a laser or laser system, preventing access to laser radiation above the applicable MPE level.

Pulse duration is the duration of a laser pulse, usually measured as the time interval between the half-power points on the leading and trailing edges of the pulse.

A **pulsed laser** is a laser that delivers its energy in the form of a single pulse or train of pulses.

A **Q-switch** is a device that produces very short (~ 10–250 ns), intense laser pulses by enhancing the storage and dumping of electronic energy in and out of the lasing medium.

A **Q-switched laser** is a laser that emits short (~10–250 ns), high-power pulses by means of a Q-switch.

Radiance is radiant flux or power output per unit solid angle per unit area.

Reflection is the deviation of radiation following incidence on a surface.

The **retina** is the sensory membrane that receives the incident image formed by the cornea and lens of the human eye. The retina lines the inside of the eye.

A **spectator** is an individual who wishes to observe or watch a laser or laser system in operation and who may lack the appropriate laser safety training.

Specular reflection is a mirrorlike reflection.

Ultraviolet radiation (UV) is electromagnetic radiation with wavelengths smaller than those of visible radiation.

A **viewing portal** is an opening in an experimental system, allowing the user to observe the experimental chamber. All viewing portals and display screens included as an integral part of a laser system must incorporate a suitable means to maintain the laser radiation at the viewing position at or below the applicable MPE (eye safe) for all conditions of operation and maintenance. It is essential that the material used for viewing portals and display screens not support combustion or release toxic vapors following exposure to laser radiation.

Visible radiation (light) is electromagnetic radiation that can be detected by the human eye. This term is commonly used to describe wavelengths which lie in the range 0.4 to 0.7 µm.

A **watt (W)** is the unit of power or radiant flux (1 watt = 1 joule per second).

A **wavelength** is the distance between two successive points on a periodic wave which have the same phase.

16.25 STANDARDS

- American National Standards Institute (ANSI) Z136.1-1993, American National Standard for the Safe Use of Lasers (or later revision)
- American National Standards Institute (ANSI) Z136.2-1988, American National Standard for the Safe Use of Optical Fiber Communication Systems Utilizing Laser Diodes and LED Sources (or later revision)
- 29 CFR 1910, *Occupational Safety and Health Standards for General Laboratory*

16.26 RELATED PUB-3000 CHAPTERS

- *Electrical Safety* (Chapter 8)
- *Gases* (Chapter 13)
- *Industrial Hygiene* (Chapter 4)
- *Lockout/Tagout* (Chapter 12)
- *Personal Protective Equipment* (Chapter 19)
- *Safety Procedures & Safety Approval* (Chapter 6)
- *Seismic Safety* (Chapter 23)

16.27 REFERENCES

- 21 CFR 1040.1 and 1040.11, Federal Laser Products Performance Standard

16.28 APPENDICES

- Appendix A: Activity Hazard Document (AHD)

APPENDIX A: ACTIVITY HAZARD DOCUMENT (AHD) OUTLINE FOR CLASS 3B & CLASS 4 LASER USERS

GENERAL INFORMATION

TITLE	LOCATION Bldg.-Room	DIVISION	LASER SAFETY CONTACT

DESCRIPTION OF ACTIVITY

Provide description including unique equipment, its application or activity and principal parameters.

DURATION (*Check One Box*)

- ❒ **Ongoing**
- ❒ **Limited Period; Enter # of Months _____**

IDENTIFICATION OF HAZARDS

- ❒ **Laser**
- ❒ **Toxic Gases**
- ❒ **Electrical**
- ❒ **Radioactive Materials**
- ❒ **Toxic Chemicals**
- ❒ **Other (*Please explain in space provided below*)**

MITIGATION OF HAZARDS

Controls to reduce the potential hazards. From a laser perspective, the following needs need to be addressed:

Identification of laser(s): Laser specifications

Complete the following chart (as much as possible), list all lasers, including low power alignment lasers:

	Laser 1	Laser 2	Laser 3
Type:			
Manufacturer:			
Model:			
Serial #			
Maximum Power			
Wavelength Range			
Wavelength Used			
Power Used			
Pulse Length			
Pulse Repetition Rate			
Beam Diameter			
Beam Divergence			
Property #			
Made In-House			
Class			

LASER USERS

Employee	Date Laser Safety Training Completed	Date Eye Examination Completed

ATTACH A DIAGRAM OF LASER USE AREA (*A simple block diagram is sufficient. The diagram should also be posted on lab door.*)

DESCRIBE ACCESS CONTROLS, INCLUDING USE OF INTERLOCKS

DESCRIBE ALIGNMENT PROCEDURES

WHERE HAVE LASER WARNING SIGNS BEEN POSTED?
(Warning signs can be obtained from LBNL-LSO or Campus LSO)

PROTECTIVE EYEWEAR

Number of Pairs on Hand	Location of Eyewear	Manufacturer	Optical Density	Wavelength

BEAM PATH – Open, Enclosed, or Partially Enclosed

NONBEAM HAZARDS *(Include non-laser items identified as hazards)*

HAZARD	CORRECTIVE ACTION

MAINTENANCE

Equipment will be maintained in accordance with PUB-3122, Maintenance Program guidelines for Programmatic Equipment. System safety devices will be tested and documented in accordance with PUB-3000, Health and Safety Manual. Accurate records will be kept of tests, calibrations, adjustments, and repairs done. The door interlock will be checked quarterly and a record kept.

EMERGENCY PROCEDURES

Authorized laser users will be familiar with the Building Emergency Plan, location of emergency equipment, and emergency procedures for fires, earthquakes, and evacuations. Emergency shut-off procedures for lasers consist of shutting off the electrical power to the laser system. The main electrical shut-off switches to the laser should be labeled.

ANNUAL REVIEW SCHEDULE

If new hazards have been introduced, a full EH&S review will be required one year from approval date. If no changes other than users have been made (an update of the users list will be sent to LSO) renewal can be granted by user's division safety coordinator.

Chapter 17

ERGONOMICS

Revised December 1997

Reviewed by: _[signature]_ 12/9/97
Date

Approved by: _[signature]_ 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 17

ERGONOMICS

17.1 POLICY

Berkeley Lab (LBNL) shall maintain and implement an Ergonomics Program that identifies, prevents, and controls ergonomic hazards in accordance with all applicable rules and regulations. The Ergonomics Program shall consist of health and risk factor surveillance, work-site evaluations and improvement, medical management, training, and program review and evaluation. Strategies for reducing risk factors shall focus on engineering controls, when feasible, and/or administrative controls. The purpose of the Ergonomics Program is to minimize employee exposure to ergonomic hazards that lead to cumulative trauma disorders (CTDs) and related injuries and illnesses. Cumulative trauma disorders are disorders of the muscles, tendons, and/or nerves that develop from or are aggravated by repeated exertions or movements of the body. This program will have an impact on employees who may be exposed to ergonomic risks, such as video display terminal (VDT) operators, material handlers, and hand tool operators. All division directors, department heads, group leaders, supervisors, and individuals have responsibilities to help ensure a safe and healthful work environment. Therefore, commitment and cooperation from all employees at all levels is required to implement this policy.

17.2 SCOPE

This policy applies to all Laboratory employees, guests, and contractors.

17.3 OVERVIEW

Ergonomics means fitting the workplace to the worker by modifying or redesigning the job, workstation, tool or environment. Ergonomics draws from the fields of engineering, and medical and health sciences to optimize the work environment. By identifying ergonomic hazards that can result in an injury or illness, and correcting these hazards, employees can be provided a healthier workplace. Some of the factors evaluated in an ergonomic analysis are:

- Repetitiveness of a task
- Posture and movement of the limbs and whole body as a task is performed
- Physical strength required for a task
- Design and use of tools
- Design and layout of the work area or equipment

While the primary goal of ergonomics is to minimize employee exposure to ergonomic hazards that lead to CTDs and related injuries and illnesses, the benefits of ergonomics are:

- Improved safety and health in the workplace
- Improved employee morale and job satisfaction
- Improved productivity
- Improved quality of work
- Improved competitiveness in the marketplace
- Reduced probability of accidents and errors
- Reduced absenteeism and employee turnover
- Reduced medical and workers' compensation costs associated with cumulative trauma disorders

Ergonomics is an on-going process, not just a quick fix. Continued awareness and cooperation among responsible groups is essential to an effective ergonomics program.

17.4 CUMULATIVE TRAUMA DISORDERS

Cumulative trauma disorder is not a diagnosis, but a group of health problems with similar characteristics. CTDs are soft tissue disorders (e.g., muscles, tendons, joints, nerves) caused by wear and tear from repetitive motion. CTDs usually occur in the upper body in the neck, shoulders, back, arms, wrists, and hands. It is important to prevent CTDs because they can lead to serious and/or permanent injuries. CTDs are also referred to as repetitive motion injuries, repetitive strain injuries, repetitive trauma disorders, and overuse injuries.

17.4.1 RISK FACTORS

Several factors, usually in combination, contribute to the risk of developing a cumulative trauma disorder due to the stress on muscles, tendons, joints, and nerves. The presence of these factors in a job, process, operation, or work environment may not necessarily cause a problem, but they do increase the risk of developing a CTD.

- **Repetition**

Tasks that require high repetition rates require more muscle effort and less recovery time, which can lead to fatigue and stress. Examples of repetitive tasks are typing (faster than 60 words per minute), sorting, and flipping through files.

- **Excessive Force**

Examples of tasks in which it is possible to use excessive force are stamping, stapling, grasping large file folders or books, and hammering into a hard surface.

- **Awkward Posture or Position**

Examples of awkward postures or positions are using the shoulder and bending the neck to hold the telephone to the ear, turning the head to the side to read, bending the back in a forward/stooped position, reaching over the shoulder, and bending the wrists. Employees should always strive to maintain a neutral wrist (see Fig. 17.1).

- **Prolonged Activities**

Holding a position without movement for prolonged periods causes fatigue and requires a long recovery time. Examples of prolonged activities are standing or sitting for hours at a time, computer operators grasping the mouse for long periods, holding elbows away from the body while typing, and grasping a hand tool for an extended period of time.

- **Localized Pressure (Mechanical Stress)**

Too much pressure on muscles, tendons, and nerves can decrease blood flow circulation. Over time, constant localized pressure can cause an injury. Examples are pressure on the median nerve in the wrist, which can cause carpal tunnel syndrome, and resting forearms and wrists on sharp or hard edges (e.g., work surface corners, hard arm rests).

- **Vibration**

Working with vibrating tools or equipment for extended periods of time can potentially cause damage to the nerves in the arms, hands, and wrists.

- **Temperature (Cold)**

Working in cold may also contribute to developing CTDs. Cold temperature can result in a loss of sensory feedback, which reduces manual dexterity.

17.4.2 COMMON CUMULATIVE TRAUMA DISORDERS

Listed below are common cumulative trauma disorders:

- **Carpal Tunnel Syndrome**

This condition involves compression or pinching of the median nerve that runs through the wrist. Symptoms include pain, numbness, or tingling in the first three fingers and the base of the thumb. An aching sensation and wrist pain (mostly at night) is also typical of many cases.

- **DeQuervain's Disease**

This disorder is marked by the progressive constriction of the tendon sheath. It affects the tendons on the side of the wrist and at the base of the thumb. Symptoms include pain and difficulty in movement.

- **Epicondylitis**

Also known as tennis elbow, epicondylitis is an inflammation of the tendons inside the elbow. Symptoms include pain, swelling, and weakness.

- **Hand-Arm Vibration Syndrome**

This condition results from vibration stress to the fingers and hands. Symptoms include paleness in the fingers, pain, numbness, and loss of finger dexterity.

- **Rotator Cuff Tendonitis**

An inflammation of one or more of the four rotator cuff tendons in the shoulder. Symptoms include pain and limited movement of the shoulder.

- **Tendonitis**

An inflammation of the tendon in the hand and wrist due to excessive use. Symptoms include pain, swelling, tenderness, and weakness in the hand, elbow, or shoulder.

- **Tenosynovitis**

An inflammation of the tendon and sheath surrounding a tendon. Symptoms include pain, swelling, and tenderness in the hand or arm.

- **Trigger Finger**

This condition results when the tendon sheath of a finger is sufficiently swollen so that the tendon becomes locked in the sheath. This will cause a snapping and jerking movement when attempting to move the finger.

- **White Finger**

This is also referred to as the vibration syndrome or Raynaud's Phenomenon. This disorder occurs when blood vessels in the fingers are damaged, especially from using vibrating tools in cold weather. Symptoms include paleness in the fingers, tingling, and a sense that the finger is "on fire."

17.4.3 PREVENTION

Prevention is the key to reduce or eliminate the risk of developing a cumulative trauma disorder. Prevention includes the use of good body mechanics, good ergonomic design (engineering controls), and the use of administrative controls. Early intervention makes a difference for employees who experience symptoms such as pain, numbness, tingling, or tenderness in the fingers, hands, or arms or muscle pain in the back, shoulders, or other parts of the body from lifting or other body motions. It is important for employees to report early signs and symptoms of work-related CTDs to their supervisor and/or to the Health Services Group for evaluation.

• Good Body Posture

Using good body posture is important for minimizing the risk of developing a CTD. Equipment, tools, and furniture are an important part of the work environment. Since frequent use of these items does have a significant impact on job performance and overall health, good body posture is essential when equipment, tools, and furniture are used. Note: This topic is covered in more detail in the Office Ergonomics and Industrial Ergonomics sections later in this chapter.

• Engineering Controls

Engineering control measures should be addressed as the first line of defense to eliminate or reduce ergonomic hazards that employees are exposed to. It is important to design out the problem when this approach is feasible.

• Administrative Controls

Administrative controls that can be used effectively are:

- Job enlargement. Have employees perform more parts of a job rather than one specific task repeatedly.
- Job rotation. Cross-train employees to perform other jobs. Rotate employees in jobs that use different muscle groups, if possible.
- Work breaks. Have employees take frequent short breaks from repetitive tasks throughout the day.
- Training. Training provides information for mitigating ergonomic hazards, strategies to improve a workstation layout, and stress-reduction exercises.

17.5 ERGONOMIC PRINCIPLES

17.5.1 A NEUTRAL WRIST

It is important to maintain a neutral wrist to minimize the potential for developing a CTD, whether the operator is sitting while conducting a task (e.g., working at a VDT workstation) or standing (e.g., using a hand tool). The workstation should be designed so that a neutral wrist position can be maintained.

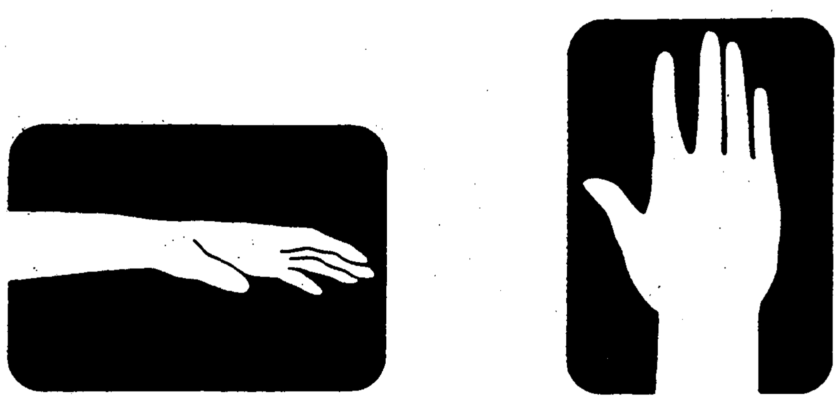


Fig. 17.1. A neutral wrist (two views).

17.5.2 THE WORK ENVELOPE

The work envelope is the zone in which an employee performs most routine tasks, whether repetitive movements (e.g., typing at a keyboard) or less frequent movements (e.g., lifting). Work should be arranged to be within easy reach and usual work located within 30.5 cm (12 inches) of the operator. Frequently used materials should be located within 45.75 cm (18 inches) maximum of the operator (see Fig. 17.2). Such an arrangement reduces potential stress to the back, shoulders, and arms by avoiding awkward postures and positions.

EMPLOYEES SHOULD NEVER REACH BEHIND THE SHOULDER.

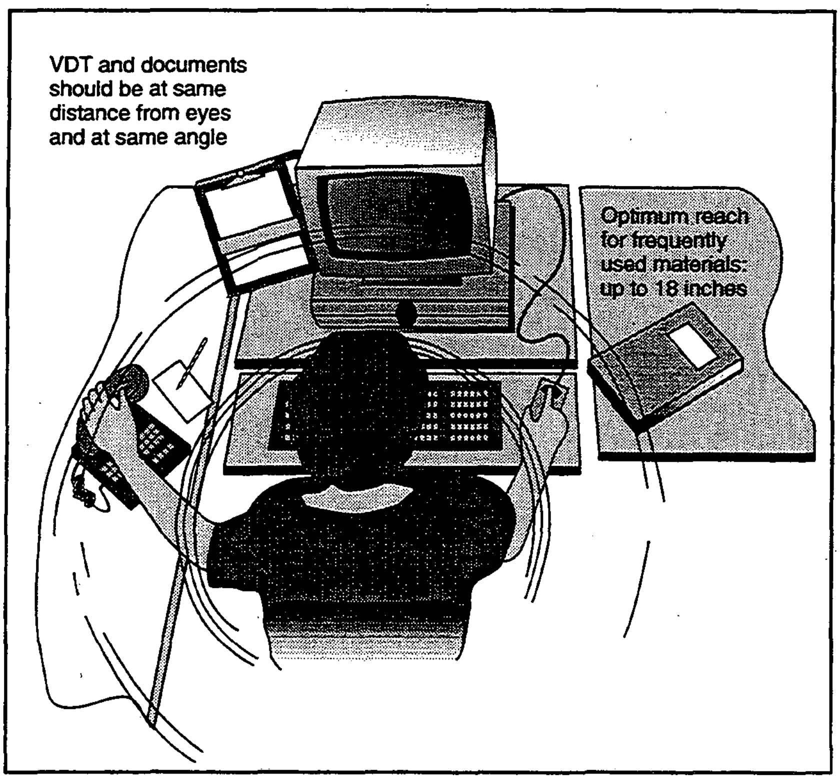


Fig. 17.2. The work envelope.

17.6 OFFICE ERGONOMICS

17.6.1 VDT ERGONOMIC RESOURCES AT LBNL

LBNL Ergonomic Display Center

The Ergonomic Display Center is located in Building 26 (Health Services). Visitors can try out displayed ergonomic furniture and accessories. Educational materials, including brochures, videos, and posters, are available for review.

Contact the following organizations for additional information on ergonomics:

- Ergonomic Furniture and Accessories

  Procurement: Tom Patock, ext. 4576

- Ergonomic Training

  EH&S Field Support Department: Larry McLouth, ext. 5286

- Lighting and Space Renovation

  Facilities Department: Work Request Center, ext. 6274.

- VDT Glasses

  Health Services: call ext. 7378.

- Workstation Evaluations

  Health Services: Charlotte Bochra, ext. 4268

You may also work through your supervisor or contact either your Division Safety Coordinator or your EH&S Division Liaison.

- Health Concerns

  Health Services: Charlotte Bochra, ext. 4268.

17.6.2 THE VDT WORKSTATION

A video display terminal (VDT) workstation should be designed to accommodate each user. Adjustability is the key. It allows each employee to adjust the VDT furniture (e.g., chair, work surface, document holder) and reorganize the work area to fit individual needs. The posture employed should minimize muscle tension and body strain. Good body posture permits employees to relax while maintaining a neutral body position (see Fig. 17.3).

General guidelines for setting up a VDT workstation are listed below. Attending the training course *Ergonomics for Computer Users* (EHS-60) will provide the information necessary to correctly set up a VDT workstation. Also, refer to the brochure *Ergonomics for Computer Users* (PUB-710).

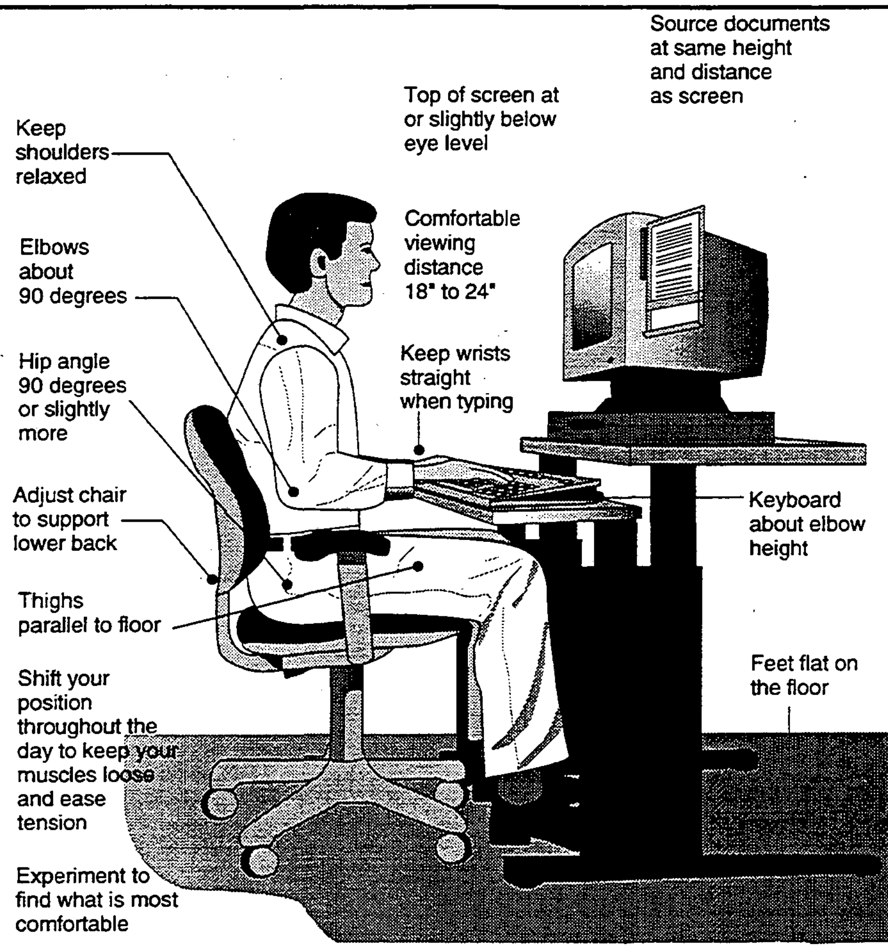


Fig. 17.3. Proper posture at the VDT.

Chairs

- Use a chair that is stable, mobile, swivels, and allows for operator movement.
- Use a chair that provides proper lower back support. The back support should be easy to adjust backward, forward, up, and down. A properly adjusted chair is important to help reduce or prevent stress on the back.
- Use a chair that has an adjustable seat height. Raise or lower the chair to a comfortable height such that the thighs are parallel to the floor and the knees are at a 90 degree angle. Rest the feet flat on the floor or use a footrest.
- Use the armrests if they allow maintaining elbows at a 90 degree angle. If the armrests obstruct sitting posture, then adjust the armrests, or get a chair that allows proper posture, or use a chair without armrests.

Work Surfaces

- Adjust the work surface so that the keyboard is at the correct height to maintain proper posture (i.e., elbows at keyboard height with the forearms parallel to the floor). If possible, use a split-level design table that has an adjustable top height: the lower level for the keyboard and mouse or trackball, and the upper level for the VDT monitor. The height of each level should adjust separately.

- Use a table large enough to hold the keyboard, monitor, wrist rest, mouse or trackball, and a document holder or all necessary documents.
- Keep adequate clearance under the table for leg length, knee height, and thighs.

VDT Monitors

- Position the VDT monitor directly in front.
- Position the VDT at a comfortable viewing distance (45-60 cm [18-24 inches] from the eyes), viewing height (top of the display screen at or slightly below eye level), and viewing angle (15 degrees below the horizontal line of sight).
- Use a VDT monitor that tilts and rotates.
- Use a VDT monitor that has adjustable contrast and brightness. Adjust the contrast to a high level and the brightness to a low level to minimize or prevent eye strain.
- Keep the display screen or glare shield clean because dust reduces character clarity and reflects light.

Keyboards

- Use a keyboard that is detached from the VDT monitor.
- Position the keyboard directly in front.
- Position the keyboard approximately at elbow height.
- Adjust the keyboard angle to a comfortable position; keep the wrists straight and in line with the forearm. The control to adjust the angle is located at the rear of the keyboard.

Other Input Devices

- When using a mouse, trackball, or special keypads, place the wrist in a neutral position.
- When using a mouse, trackball, or special keypads, rest the arm and hand close to the body and at a natural elevation--not reaching forward or raising the shoulder.
- Locate the input device adjacent to the keyboard.
- Use the whole arm to move the input device instead of just the wrist.
- If the arm is resting on the table edge (hard work surface) when using the mouse or trackball, then use a mousepad rest to provide cushion.

Wrist Rests/Pads

- Use a wrist rest for support to help maintain a neutral wrist.
- Use a wrist rest for cushioning to protect the wrist from resting on a hard or sharp work surface. Note that wrist rests are designed to be used during pauses in typing.

Document Holders

- Use a document holder that has an adjustable height.
- Use a document holder large enough to support the documents the operator uses.
- Position the document holder beside and parallel to the display screen.
- Position the document holder at the same height and distance as the display screen. Such positioning minimizes the amount the operator has to turn his/her head to look from the document to the display screen and reduces eye muscle fatigue by maintaining the same focal distance.

Footrests

A footrest may be necessary if the operator cannot rest his/her feet comfortably on the floor.

- Use a footrest that has an adjustable height and heel stop.
- Use a footrest that is large enough to allow for operator movement.

Eyewear

The VDT operator should have eye check-ups on a regular basis. Some VDT operators who wear corrective lenses/contacts should wear lenses designed specifically for VDT use. Contact Health Services, ext. 7378, regarding eligibility requirements for VDT glasses.

Printers

- Use a printer with a low noise level. Otherwise, enclose the printer in a noise-proof box.
- Locate the paper supply where the operator can easily reach it.

Lighting Glare

To minimize eye fatigue and eyestrain:

- Set up VDT workstations at right angles to windows and parallel to and between light fixtures.
- Locate the VDT equipment so that bright light sources are not in the visual field while viewing the display screen.

- Use appropriate illumination level for VDT tasks, which is usually approximately half the intensity of normal office lighting. Ambient illumination in the room should be approximately 50 footcandles (200 lux).
- Use shades, drapes, or blinds to shield light from windows.
- Call the Facilities lighting crew, ext. 6274, to help lower the light level by removing every other bulb or by changing the intensity of the bulb illumination.
- Properly adjust the VDT brightness and contrast controls to increase character resolution.
- Get a glare screen for the monitor and keep it clean.
- Use additional task lighting for reading copy when the room is darkened.

Exercises

- For the eyes, look away from the work to a distant point at least every hour.
- For the body, stretch the neck, shoulders, back, legs, arms, and fingers at least twice a day. Stand up and walk around often to increase blood flow circulation.

17.6.3 THE VDT WORKSTATION CHECKLIST

The following is a checklist of good practices that should be followed by employees using VDT workstations.

Breaks

- Take frequent short breaks from repetitive tasks throughout the day.

Head/Neck/Shoulders

- The head is straight or slightly tilted forward, not tilted up or turned to one side.
- The VDT monitor is directly in front.
- The top of the display screen is at or slightly below eye level.
- The eyes are at the proper viewing distance: 45-60 cm (18-24 inches) from the display screen.
- The display screen is clean, free of dust.
- The document holder is at the same height and eye distance as the display screen.
- The document holder is beside and parallel to the display screen.
- The shoulders are relaxed, not hunched up or pulled back.
- If substantial time is spent writing or typing while on the phone, the employee should consider a headset phone. A headset phone will eliminate awkward and prolonged bending of the neck.

Back

- The backrest of the chair is used. The lumbar support cushion firmly supports the lower back.
- The employee sits up straight, not leaning forward or backward, or hunched over. A slightly reclined position is acceptable posture too.
- Equipment (e.g., phone) and reference materials are located within easy arm reach to minimize leaning forward or reaching.
- The body is not twisted while sitting in the chair.

Legs/Feet

- The thighs are parallel to the floor.
- The knees are at a 90 degree angle to the legs.
- The legs, knees, and thighs fit under the work surface/table, not rubbing or hitting the work surface.
- Circulation under the thighs and behind the knees is not restricted; a numbness or tingling sensation is not experienced.
- The feet are flat on the floor or supported by a footrest. The angle or height of the footrest can be adjusted.

Arms/Wrists/Hands

- The elbows are at a 90–110 degree angle. The keyboard is located at elbow height or slightly below. (Some people find it more comfortable to have the keyboard located slightly below elbow height.)
- The elbows are close to the body.
- The forearms are in a comfortable relaxed position.
- The keyboard is directly in front, not at an angle or to one side.
- The keys are not pressed with too much force. Only enough finger force to activate the keys should be used.
- The wrists are in line with the forearm.
- The wrists are supported by a wrist rest and/or mousepad rest, not resting on the work surface, keyboard, or the hard edge of the work surface.
- The wrists are held in a straight, neutral position. The wrists are not extended, flexed, or bent to one side (see Fig. 17.4).

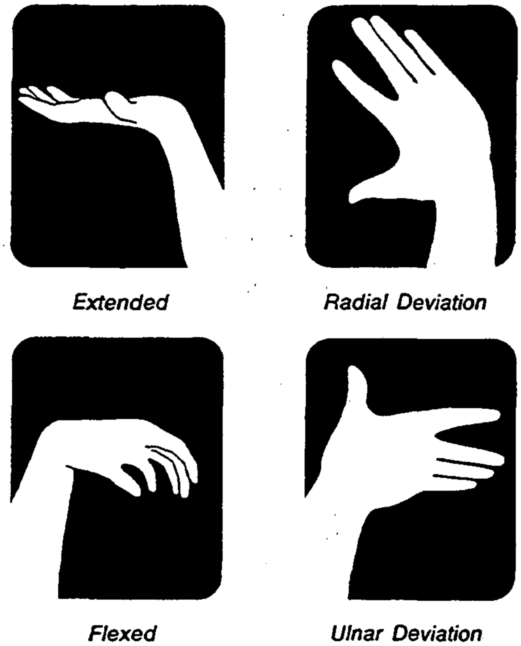


Fig. 17.4. Awkward wrist positions to avoid.

17.7 INDUSTRIAL ERGONOMICS

When ergonomics is applied at an industrial work area (e.g., work shops, labs, manufacturing process areas) it is referred to as "Industrial Ergonomics." It encompasses all other workstations except VDT workstations. The CTD risk factors are still relevant, only the setting is different. As mentioned previously, good body posture should always be employed to minimize muscle tension and body strain.

17.7.1 MANUAL MATERIAL HANDLING

Manual material handling involves sitting, lifting, lowering, and carrying objects; it may also involve getting up and down from a standing position. All of these movements involve using the back. To avoid the risk of developing back problems, ergonomic principles should be applied while using the back. If ergonomics is ignored, daily stresses on the muscles, joints, and disks in the back can eventually cause a CTD in the back. For objects that are too heavy or bulky for safe manual handling by employees, mechanical lifting devices must be used for lifting and moving (see Chapter 5, Part IV, *Material Handling and Storage*).

ALTHOUGH THERE ARE NO LEGAL MAXIMUM WEIGHT LIMITS FOR OBJECTS LIFTED BY EMPLOYEES, THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH) RECOMMENDS A 23-KG (51-LB) MAXIMUM WEIGHT LIMIT FOR LIFTING COMPACT OBJECTS.

To minimize the risk of developing a CTD in the back, employees should follow these guidelines:

- Keep the back/torso erect with the natural curve of the spine intact.
- Keep the load close to the body.
- Avoid bending forward or backward or twisting while lifting or carrying the load.
- Avoid lifting, pushing, or pulling a load that is too heavy. Always get assistance when needed. The maximum weight of the load that can be handled will vary for each employee.
- Lift and carry a heavy load with two hands instead of one.
- Do not lean forward, backward, or to either side without support.
- Use a chair that supports the weight of the upper body when sitting for long periods. Adequate low back support should also be provided to retain the natural curve of the spine.
- Lift loads at about waist height.
- Store loads above knee height, but below shoulder height.
- Bend at the knees to lift objects, not the back.
- Stay in good physical condition.

17.7.2 STANDING WORKSTATIONS

Standing for extended periods of time places static load on the back muscles, which can contribute to a back injury. To minimize the risk of developing a CTD in the back when standing, follow these guidelines:

- Keep the back/torso erect with the natural curve of the spine intact.
- Stand on a rubber antifatigue mat for cushioning, not on hard floor surfaces. Footrests or footbars can also be used to change positions.
- Tilt the work surface instead of bending continuously (see Fig. 17.5).
- Adjust the work to the appropriate height whenever possible. Generally, work should be done at approximately elbow height. The optimum work height, for standing or sitting, is based on the elbow height.
- For light duty tasks, set the work height so that the hands are positioned slightly (approximately 5 cm [2 inches]) below the elbow.
- For tasks that require lifting or downward forces, the work height should be lower. Examples are manual material handling and heavy grinding.
- For tasks that have extensive vision requirements, the work height should be increased. Examples are precision grinding and using a microscope (see Fig. 17.6).

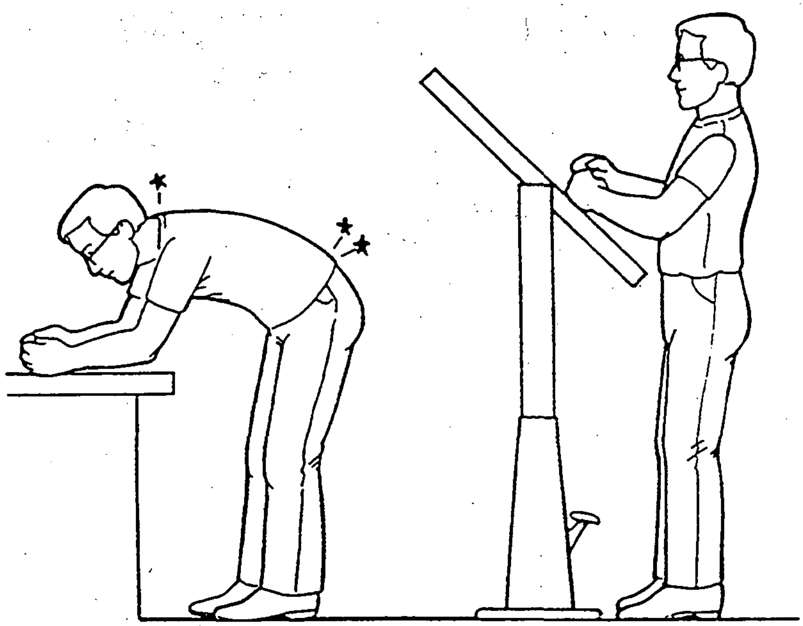


Fig. 17.5. Tilted work surfaces.

THE WORK HEIGHT IS NOT THE SAME AS THE WORK SURFACE HEIGHT. THE WORK HEIGHT IS THE HEIGHT OF THE INTERFACE BETWEEN THE OPERATOR (GENERALLY HIS/HER HANDS) AND THE WORK. THE WORK SURFACE HEIGHT IS THE HEIGHT OF THE TABLE/BENCH THAT THE WORK IS SITTING ON.

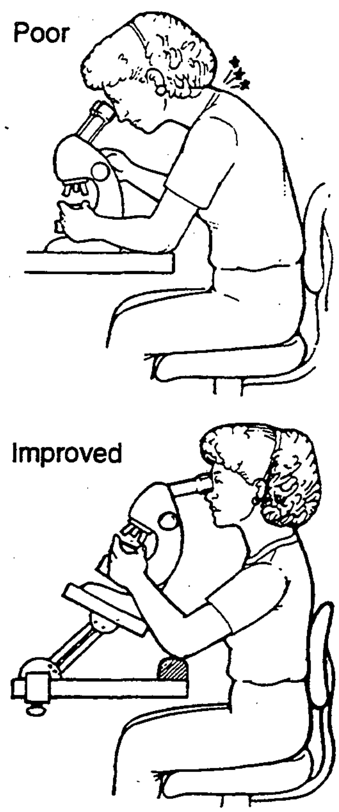


Fig. 17.6. Improved posture: raising the work height.

RAISING THE WORK HEIGHT TO IMPROVE POSTURE (I.E., TO MINIMIZE STRESS TO THE NECK/SHOULDERS/BACK) APPLIES WHETHER AN EMPLOYEE IS STANDING OR SITTING. ALSO, A CUSHION/REST SHOULD BE USED TO PROTECT THE ELBOW FROM THE HARD WORK SURFACE.

- Locate objects within easy arm reach to minimize leaning forward and awkward reaching (e.g., reaching over your head or behind your back). (See Fig. 17.2.)
- Alternate between standing and sitting when possible. Use a sit-lean stand as an alternative to a chair stool (see Fig. 17.7).

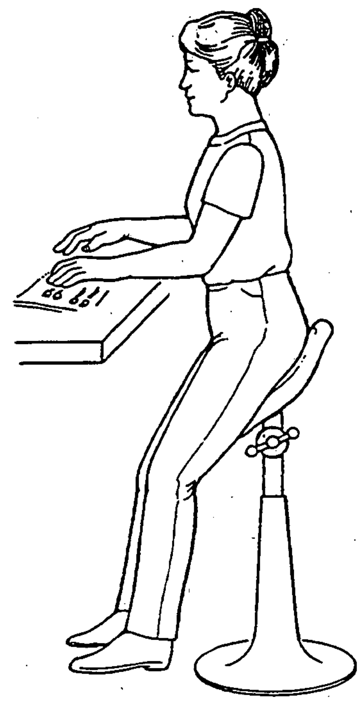


Fig. 17.7. Sit-lean stand.

17.7.3 HAND TOOLS

Improper hand tool selection or improper use of tools can cause CTDs. Hand tools should fit the employee's hand; employees with small hands or who are left-handed may need tools designed specifically for these situations. Hand and wrist posture are important because they affect how much force the muscles must produce to hold objects. When selecting and purchasing hand tools, these guidelines should be followed:

- Select tools that allow the wrist to be held straight and that minimize twisting of the arm and wrist (see Fig. 17.8). Good working posture can be maintained when properly designed tools are used.

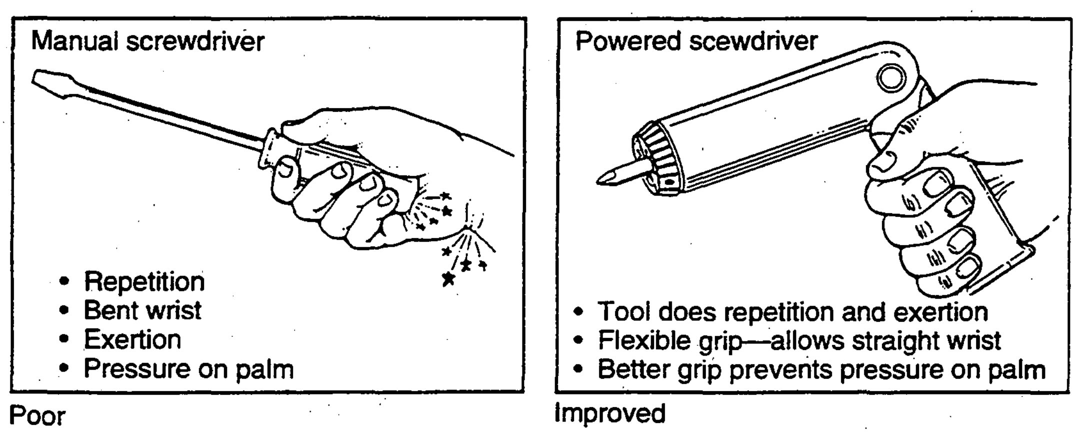


Fig. 17.8. Manual screwdriver/powered screwdriver.

- Select tools that allow the operator to use a power grip, not a pinch grip (see Fig. 17.9). Minimal muscle force is required to hold objects in a power grip posture. The pinch grip requires excessive fingertip pressure, and can lead to a CTD.

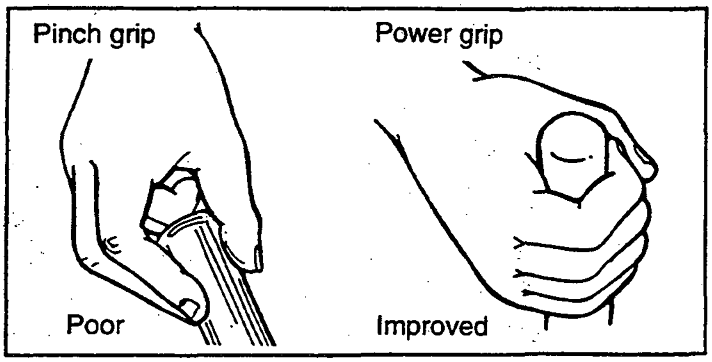


Fig. 17.9. Pinch grip/power grip.

- Avoid tools that put excessive pressure on any one spot of the hand (i.e., sides of fingers, palm of the hand) (see Fig. 17.10).

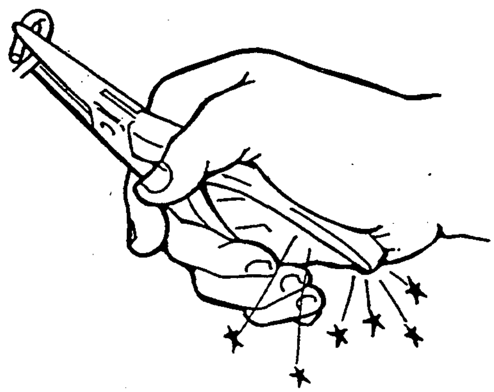


Fig. 17.10. Pliers.

- For power or pneumatic tools, select tools with vibration dampening built in whenever possible (see Fig. 17.11). Provide personal protective equipment such as gel-padded gloves to reduce exposure to vibration.

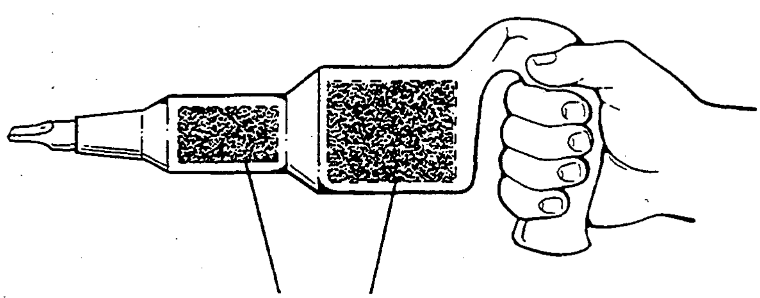


Fig. 17.11. Vibration dampening.

17.8 RESPONSIBLE PARTIES

The individuals, groups, and organizations listed in the following sections are responsible for implementing the ergonomics policy.

17.8.1 MANAGERS AND SUPERVISORS

Managers and supervisors shall be responsible for providing an ergonomically safe workplace through self-assessments and work station evaluations, participation in ergonomics training, implementation of control measures using a graded-risk approach, and by ensuring that all employees who report CTD symptoms are referred to the Health Services Group and complete the required training.

17.8.2 EMPLOYEES

Employees identified at risk for developing work-related CTDs shall attend ergonomics training and shall be responsible for reporting early signs and symptoms of work-related CTDs to their supervisor and/or to the Health Services Group.

17.8.3 FIELD SUPPORT DEPARTMENT (FSD)

The EH&S FSD shall be responsible for identifying and analyzing cumulative trauma disorder risks by collecting, maintaining, and reviewing all CTD-related injury and illness reports. FSD Safety Engineers and Industrial Hygenists shall conduct ergonomic work site evaluations of office workstations, laboratories, workshops, and other industrial work sites for employees who report CTD symptoms to the Health Services Group. Additionally, these groups shall provide assistance to supervisors who request ergonomics advice for a specific workstation or operation. FSD will also coordinate Ergonomic training.

17.8.4 FACILITIES

The Facilities Department shall be responsible for integrating ergonomics considerations into workspace planning, workstation design, and building modifications. Additionally, the Facilities Department shall design for optimal environmental factors such as temperature, noise, vibration, and lighting during facility planning.

17.8.5 MATERIEL MANAGEMENT

The Procurement Department shall be responsible for making ergonomic furniture and accessories available for purchase. Additionally, Materiel Management shall coordinate with EH&S Training to maintain and upgrade the LBNL Office Ergonomics Laboratory.

17.8.6 HEALTH SERVICES GROUP

The EH&S Health Services Group shall maintain an ergonomics medical management program. This program shall consist of identification of employees at ergonomic risk and medical surveillance of such employees through preplacement, periodic, and return-to-work examinations. Trained and qualified health care professionals (HCPs) from Health Services shall evaluate all employees who are referred to them with work-related CTD symptoms. Employees who are VDT operators and who meet the eligibility requirements may participate in LBNL's Safety Glass Program.

17.8.7 LBNL ERGONOMICS COMMITTEE

The interdisciplinary Ergonomics Committee with representation from Administration, Facilities, Health Services, Industrial Hygiene, Procurement, Occupational Safety, and Workers Compensation shall be responsible for program review, coordination, and evaluation.

17.9 GLOSSARY

Administrative controls are procedural risk-control measures that include, but are not limited to: redesign of work duties, adjustment of work pace, use of rest periods/breaks, training, or altering work duties to interrupt activities that pose a risk to the employee.

Cumulative trauma disorder (CTD) is the term used for health disorders arising from repeated biomechanical stress on the body due to ergonomic hazards. CTDs are disorders of the muscles, tendons, and/or nerves that develop from or are aggravated by repeated exertions or movements of the body. CTDs are also referred to as repetitive motion injuries, repetitive strain injuries, repetitive trauma disorders, and overuse injuries.

CTD risk is the presence of the following factors in work activity whereby a CTD is substantially likely to result: frequency (repetition), force, duration, posture, exposure to localized or whole-body vibration, and exposure of hands and feet to temperatures cold enough to cause discomfort.

CTD symptom is any of the following, when persisting or recurring: pain from movement, from pressure, or from exposure to cold or vibration, except when the pain is due to an acute injury; numbness or tingling in an arm, leg, or finger, especially fingertips at night; decreased range of joint motion; decreased grip strength; and swelling of a joint or part of an arm, leg, or finger.

Disorder is a physical ailment or abnormal condition.

Engineering controls are engineered risk-control measures that include, but are not limited to: devices such as adjustable workstations, tables, chairs, equipment, and tools; and physical modifications to workstations, equipment, tools, production processes, or any other aspect of the work environment.

Ergonomics is the study of human interaction with the tools workers use, the work process, and the environment workers function in. The goal is to fit the job to the person. Ergonomics recognizes the capabilities, differences, and limitations of individuals, and adjusts the tools or environment accordingly.

Ergonomic hazards refer to the workplace conditions that pose a biomechanical stress to the worker.

Health Care professional (HCP) is a licensed physician, a registered nurse, or other health care professional who has received appropriate medical training.

Manual material handling (MMH) refers to m

aterials being moved directly by people.

Personal protective equipment (PPE) are clothes, padding, gloves, devices, equipment, or other items worn on or attached to the body and used for the purpose of controlling CTD risk. *Note: Splints or braces are not considered to be PPE.*

Risk factors are conditions that contribute to the risk of developing a disorder.

Repetitive motion means to perform the same motion continuously for hours.

Surveillance is the ongoing systematic collection, analysis, and interpretation of health and exposure data for the purpose of describing and monitoring a health event. Surveillance data are used to determine the need for occupational safety and health action and to plan, implement, and evaluate ergonomic interventions and programs.

Trauma is bodily injury from mechanical stress.

Video display terminal (VDT) is any device or set of devices not designed for hand-held use that involves a cathode-ray tube or other electronic device for display of data or text and a keyboard for entry.

VDT operator is an employee who routinely works at a VDT for a cumulative total of four or more hours, inclusive of breaks, during any 12-hour period.

17.10 STANDARDS

- Public Law 91-596 Section 5(a)(1), Occupational Safety and Health Act, General Duty Clause

17.11 RELATED PUB-3000 CHAPTERS

- *EH&S Training* (Chapter 24)
- *Occupational Safety* (Chapter 5)—Section xx, *Material Handling and Storage*

17.12 REFERENCES

- ANSI/HFS VDT-100 Standard, *American National Standard for Human Factors Engineering of Visual Display Terminal Workstations*, 1988
- ANSI/Z-365 CTD Standard (draft), *American National Standard for Control of Cumulative Trauma Disorders*, June 1993
- *Ergonomics for Computer Users*, Lawrence Berkeley Laboratory, PUB-710(R2), February 1994
- "Safety in Manual Materials Handling," National Institute for Occupational Safety and Health, Publication No. 78-185

Chapter 18

LOCKOUT/TAGOUT

Revised December 1997

Reviewed by: 12-11-97
Date

Approved by: 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 18

LOCKOUT/TAGOUT

18.1 POLICY

It is the policy of LBNL to prevent an undesirable release of hazardous energy during any servicing, maintenance, or modification activity. This policy is implemented through Lockout/Tagout (LOTO) procedures for shutting off and securing such equipment. These procedures must be strictly followed when it is necessary to work on **any** equipment that may release **any** form of hazardous energy including, but not limited to, electrical, rotational, mechanical, chemical, hydraulic, or pneumatic energy, while the equipment is shut down.

This document covers training and authorization, responsibilities of employees, General Procedure, Group LOTO Procedure, Equipment-Specific Written LOTO Procedure, Tag-Out Only Procedure, hardware required for LOTO, personnel shift changes, subcontractors' and visitors' responsibilities, periodic inspections, and LBNL's Tag-On policy.

18.2 WHERE REQUIRED

LOTO is required whenever servicing, maintenance, or modification is being performed on equipment in which the unexpected energization or start-up of the equipment, or the release of stored energy, could cause injury to people or damage to equipment. All sources of hazardous energy must be shut off and secured. LOTO must be performed by each person who works on the equipment.

YOU MUST APPLY LOTO WHENEVER YOU ARE SERVICING, MAINTAINING, OR MODIFYING MACHINERY OR EQUIPMENT, REGARDLESS OF THE DURATION OF THE JOB OR YOUR PROXIMITY TO THE ENERGY-ISOLATING DEVICE (E.G., CIRCUIT BREAKER, SWITCH, OR VALVE).

18.3 EXCLUSIONS

LOTO procedures **do not apply** under the following conditions:

- Routine operations (e.g., minor tool changes, adjustments, and other minor servicing taking place during normal production operations), provided the operation is repetitive and integral to the use of the equipment. The work must be performed using alternative measures that provide effective protection.

If, during routine operations, a guard or other safety device is removed or bypassed, or an employee is required to place any body part into an area of a machine or piece of equipment where work is actually performed upon the material being processed (*point of operation*), this exclusion does not apply and LOTO must be performed.

- Work on cord- and plug-connected electrical equipment, if all of the energy is controlled by unplugging the equipment **and** the plug remains under the continuous control of the employee performing the servicing, maintenance, or modification.
- Operations on energized equipment (e.g., calibration), where continuity of service is essential or shutdown of the system is impractical. Documented safety procedures that provide an equivalent level of safety must be established and followed. Special safety equipment may be required.

18.4 LOTO VS. ADMINISTRATIVE LOCKING

A careful distinction must be made between LOTO and various other locking practices, collectively referred to as **Administrative Locking**. The LOTO procedure is specifically reserved for those instances in which a zero-energy state must be ensured to allow personnel to service, maintain, or modify equipment. Administrative locking is normally **not** used as the primary means of protection during a servicing, maintenance, or modification procedure, and is not a substitute for LOTO.

Administrative locking is distinguished from LOTO in both practice and purpose. An administrative lock may be controlled by a group rather than an individual, and an administrative application must not use LBNL-designated LOTO locks or LOTO tags.

Administrative locking may be performed for many reasons, including equipment security, programmatic purposes, or general safety.
Examples of administrative locking are:

- Locked fences around high-voltage transformers.
- Locks on overhead-crane disconnect switches.
- A locked door to a laboratory containing hazardous equipment.

In some applications it is appropriate to use a combination of administrative and LOTO controls. For example, if one group or shop must retain oversight of a utility while others are performing work associated with that system, an administrative lock may be placed by the oversight group in parallel with the individual LOTOs placed by each worker.

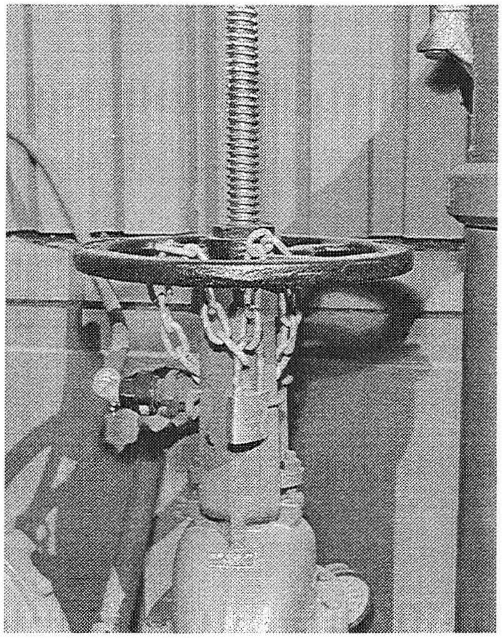


Fig. 18.1. Example of administrative locking.

18.5 TRAINING AND AUTHORIZATION

18.5.1 GENERAL

All **authorized employees** are required to be trained.

LOTO MAY ONLY BE PERFORMED BY EMPLOYEES WHO ARE TRAINED AND AUTHORIZED.

Any LBNL employee may be near to or affected by equipment on which LOTO is performed; therefore, all employees receive LOTO awareness training through the *New Employee Health and Safety Orientation and Training* course, EH&S-10. All employees must know how to recognize LOTO, why LOTO is implemented, and the importance of leaving LOTO devices in place. Employees are prohibited from tampering with LOTO devices or attempting to restart equipment to which LOTO is applied.

TAMPERING WITH OR REMOVING LOTO DEVICES, OTHER THAN ONE'S OWN, IS A SERIOUS SAFETY VIOLATION!

An **authorized employee** is an employee who is: (1) trained and (2) specifically authorized by a supervisor to perform LOTO.

18.5.2 TRAINING

The training requirement may be satisfied in either of two ways. The employee may take the *Lockout/Tagout Training* course, EH&S-256, or the *Lockout/Tagout Training by Supervisors* course, EH&S-257. EH&S-256 is provided by the EH&S Division on a regular basis and consists of a comprehensive course in LBNL LOTO policy and procedure. EH&S-257 is provided to an employee by his or her supervisor and consists of LOTO instruction limited to the employee's specific areas of responsibility. The supervisor must complete EH&S-256 before he or she is considered qualified to teach EH&S-257.

18.5.3 AUTHORIZATION

Specific authorization is provided by the supervisor **after** the employee satisfies the training requirement. The supervisor must ensure that the employee is thoroughly familiar with the equipment (within the context of his or her job function) and with the energy-control procedures. A practical exercise may be required to demonstrate proficiency.

Once satisfied that both the training and authorization requirements have been met, the supervisor may authorize an employee to perform LOTO. This authorization stipulates the specific equipment or types of equipment on which the **authorized employee** may perform LOTO.

18.5.4 OPTIONAL TRAINING

Authorized employees may be required by their supervisors to take the optional *LOTO Refresher* course, EH&S-258.

18.5.5 REAUTHORIZATION AND RETRAINING

Reauthorization is required when:

- An **authorized employee's** job changes or he or she is reassigned.
- New equipment is to be used.
- New energy-control procedures are to be implemented.

Retraining and/or reauthorization may be required when:

- A supervisor has reason to believe that an employee has inadequate knowledge of LOTO procedures or policy.
- A periodic inspection shows a deficiency in the **authorized employee's** ability to implement LOTO policy correctly.

18.6 LOCKS

Only LBNL-approved locks may be used when performing LOTO. The currently approved lock is a padlock, American #1107. This lock is color-coded to indicate the user, as in the following table:

COLOR	USER
Brown	Painters and carpenters
Blue	Electricians
Black	Refrigeration Shop
Green	Maintenance personnel
Gold	Riggers
Red	General (LBNL-wide)

Note that the red lock, LBNL stock #424072251, is used by all LBNL **authorized employees** outside of the Facilities Department.

LBNL LOTO LOCKS MAY *NOT* BE USED FOR ANY PURPOSE OTHER THAN LOTO.

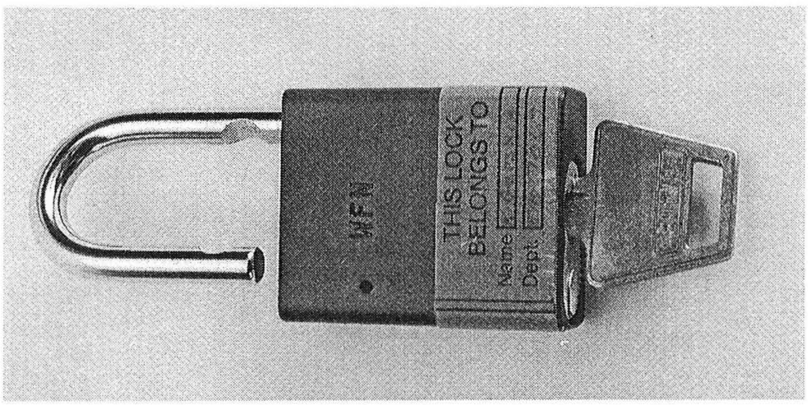


Fig. 18.2. LBNL-approved LOTO lock and key.

A LOTO lock must always be accompanied by an LBNL-approved tag. (See *Tags*.)

LBNL-approved locks must be obtained from LBNL Stores.

Supervisors may purchase a group of locks to be distributed to his or her **authorized employees**. **Authorized employees** may also obtain locks directly from LBNL Stores with the approval of their supervisors.

A supervisor may elect to utilize a checkout system that permits **authorized employees** to borrow locks from a common local supply. In such cases, the **authorized employee** checking out a lock must relabel it with his or her name unless the checkout system includes a reliable means of identifying the lock user. This system shall not depend on a tag to identify the lock user.

18.7 KEYS

Each LBNL-approved LOTO padlock has two keys, primary and emergency. The primary key must be in the possession of the **authorized employee** who applied the lock. The emergency key must be kept in a secured area (e.g., a lock box) with access limited to the **authorized employee's** immediate supervisor and one level of management above the **authorized employee's** supervisor.

A group of locks with a common key may be used for equipment with multiple energy-isolation devices, if desired. If a group of locks is keyed alike for this purpose, one key only may be issued for use by the **authorized employee** and a second key may be kept for emergency use, as described above.

18.8 LABELS

Each lock must be clearly labeled with the **authorized employee's** name. Plastic self-laminating adhesive labels, LBNL stock #424072253, may be used. Other means of identification (e.g., engraving) are also permissible.

It is also acceptable to use a system which reliably identifies the lock user by means of a unique ID number and telephone extension imprinted on the lock. This system shall not depend on a tag to identify the lock user.

18.9 TAGS

Only LBNL-approved LOTO tags may be used.

The LBNL-approved LOTO tag, stock #4280-71326, is 140mm X 76mm (5-1/2" X 3"), states "DANGER DO NOT OPERATE" on the front, and "This Energy Source Has Been Locked Out" on the back. The tag is reusable.

A tag must always be used in conjunction with a lock unless the energy-isolating device is not physically capable of being locked. (See *Tag-Out Only*.)

The **authorized employee** performing LOTO must write his/her name, telephone extension, and the date on the tag. The back of the tag is reserved for any other information relevant to the lockout.

18.9.1 OBTAINING TAGS AND TIES

LBNL-approved tags, and ties may be obtained from LBNL Stores.

18.10 LOTO HARDWARE

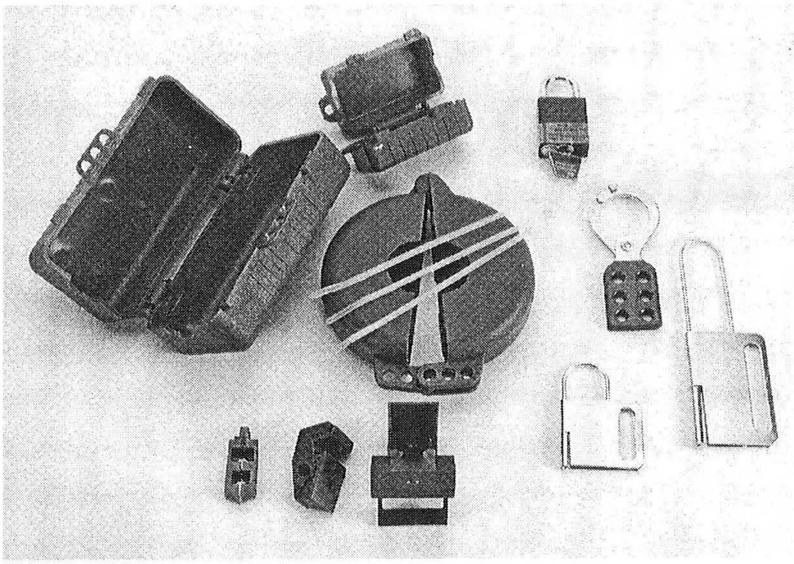


Fig. 18.3. LOTO hardware.

Center: *Valve handle lockout device with three plastic locking ties*
Left and top: *Lockout devices for electrical plugs*
Top-right: *LBNL-approved LOTO lock*
Right: *Multiple lockout devices*
Bottom: *Circuit breaker lockout devices*

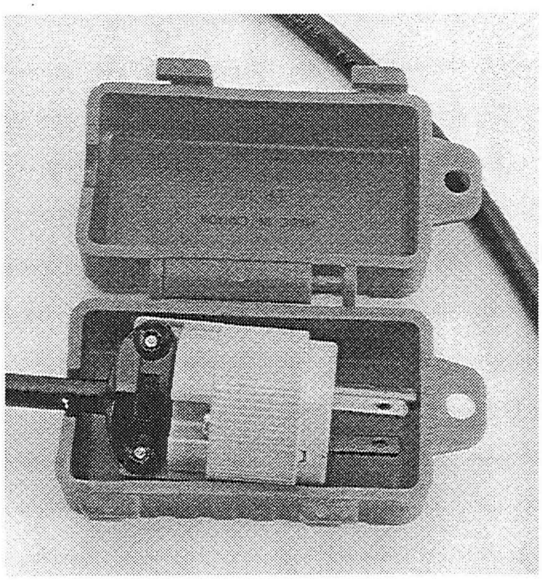


Fig. 18.4. Lockout box for plugs.

18.11 GENERAL PROCEDURE

The LOTO General Procedure is divided into two sections: (1) Application of Lock/Tag, and (2) Release from Lockout/Tagout.

18.11.1 APPLICATION OF LOCK/TAG

Preparation and Notification

1. Use written procedure, if applicable.

   The **authorized employee** must determine if an Equipment-Specific Written Procedure is applicable to the task. (See *Equipment-Specific Written Procedures*.) If so, the **authorized employee** must obtain and follow the equipment-specific written procedure. If a new written procedure must be generated, the **authorized employee** must contact his or her supervisor.

2. Assess energy type and magnitude.

   The **authorized employee** must assess the type, magnitude, and hazards of the energy to be controlled.

3. Determine methods of control.

   The **authorized employee** must determine the appropriate methods of controlling the hazardous energy (e.g., disconnect switch or valve). See Figure 18.5.

PUSH BUTTONS, SELECTOR SWITCHES, INTERLOCK CIRCUITS, AND OTHER CONTROL-TYPE DEVICES ARE *NOT* ENERGY-ISOLATING DEVICES.

4. Notify all affected personnel.

   The **authorized employee** must notify all affected employees of the impending shutdown and the reasons for it.

Shutdown

5. Verify that it is safe to shut down equipment.

   The **authorized employee** must verify that it is safe to shut down the equipment.

6. Perform normal equipment shutdown.

   The **authorized employee** must turn off or shut down the equipment using established methods for that equipment.

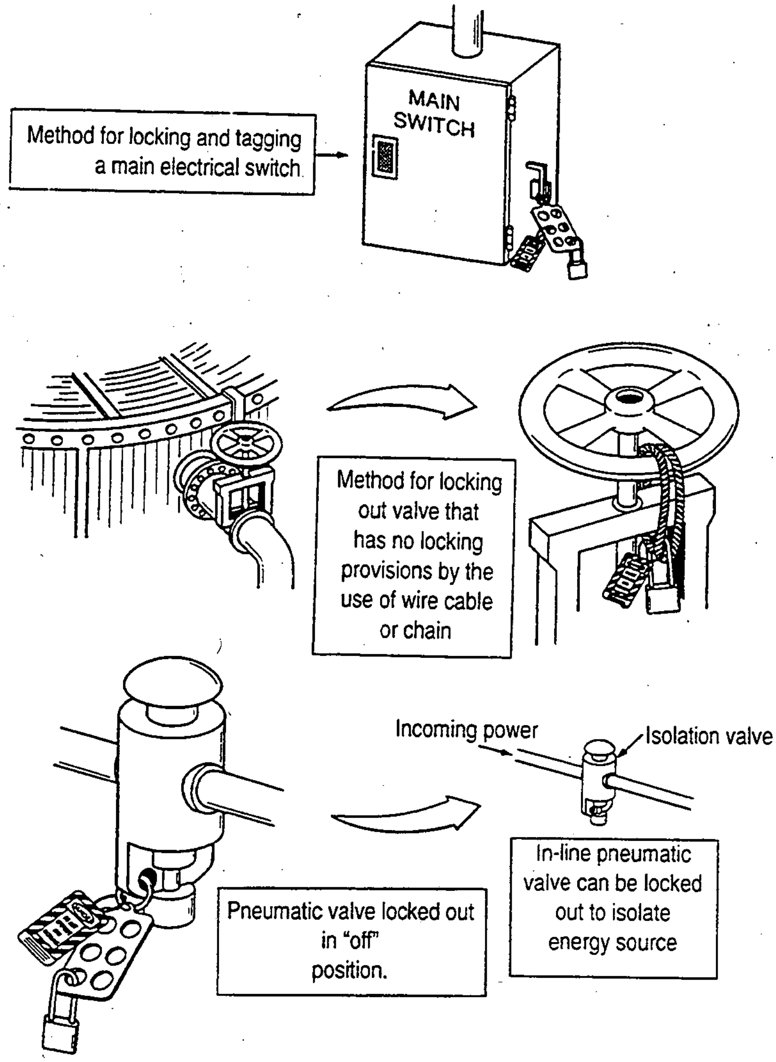


Fig. 18.5 Lockout/Tagout methods.

7. Isolate and lock out energy sources.

   The **authorized employee** must operate the energy-isolating device and affix his or her LOTO lock to this device. The lock must be affixed so as to hold the energy-isolating device in an *off* or *safe* position that physically prohibits normal operation of the energy-isolating device.

THE AUTHORIZED EMPLOYEE MUST TAKE STEPS TO ENSURE THAT THE MEANS USED FOR ENERGY ISOLATION CORRECTLY CORRESPOND TO THE EQUIPMENT ON WHICH LOTO IS BEING PERFORMED.

8. Write name and date, along with any other relevant information, on the tag and apply with lock or plastic locking tie.

   If the placement of the tag would compromise safety by obscuring indicator lights or controls, the tag may be located as close as is safely possible to the device, in a position that will be immediately obvious to anyone attempting to operate the device.

9. Release stored energy.

   The **authorized employee** must completely release or otherwise control any stored energy and block any undesired motion. In the case of stored mechanical energy, vent valves, spring releases, blocking devices, or equipment repositioning (as appropriate) must be utilized. In the case of stored electrical energy, approved grounding wands or discharge devices must be used

   If there is a possibility of reaccumulation of stored energy to a hazardous level, verification of isolation must be continued until the servicing, maintenance, or modification is completed or until the possibility of such accumulations no longer exists.

   The equipment must be in a **ZERO-ENERGY STATE**. (See the *Glossary* on page 18-v for a definition of this term.)

THE PRESENCE OF STORED ENERGY USUALLY INDICATES THAT AN EQUIPMENT-SPECIFIC WRITTEN PROCEDURE IS REQUIRED. (SEE THE SECTION OF THIS CHAPTER ON *EQUIPMENT-SPECIFIC WRITTEN PROCEDURES*.)

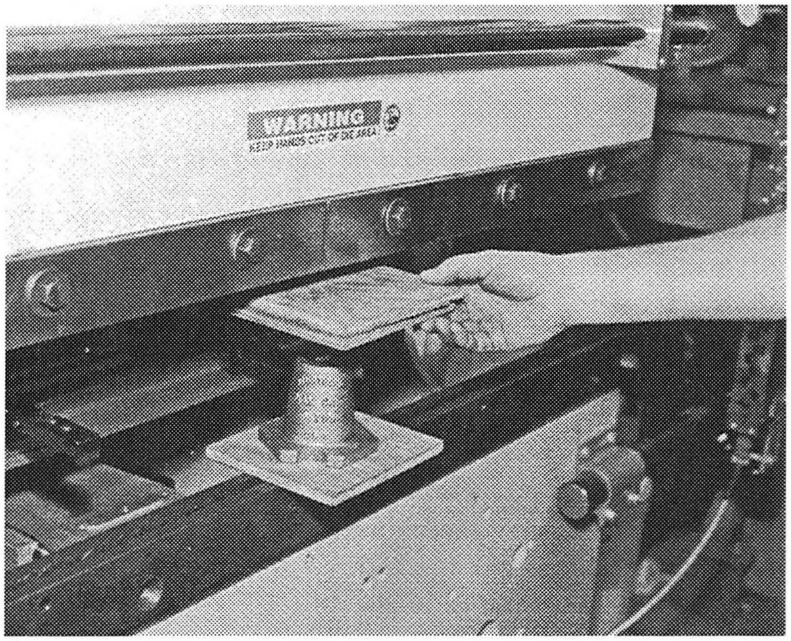


Fig. 18.6. Insertion of a blocking device.

18.11.2 VERIFICATION OF LOTO APPLICATION PROCEDURE

10. Attempt to restart the equipment.

    The **authorized employee** must physically attempt to operate the energy-isolating device and attempt to restart the equipment using the normal equipment controls (e.g., start buttons or computer software controls).

11. Test equipment for zero-energy state.

    The **authorized employee** must test potential energy sources using appropriate instruments or testers. Any instrument used to test for voltage, pressure, or temperature must be checked for proper operation both before and after use.

    If the **authorized employee** is not qualified to test the energy being isolated, he or she must ensure that the energy is tested by a qualified person. The qualified tester, if other than the **authorized employee**, must be identified in the Remarks section on the tag.

18.11.3 RELEASE FROM LOTO

Before LOTO devices are removed and energy is restored to the equipment, the **authorized employee** must follow the procedures below:

12. Verify that it is safe to reenergize.

    The last **authorized employee** to remove his/her LOTO must verify that the work for which the LOTO was applied has been completed and that it is safe to reenergize equipment.

13. Clear all tools and personnel.

    The **authorized employee** must check the work area to ensure that all tools and personnel are at a safe distance from the equipment.

14. Remove all isolating devices.

    The **authorized employee** must remove any devices applied under Step 9 (*Release stored energy*).

15. Replace safety guards.

    The **authorized employee** must check the equipment to ensure that any removed guards are reinstalled.

THE LOCK AND TAG MAY NOW BE REMOVED, THE ENERGY-ISOLATING DEVICE RESET, AND THE MACHINERY RETURNED TO SERVICE.

EACH LOTO DEVICE MUST BE REMOVED ONLY BY THE AUTHORIZED EMPLOYEE WHO APPLIED IT.

If safety is compromised by following the prescribed sequence of the General Procedure, the **authorized employee** may modify the sequence; however, all steps must be performed.

18.12 TEMPORARY REMOVAL OF LOTO DEVICES

When LOTO devices must be temporarily removed from the energy-isolating device so that the equipment or component can be energized for testing or positioning, the following sequence of actions must be taken:

1. Notify the affected employees and area supervisor.

2. Clear the equipment of tools and materials.

3. Remove employees from the machine or equipment area and ensure that required tools are safely and properly positioned.

4. Remove all repositioning and blocking devices and return all vents and valves to their normal operating positions.

5. Remove all grounding/shorting conductors.

6. Energize and proceed with testing or positioning.

7. De-energize all systems and reapply lockout/tagout measures to continue the servicing, maintenance, or modification of the equipment.

18.13 EMERGENCY REMOVAL OF LOTO DEVICES

When the **authorized employee** who applied a LOTO device is not available to remove it, that device may be removed by his or her supervisor. This is considered to be an emergency procedure, only to be undertaken in extreme circumstances.

Extreme care must be taken and the following steps must be performed:

1. The supervisor must verify that the **authorized employee** is not at the facility.

2. The supervisor must make every reasonable effort to contact the **authorized employee**. This may include a telephone call to the employee's home or other location.

3. If the employee is contacted, the supervisor must inform the employee that his or her LOTO devices are being removed.

4. The supervisor must verify that it is safe to remove the LOTO devices.

5. The supervisor may then use the emergency key to remove the LOTO devices, or the lock may be cut off if the key is not available. (See the section of this chapter on *Keys*.)

6. The supervisor must ensure that the **authorized employee** is presented with the removed lock upon returning to work and is informed of the reasons for the emergency removal.

7. The emergency procedure must be duly recorded in the department's lockout/tagout records and signed by both the supervisor and **authorized employee**.

18.14 TAG-OUT ONLY

If a device is incapable of being locked out, a **"tag-out only" procedure** may be employed.

ANY ENERGY-ISOLATING DEVICE CAPABLE OF BEING LOCKED MUST BE LOCKED *WITHOUT EXCEPTION.*

To conduct a tag-out only procedure, the **authorized employee** must follow all of the steps outlined in the *General Procedure*. (See the *General Procedure* section of this chapter.)

The placement of the lock in Step 7, *Isolate and lock out energy sources,* in the *General Procedure* is omitted. Instead, the **authorized employee** must utilize a second means of isolating the hazardous energy. Removal of an isolating circuit element, blocking of a controlling switch, opening of an extra disconnect device, or removal of a valve handle are all examples of secondary measures. The second means of isolation must be identified on the tag, and the tag must be affixed as in Step 8 of the *General Procedure*.

EXTRA CAUTION MUST BE EXERCISED WHEN USING A TAG-OUT ONLY PROCEDURE. TAGS MAY EVOKE A FALSE SENSE OF SECURITY. TAGS ARE WARNING DEVICES AND DO NOT PROVIDE THE PHYSICAL RESTRAINT PROVIDED BY A LOCK.

18.15 EQUIPMENT-SPECIFIC WRITTEN PROCEDURES

If the equipment undergoing servicing, modification, or maintenance has more than one energy source, requires the operation of more than one device to isolate the hazardous energy, or has potential for stored, residual, or accumulated hazardous energy, an **equipment-specific written procedure** must be used.

18.15.1 PREPARING AN EQUIPMENT-SPECIFIC WRITTEN PROCEDURE

A written energy-control procedure must be generated by the department, group, or **authorized employee** most familiar with the equipment. This procedure must be used by any **authorized employee** who will perform LOTO on the equipment.

Supervisors must ensure that equipment which requires a written procedure is so identified and that the procedure is readily available to the employees authorized to perform LOTO on the equipment.

Any equipment with an equipment-specific written LOTO procedure must be clearly labeled as such. The supervisor or employee responsible for the equipment may determine the appropriate format and content of the label, for example:

*CAUTION—An equipment-specific written procedure exists for the locking and tagging of this equipment. This equipment-specific written procedure may be obtained from ___________.**

**Entry to be determined by the supervisor.*

18.15.2 ELEMENTS OF AN EQUIPMENT-SPECIFIC WRITTEN PROCEDURE

The equipment-specific written procedure must incorporate each step in the *General Procedure*, as enumerated in the *General Procedure* section of this chapter.

It is essential that the specific application of each LOTO step be clearly explained in the context of the specific equipment.

18.16 GROUP LOTO PROCEDURE

18.16.1 OVERVIEW

When servicing, maintenance, or modification is performed by a crew, the supervisor may determine that the use of a group LOTO procedure is appropriate. This determination must be made **only** if the size of the crew and the nature of the work precludes the feasibility of individual LOTOs **and** if the level of protection provided by the group LOTO procedure is equivalent to that of individual LOTO.

A group LOTO procedure is a special procedure wherein the responsibility for applying and removing the lockout devices of a group of **authorized employees** is vested in a single **designated authorized employee**.

There are two acceptable methods of implementing a Group LOTO procedure.

18.16.2 METHOD ONE: PROCEDURE/APPLICATION OF GROUP LOTO USING A GANG LOCK BOX:

1. The unit or section leader must determine that group LOTO is appropriate.

2. The unit or section leader must convene a meeting of all members of the group to be covered under the procedure.

a. The unit or section leader must describe the tasks to be performed.

b. The unit or section leader must delegate primary responsibility to a designated authorized employee for a specified group of employees working under the protection of the group's LOTO.

c. Each member of the specified group must be trained and authorized, as described in Training and Authorization.

3. The designated authorized employee is responsible for ensuring that each step of the general or equipment-specific written procedure is completed.
4. The designated authorized employee must apply his or her personal LOTO lock(s) and tag(s) to the energy-control device(s) and indicate on the tag(s) that a "group lockout" is in effect.
5. The designated authorized employee shall place his/her key(s) inside of a gang lock box. The gang lock box shall be constructed in such a way as to permit multiple locks to be attached to the outside of the enclosure, preventing it from being opened.
6. All other workers performing work on the equipment shall independently lock and tag the gang lock box.
7. When the work has been completed and after each worker has removed his/her respective lock from the gang lock box, the designated authorized employee shall remove his/her keys from the lock box and return the equipment to service as described in RELEASE FROM LOTO, # 12-15, above.

18.16.3 METHOD TWO: PROCEDURE/APPLICATION OF GROUP LOTO USING CONTROLLED RECORDKEEPING

1. The unit or section leader must determine that group LOTO is appropriate.
2. The unit or section leader must convene a meeting of all members of the group to be covered under the procedure.

   a. The unit or section leader must describe the tasks to be performed.

   b. The unit or section leader must delegate primary responsibility to a designated **authorized employee** for a specified group of employees working under the protection of the group's LOTO.

   c. The structure of the group, the names of all group members and the designated **authorized employee**, and reasons for the group LOTO must be documented in a logbook.

d. Each member of the specified group must be trained and authorized, as described in *Training and Authorization*.

3. The designated **authorized employee** is responsible for ensuring that each step of the general or equipment-specific written procedure is completed.

4. The designated **authorized employee** must apply his or her personal LOTO lock(s) and tag(s) to the energy-control device(s) and indicate on the tag that a "group lockout" is in effect.

5. The designated **authorized employee** must communicate to each person in the crew that LOTO is in place and work may commence.

If the makeup of the crew changes while work is in progress, the designated **authorized employee** must inform any new group member that a group lockout is in place and communicate to him or her all of the information relating to the group lockout. The names of the new group members must be added to the log.

Anyone leaving the group before the servicing, maintenance, or modification is completed must notify the designated **authorized employee**. The group member leaving must communicate the status of his or her activities to the designated **authorized employee**. The designated **authorized employee** must make a logbook entry indicating the date and time of each group membership change.

6. When the work is completed, the designated **authorized employee** must communicate to each group member that the group LOTO is being considered for removal and:

   a. Must verify with each member that all tasks performed in conjunction with the specific job are complete.

   b. Must verify that the equipment has been returned to a safe restart condition.

7. After positive verification is received from all crew members, the designated **authorized employee** may remove the group LOTO devices and perform equipment restart.

If any group member is not present to provide the verification that is required under Steps 6 and 7, the **Designated Authorized Employee** must follow all of the procedures as outlined in *Emergency Removal of LOTO Devices*.

EACH MEMBER OF A GROUP LOCKOUT IS CONSIDERED TO HAVE A *LOCK AND TAG* ON THE EQUIPMENT AND MUST COMPLY WITH ALL OTHER REQUIREMENTS IN THIS CHAPTER.

8. The designated **authorized employee** is responsible for making all appropriate logbook entries.

18.17 SHIFT CHANGES

18.17.1 GENERAL

To ensure the continuity of LOTO protection during shift or personnel changes, if work is to be continued by an oncoming shift, an orderly transfer of LOTO devices between **authorized employees** from the offgoing and oncoming shifts must be performed. The **authorized employees** from both shifts must both be present at the lockout device. The **offgoing authorized employee** must remove his or her lock and tag, and the **oncoming authorized employee** must immediately place his or her lock and tag on the group LOTO device. The authorized offgoing employee must inform the authorized oncoming employee of any potential hazards.

18.7.2 WHEN THERE IS A GAP BETWEEN SHIFTS

If the orderly transfer of LOTO devices is not possible because of a gap in shifts, one of the following procedures must be implemented to provide continuity of LOTO protection.

<u>Option 1:</u> Transfer to Administrative Control (see LOTO v. Administrative Locking, p.18-2)

1. The **authorized employee** who is going off shift replaces his/her LOTO lock with an administrative lock which is controlled by the affected group.

2. The oncoming employees replace the administrative lock with their individual LOTO locks.

<u>Option 2:</u> Transfer Of LOTO By Controlled Logbook Consent

1. If the **authorized employees** from both shifts cannot be present simultaneously at the lockout device because there is a gap between their shifts, the **authorized employee** of the offgoing shift may acknowledge, by written logbook entry, prior consent to remove his or her LOTO devices during the oncoming shift. The supervisor of the **authorized employee** must make a corresponding logbook entry.

   a. The logbook entries must include the **authorized employee's** and supervisor's printed names and signatures, the equipment identification, maintenance procedure being performed, and all other pertinent safety information regarding the equipment and/or procedure.

2. The supervisor of the oncoming shift must read and understand the logbook entries and is authorized to remove the LOTO device of the **authorized employee** from the offgoing shift.

3. The **authorized employee** of the oncoming shift must apply his or her LOTO devices.

4. Both the oncoming **authorized employee** and his or her supervisor must make logbook entries acknowledging the performance of this special procedure.

5. All subsequent LOTO actions must conform with the standard LOTO policy and procedures.

6. Before resuming work, the **authorized employee** who gave prior consent for removal of his or her LOTO devices must be personally informed by the supervisor that the **authorized employee's** devices have been removed. This **authorized employee** and supervisor must make confirming logbook entries, and the supervisor must then return the LOTO devices to the employee.

18.18 LBNL SUBCONTRACTORS

The **Project Manager** is responsible for ensuring that all construction subcontractors are informed of and adhere to LBNL LOTO policy.

Construction subcontractors will be required, when applicable, to include LOTO procedures in accordance with this chapter in their construction safety plans. The Project Manager must ensure that the subcontractor's safety plan is consistent with the intent of LBNL LOTO policy and 29 CFR 1910.147. Subcontractor employees are not required to take the LBNL LOTO course, but they must be trained in their company's LOTO procedure.

All subcontractor employees have the responsibility to apply LOTO to equipment which they are working on. Regardless of whether or not they will perform LOTO, all subcontractor employees have potential exposure to LOTO activities and must be trained in the recognition of the procedure and the importance of respecting locks and tags.

A Subcontractor operating under an approved safety plan generally will provide its own LOTO equipment. The LOTO hardware used must be approved by the Project Manager.

When the Facilities Department requires local oversight of a utility or other system which is associated with Subcontract work, it may forbid the Subcontractor from operating that system. In such an instance, the cognizant LBNL shop would apply an administrative lock on a multiple lockout device on the energy isolating device after securing the system. All of the Subcontractor employees are still responsible for applying personal LOTOs while they are working on that system. After the work is completed, and all of the subcontractors' locks are removed, the LBNL shop removes the administrative lock and reenergizes the system.

18.19 VISITORS

Visiting scientists and students are also required to be trained and authorized in LOTO if they service, maintain, or modify equipment, as described in the section on *General Procedure.*

The LBNL supervisor responsible for a guest has all of the responsibilities of a supervisor, as described in this chapter. All visiting scientists and students are considered affected employees. (See *Training and Authorization* and *Responsible Parties.*)

18.20 PERIODIC INSPECTIONS

Each division is responsible for ensuring that a periodic inspection and certification of its energy-control procedures be conducted at least annually.

The periodic inspection must be performed and documented by a member or designee of the Mechanical Safety Subcommittee or Electrical Safety Subcommittee, other than the one(s) utilizing the energy-control procedures being inspected.

The periodic inspection must be designed to correct any deviations or inadequacies observed.

The certification must state that the periodic inspection has been performed. The certification must identify the machine(s) or equipment on which the energy-control procedure was utilized, the date of the inspection, the employees included in the inspection, and the person performing the inspection.

18.21 TAG-ON

Sump pumps, emergency lights, refrigerators, or equipment that must be shut down in a controlled manner fall into a class of equipment that should not be accidentally deenergized. When a circuit breaker, disconnect switch, or energy-securing device is readily accessible to any employee, the circuit breaker or disconnect switch may be tagged to indicate that it is not to be turned off. The energy-securing device must not be locked by any means that would prevent the device from being used as an emergency disconnect.

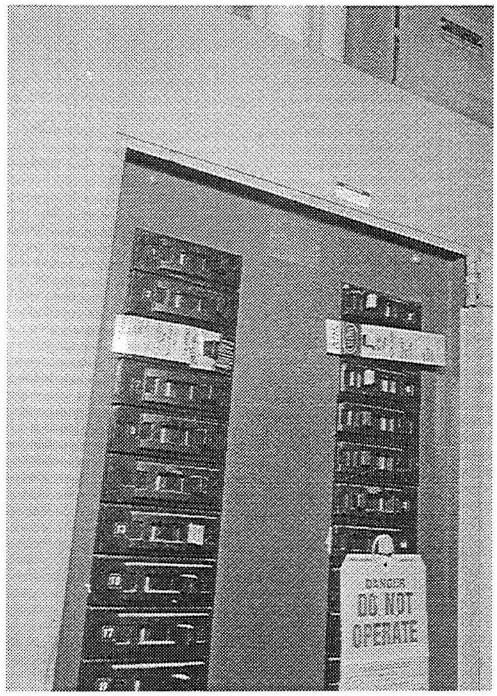


Fig. 18.7. Tag-On.

18.22 RESPONSIBLE PARTIES

18.22.1 ALL EMPLOYEES

You, as an employee, are responsible for your own safety. Never undertake a task that you feel is unsafe.

All employees are responsible for recognizing when LOTO is being used, the general reasons for LOTO, and the importance of not tampering with or removing a lock and tag.

18.22.2 AUTHORIZED EMPLOYEES

Authorized employees, in addition to the responsibilities of all employees, have responsibility for recognizing the conditions of work that require LOTO, assessing all of the hazardous energy sources, using correct procedures and materials to implement LOTO, and maintaining control over their key.

EACH EMPLOYEE PERFORMING SERVICING, MAINTENANCE, OR MODIFICATION IS RESPONSIBLE FOR APPLYING HIS OR HER OWN LOCK AND TAG.

NEVER APPLY LOTO FOR ANYONE ELSE.

18.22.3 SUPERVISORS

Supervisors are responsible for:

- Prohibiting employees from working on equipment requiring LOTO until they are trained in and authorized to perform LOTO.
- Generating and maintaining equipment-specific written procedures where required (see *Equipment-Specific Written Procedures*).
- Assigning and documenting employee LOTO authorization, including:
  - Designating specific equipment or categories of equipment to be controlled.
  - Verifying that the employee is qualified to perform the necessary energy-control procedures.
- Determining the appropriate levels of training required for each employee.
- Ensuring consistent policy implementation and reinforcing LOTO rules.
- Removing LOTO devices in case of emergency and controlling emergency keys for LOTO locks.
- Ensuring that necessary hardware is available.

Supervisors may elect to instruct employees in the *Lockout/Tagout Training* course, EH&S-257.

18.22.4 EH&S DIVISION

The EH&S Division is responsible for:

- Maintaining, administering, and revising the LOTO program as needed.
- Ensuring that LOTO equipment is available and consistent with LBNL standards.
- Designing and implementing the *Lockout/Tagout Training* course, EH&S-256.

The EH&S Field Support Department will make periodic checks for LOTO compliance in conjunction with Functional Appraisal Inspections.

18.22.5 FACILITIES DEPARTMENT MANAGER

The Facilities Department Manager is responsible for ensuring that all outside contractors operating under the supervision of the Facilities Department are informed of and adhere to the LBNL LOTO policy.

18.23 GLOSSARY

An **authorized employee** is any employee who is trained in and authorized to perform LOTO.

An **energy-isolating device** is a mechanical device that physically prevents the transmission or release of energy. Energy-isolating devices include, but are not limited to:

- Manually operated electrical circuit breakers
- Valves
- Disconnect switches
- Similar devices that can block or isolate an energy source

LOTO is an acronym for lockout/tagout.

Zero-energy state is a condition that is reached when all energy sources to or within equipment are isolated, blocked, or otherwise relieved, with no possibility of reaccumulation. Equipment is not safe to work on until it is in a zero-energy state.

18.24 STANDARDS

- 29 CFR Part 1910.147, *The Control of Hazardous Energy (Lockout/Tagout)*
- 29 CFR Part 1910, *Subpart S, Electrical*

Chapter 19

PERSONAL PROTECTIVE EQUIPMENT

Revised December 1997

Reviewed by: Paul Davis 12/10/97
Date

Approved by: D. C. McGraw 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 19

PERSONAL PROTECTIVE EQUIPMENT

19.1 POLICY

The Laboratory requires suitable equipment to protect employees from hazards in the workplace as prescribed in 29 CFR 1910.132. The Environment, Health and Safety (EH&S) Division advises on the protective equipment required for a task, but the supervisor of the operation must obtain this equipment and see that it is used.

Protective clothing is not a substitute for adequate engineering controls.

Appendix B to 29 CFR 1910, Subpart I, provides non-mandatory compliance guidelines for making a hazard assessment to determine the type of personal protective equipment needed for activities and operations. These guidelines are available from an EH&S Industrial Hygienist, ext. 5176 or 7170.

19.2 PROTECTIVE CLOTHING

- **Criteria for Issue**

To protect their health and safety, protective clothing will be issued to employees who work with hazardous material.

EH&S is available for consultation as needed. Page E-4 of the *Chemical Hygiene and Safety Plan*, PUB-5341, gives additional guidance for body, foot, eye, respiratory, and hand protection. Appendix 6 of PUB-5341 provides glove-selection guides.

- **Authority**

Supervisors authorize protective clothing for their employees. Protective clothing is purchased from the Central Storeroom (Bldg 78), with the approval of a person authorized to sign for the account, as shown in the *Account Authorization Book.*

- **Radioisotope Areas**

Protective clothing must be monitored for radioactive contamination before being sent to the laundry.

19.3 FOOT PROTECTION

The Laboratory encourages the wearing of safety shoes by making them available to all employees at cost, delivered from a manufacturer's shoemobile. For certain types of work, wearing safety shoes is required by Laboratory policy or by federal regulations (29 CFR 1910.136) as specified in American National Safety Standard Z41.1. Examples are work that exposes employees to foot injuries from hot, corrosive, or poisonous substances; work in shops, in equipment handling, or in construction jobs where there is a danger of falling objects; or work in abnormally wet locations.

When safety shoes are required by Laboratory policy, the department requesting them will contribute an amount toward their cost, as determined each year by the Director's Office. However, if the employee selects safety shoes for which the total cost (including sales tax) exceeds this amount, the difference must be paid by the employee. Authorization forms (#7600-65158) are available from the Central Storeroom. The manufacturer's shoemobile sells safety shoes without a supervisor's authorization when employees wish to purchase them through the low-cost program (payroll deduction). Safety shoes are furnished by LBNL for certain off-site operations for which a formal hazard evaluation has established the need for this protection.

19.4 HAND PROTECTION

The Laboratory provides proper hand protection to employees exposed to known hand hazards such as those from absorption of harmful substances, severe cuts, lacerations or abrasions, chemical burns, and extreme temperatures. Supervisors must obtain suitable hand protection and ensure that it is used. The Central Storeroom in Building 78 stocks a variety of protective hand protection. Individual departments are responsible for maintaining a supply of adequate hand protection.

Assistance in selecting the proper hand protection may be obtained by consulting an Industrial Hygienist, ext. 7170 or 5176.

19.5 HEAD PROTECTION

The Laboratory provides helmets for employees who work in areas or situations in which there is a potential for head injury from falling objects or when they are near exposed electrical conductors that could contact the head as described in 29 CFR 1910.135. Some head protection devices are available from the Central Storeroom. Supervisors must also maintain sufficient supply of head protection devices for visitors in their areas. Helmets must meet ANSI Standard Z89.1.

19.6 EYE PROTECTION

19.6.1 INTRODUCTION

All persons must wear safety glasses whenever they run a reasonable probability of eye injury resulting from work being performed. Staff must use appropriate eye or face protection when exposed to hazards from flying particles, molten metal, liquid chemicals, acids or caustics, chemical gases or vapors, or potentially injurious light radiation. Eye protection with side shields must be used when there is a hazard from flying objects. Some work areas (e.g., chemical laboratories and workshops) are designated as "Eye-Hazard Areas." Signs must be posted in these areas that state the eye-protection requirement (e.g., "Eye Protection Must be Worn in This Area").

The Laboratory provides appropriate eye-protection devices for employees assigned to tasks that expose them to an eye-injury hazard.

19.6.2 RESPONSIBILITY AND TRAINING

The supervisor of an operation is responsible for determining when eye protection is needed and what eye-protection devices are suitable, and is responsible for ensuring that all employees and visitors use them when in active eye-hazard areas. The EH&S Bio Energy Sciences and General Sciences/Operations Groups assist supervisors in defining eye-hazard operations and in selecting appropriate eye protection. The Health Services Group optometrist is available for consultation regarding occupational eye protection. Personnel requiring prescription safety glasses or laser safety glasses should schedule an examination with the optometrist, who issues all safety glasses and screens individuals for use of laser safety glasses.

When prescription safety glasses are issued, the Health Services Optometrist completes a "Notification of Issue of Safety Glasses" form for the individual receiving the safety glasses and sends a copy to his/her supervisor. The form specifies the conditions under which the employee must wear safety glasses.

It is the individual's responsibility to wear eye protection devices at all times in eye-hazard areas and whenever his/her work poses a reasonable probability of eye injury.

19.6.3 TYPES OF EYE-PROTECTION EQUIPMENT

All eye-protection devices issued by the Laboratory must comply with ANSI Standard Z87.1 (1989) and provide protection against impacts three times greater than dress-wear glasses can normally withstand. When in use as eye-protection devices, safety glasses must have side shields or be worn with safety goggles that have the same ANSI approval. ANSI-approved safety glasses and goggles can be identified by the ANSI Z87.1 imprint found on them.

Four types of eye-protection devices are available:

- Personal prescription safety glasses, issued through the Health Services Group.
- Goggles, face shields, etc. available from the Central Storeroom.
- Temporary nonprescription safety glasses provided to visitors in eye-hazard areas.
- Laser-safety eyewear is the responsibility of the user. The Laser Safety Officer, ext. 7658, will provide consultation regarding the appropriate type of eyewear and where to obtain it. (see Chapter 16, *Lasers,* for information on obtaining eyewear approved for protection against laser light and for information on required medical examinations).

19.6.4 ELIGIBILITY FOR PERSONAL SAFETY GLASSES

All LBNL full-time employees who engage in eye-hazard operations are eligible to obtain prescription safety glasses at Laboratory expense. Potential eye-hazard operations are those that produce flying particles (e.g., using machining equipment or portable power tools), that involve the handling of hazardous liquids (e.g., chemical labs or plating and plastic shops), or that involve exposure to intense light (e.g., working with UV). Prescription or nonprescription dark glasses are available only upon completion of a "Request for Tinted Safety Glasses form by the supervisor. This form is available from Health Services in Building 26.

19.6.5 ISSUANCE OF SAFETY GLASSES

The supervisor determines the need for safety glasses, and the employee makes an appointment with the optometrist at the Health Services Group if prescription glasses are required. Nonprescription (plano) glasses may be obtained from the Central Storeroom at Building 78.

The optometrist may perform refractions only for employees who require safety glasses. A nominal fee is charged for this examination. Employees have the option of using a prescription from a personal optometrist; however, the employee must pay the fee for this personal service. To ensure proper fit, the Health Services Group optometrist must issue all prescription safety glasses. Replacement glasses may be ordered from a prescription on file as long as the prescription has not expired (i.e., is less than 2 years old).

19.6.6 ADJUSTMENTS AND REPAIRS

Damaged prescription safety glasses or frames issued by the Laboratory are replaced or repaired as necessary. The Health Services Group optometrist must make all adjustments and repairs to these safety glasses.

19.6.7 SAFETY GLASSES FOR PART-TIME EMPLOYEES

Whenever possible, eye-protection available at the Central Storeroom should be used by part-time or short-term employees. If this type of eye protection is inadequate or unreasonable, personal safety glasses must be issued as outlined above.

19.7 HEARING PROTECTION

Contact the General Sciences/Operations Group to evaluate noise that could potentially damage hearing. An Industrial Hygienist and/or Health Services may recommend hearing protectors. Health Services may follow up with an audiometric evaluation of employees who are exposed to potentially damaging noise. A variety of hearing protection is available from the Central Storeroom.

19.8 RESPIRATORY PROTECTION

19.8.1 INTRODUCTION

Any operation that generates harmful airborne levels of dusts, fumes, sprays, mists, fogs, smokes, vapors, or gases or that may involve oxygen-deficient atmospheres requires the use of effective safety controls (29 CFR 1910.134). This must be accomplished, as much as feasible, by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate respiratory protection must be used.

19.8.2 RESPONSIBILITIES

To ensure that the respiratory protection program is conducted in accordance with ANSI Standard Z88.2-1992, certain responsibilities are required of employees, supervisors, and the General Sciences/Operations and Health Services Groups. A brief description of these responsibilities is given below. For more specific information on respiratory protection, please refer to *Respiratory Protection for LBNL*, available through the General Sciences/Operations Group.

Employees are responsible for:

- Wearing a respirator in accordance with the instructions and training received.
- Maintaining and storing the respirator in good condition.
- Returning the respirator at the end of the required use for overhaul, cleaning, and disinfection.

Supervisors are responsible for:

- Identifying those employees who may need to use respiratory protection (an Industrial Hygienist will provide assistance in this determination).
- Ensuring that their employees have been properly trained and fitted by the General Sciences/Operations Group.
- Ensuring that their employees use the respirators as required.

The General Sciences/Operations Group is responsible for:

- Providing respiratory protective equipment.
- Maintaining the equipment in good condition.
- Fitting employees with proper respirators and providing training for their use.
- Evaluating employee exposures and work conditions, including inspection of respirator use.

The Health Services Group is responsible for:

- Evaluation for medical approval for each respirator user.

19.8.3 RESPIRATORY PROTECTIVE EQUIPMENT

The General Sciences/Operations Group has selected the types of respiratory protective equipment to be used at the Laboratory. *Any changes to protective equipment, its application, or the substitution of alternative protective equipment must be approved by the General Sciences/Operations Group before its use.*

The Laboratory has a wide variety of respiratory protective equipment available. Each respirator has certain capabilities and limitations that are taken into account when issued. This equipment is issued by the Industrial Hygiene Respirator Program Administrator of EH&S, located at the Building 75 respirator fit test room, Room 112A. To arrange for respirator fit testing and training, call ext. 7625.

The types of respiratory protective devices provided by the Laboratory are described below. For more information on respiratory protection, refer to Chapter 4 of this manual, *Industrial Hygiene*, and to *Respiratory Protection for LBNL*, a more detailed source of information, available from the General Sciences/Operations Group.

- **Disposable Dust Respirators**

Disposable dust respirators are approved for protection against low (nonhazardous) levels of nuisance dusts. They provide *no protection against vapors or gases*, and they *cannot be used in oxygen-deficient areas.*

- **Air-Purifying Respirators**

Air-purifying, half and full facepiece respirators are approved for protection against low concentrations of particulates, organic vapors, acid gases, ammonia, mercury, and a variety of other contaminants. Specific cartridges and filters must be selected for protection against each material. *They must never be used in atmospheres deficient in oxygen, when carbon monoxide or oxides of nitrogen are suspected, or when conditions prevent a good face seal.*

- **Supplied-Air Respirators**

Supplied-air, half and full facepiece respirators may be used in atmospheres unsuitable for air-purifying respirators *but cannot be used in areas that are immediately dangerous to life or health* unless these units are equipped with the proper emergency escape air supply. *Compressors* are normally used to supply breathing air, but *compressed air cylinders* may also be used.

- **Supplied-Air Hoods**

Supplied-air hoods are approved for respiratory protection in any atmosphere not immediately dangerous to life or health *and from which the wearer can escape without the aid of a respirator*. In most cases, the presence of a beard, sideburns, skullcap, or eyeglasses will not affect the performance of this type of respirator.

Personnel will not be fitted or issued a respirator if there is any condition that may prevent a good face seal, such as a beard, sideburns, skullcap, or temple pieces on eyeglasses. For more information on this issue, please refer to the Laboratory's facial hair policy in *Respiratory Protection for LBNL*, available from the General Sciences/Operations Group.

Before respiratory protective equipment (including disposable respirators) may be issued and used, a hazard evaluation must be performed by an Industrial Hygienist. Additionally, respirator users must be medically approved by the Health Services Group and receive training and fit testing from the General Sciences/Operations Group.

19.9 STANDARDS

- 29 CFR 1910, Appendix B, Subpart 1, *Personal Protective Equipment*
- 29 CFR 1910.132, *General Requirements*
- 29 CFR 1910.133, *Eye and Face Protection*
- 29 CFR 1910.134, *Respiratory Protection*
- 29 CFR 1910.135, *Head Protection*
- 29 CFR 1910.136, *Foot Protection*
- 29 CFR 1910.137, *Electrical Protective Equipment*
- 29 CFR 1910.138, *Hand Protection*

19.10 REFERENCES

- *Respiratory Protection for LBNL,* General Sciences/Operations Group, EH&S Division
- ANSI Standard Z41.1, *USA Standard for Men's Safety-Toe Footwear*
- ANSI Standard Z87.1, *USA Standard for Occupational and Educational Eye and Face Protection*

- ANSI Standard Z88.2, *Standard Practices for Respiratory Protection*
- ANSI Standard Z89.1, *American National Standard for Personal Protection: Protective Headwear For Industrial Workers—Requirements*

Chapter 20

HAZARDOUS WASTE DISPOSAL

Revised December 1997

Reviewed by: Robin Wendt 12/10/97
Date

Approved by: D. C. McGraw 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 20

HAZARDOUS WASTE DISPOSAL

20.1 POLICY

The Berkeley Lab Waste Management policy is to:

- Remove hazardous, radioactive, mixed, and medical wastes from generator areas safely and efficiently.
- Comply with all laws and regulations governing these wastes.
- Minimize the wastes generated at Berkeley Lab.
- Operate the Hazardous Waste Handling Facility (HWHF) in a manner that complies with all regulations.

20.2 SCOPE

This chapter provides general information on the management of the following kinds of wastes:

- Hazardous waste (i.e., wastes that are corrosive, ignitable, reactive, or toxic)
- Radioactive waste (containing radioactivity distinguishable from background)
- Mixed waste (waste that is both hazardous and radioactive)
- Medical waste (including biohazardous waste)

This chapter does not apply to solid or liquid sanitary wastes.

This chapter also provides guidance on how to find more specific information on selected waste management topics detailed in other documents and how to contact waste management personnel for consultations on specific topics.

20.3 HAZARDOUS, RADIOACTIVE, MIXED, AND MEDICAL WASTE GUIDELINES AT BERKELEY LAB

Hazardous, radioactive, mixed, and medical wastes are generated during routine research and support activities at Berkeley Lab. Waste generators are responsible for accurate and complete characterization of their wastes, for compliant management of them within their workplaces, and for minimizing the amount of waste generated. Consult the following publications and your Generator Assistant Specialist for these responsibilities:

- PUB-3092, *Guidelines for Generators to Meet HWHF Acceptance Requirements for Hazardous, Radioactive, and Mixed Wastes at Berkeley Lab*
- PUB-3093, *Guidelines for Management of Waste Accumulation Areas (WAAs) at Berkeley Lab*
- PUB-3095, *Medical and Biohazardous Waste Generator's Guide*

20.3.1 CHARACTERIZATION: DETERMINING IF YOUR WASTE IS HAZARDOUS, RADIOACTIVE, MIXED, OR MEDICAL

The first step in waste disposal is to determine if your waste is hazardous, radioactive, mixed, or medical/biohazardous.

- Use the information in PUB-3092 to determine if your waste is hazardous, radioactive, or mixed.
- Use the information provided in PUB-3095 to determine if your waste is medical or biohazardous.
- If you have any questions about the nature of your waste, you should contact an EH&S Generator Assistance Specialist to help you in your determination.

It is vitally important that wastes be accurately and completely characterized. Doing this properly is the generator's responsibility. If improperly characterized hazardous, radioactive, mixed, or medical waste were to be accidentally shipped as nonhazardous, the health and safety of the general public could be compromised.

20.3.2 COMPLIANCE: STORING WASTE AT THE SITE OF GENERATION

All generators are required to set up special areas for the storage of hazardous, radioactive, mixed, or medical waste while it is stored at the generator's site.

The generator is responsible for following all rules regarding storage of hazardous, radioactive, mixed, and medical wastes, including:

- The amount and kind of waste that can be stored
- Segregation and separation of waste according to its hazard category
- Primary and secondary containment
- Packaging and labeling
- The length of time waste can be stored on site
- Satellite Accumulation Areas (SAAs) are used for the accumulation of small amounts of hazardous wastes for up to 275 days (nine months). Details about setting up and maintaining SAAs appear in Sections 4-7 of *Guidelines for Generators to Meet HWHF Acceptance Requirements for Hazardous Wastes at Berkeley Lab* (part of PUB-3092).

- Low-level radioactive wastes must be stored in a Radioactive Waste Collection Area (RWCA). Details about setting up and maintaining RWCAs appear in *Guidelines for Generators to Meet HWHF Acceptance Requirements for Radioactive Wastes at Berkeley Lab* (part of PUB-3092).
- Mixed Waste Satellite Accumulation Areas (MWSAAs) are used for the accumulation of mixed wastes for up to 275 days (nine months). Details about setting up and maintaining MWSAAs appear in *Guidelines for Generators to Meet HWHF Acceptance Requirements for Mixed Wastes at Berkeley Lab* (part of PUB-3092).
- Waste Accumulation Areas (WAAs) are used for the accumulation of larger amounts (> 55 gallons) of hazardous wastes for up to 60 days. WAAs are most appropriate for areas such as shops, where only a few kinds of hazardous wastes are generated in large quantities. Specific rules apply to WAAs, including security, labeling and signage, contingency plans, and emergency equipment, as detailed in PUB-3093, *Guidelines for Management of Waste Accumulation Areas (WAAs) at Berkeley Lab*.
- Medical and biohazardous waste is stored at the generator's site according to the guidance in PUB-3095, *Medical and Biohazardous Waste Generator's Guide*. Medical and biohazardous wastes are transferred from the generator's laboratory to an approved medical waste pickup site, where they are picked up according to a prearranged schedule.

20.4 RESPONSIBILITIES OF THE WASTE MANAGEMENT GROUP

EH&S's Waste Management personnel at Berkeley Lab are responsible for:

- Aiding generators in all questions regarding wastes, including characterization, labeling, packaging, and safe and compliant management in the workplace (Generator Assistance Specialists).
- Ensuring that generators have properly characterized their waste and have correctly, packaged and labeled it before it is picked up.
- Removing all waste from the generator's site in a safe and timely manner.
- Operating the HWHF in a manner that ensures safety and complies with all regulations.
- Tracking the waste from the time it is created to its final disposition in a treatment, storage, and disposal facility (TSDF) or other storage site.
- Maintaining all records regarding the waste.

More detailed responsibilities of individuals and groups are provided in PUB-3092, PUB-3093, and PUB-3095.

20.5 REQUIRED TRAINING

The following training is required for generators of hazardous, radioactive, mixed, and medical wastes.

- EH&S 604, Hazardous Waste Generator Training, is required for all generators of hazardous waste at Berkeley Lab.
- EH&S 622, Radioactive and Mixed Waste Generator Training, is required for all generators of radioactive and/or mixed wastes at Berkeley Lab.
- EH&S 610, Waste Accumulation Area Training, is required for WAA managers at Berkeley Lab.
- EH&S 737, Blood Biosafety and Medical Waste, is required for all generators of medical and biohazardous waste at Berkeley Lab.

20.6 GLOSSARY

Acutely hazardous waste is any waste that is listed in 22 CCR, Chapter 11, Article 4, as an EPA-defined "P-listed" hazardous waste. These wastes typically are toxic or reactive. **Acutely hazardous waste** is a federal definition, whereas **extremely hazardous waste** (see definition below) is a State of California definition.

Biohazardous waste includes:

- Laboratory waste, including human or animal specimen cultures or specimens from medical and pathological laboratories.
- Infectious agents in cultures and stocks from research and industrial laboratories.
- Waste from the production of bacteria or viruses or from the use of spores.
- Live and attenuated vaccines and any container or device used to transfer, inoculate, or mix cultures.
- Waste containing microbiological specimens sent to a laboratory for analysis.
- Human specimens or tissues removed at surgery or autopsy suspected by attending staff of being contaminated with infectious agents contagious to humans.

Biological waste consists of biological material and/or biomedical devices (e.g., Pasteur pipettes, culture flasks including petri dishes, certain gloves, syringes, and hypodermic needles).

Characterization is the detailed documentation necessary to certify that the waste is what it is claimed to be. Characterization can include knowledge of process (see definition below), required analyses, or written documentation (log books, formulas, etc.).

Extremely hazardous waste is any hazardous waste or mixture of hazardous wastes that, if human exposure should occur, may likely result in death, disabling personal injury, or serious illness because of its quantity, concentration, or chemical characteristics. (From 22 CCR 66260.10.)

Hazardous waste is defined as:

- Wastes that exhibit one or more of the criteria for identification of "hazardous waste" (22 CCR 66261.21–66261.24). These criteria are:
  - Toxicity
  - Ignitability
  - Reactivity
  - Corrosivity
- Wastes listed in the California Code of Regulations (22 CCR 66261) and the Code of Federal Regulations (40 CFR Part 261). These wastes include certain discarded commercial chemical products, off-specification products, container residues, and spill residues.
- Wastes listed as "dangerous" or "extremely hazardous" in the Washington Administrative Code, Chapter 173-303.

Infectious waste (see **Medical Waste** below) includes all of the following:

- Laboratory wastes, including cultures of etiologic agents, that pose a substantial threat to health due to their volume and virulence.
- Pathologic specimens, including human or animal tissues, blood elements, excreta, and secretions that contain etiologic agents; and attendant disposable fomites.
- Surgical specimens that contain etiologic agents and attendant disposable fomites.
- Equipment, instruments, utensils, and other disposable materials that are likely to transmit etiologic agents from the rooms of humans, or the enclosures of animals, that have been isolated because of suspected or diagnosed communicable disease.
- Human dialysis waste materials, including arterial lines and dialyzate membranes.
- Carcasses of animals infected with etiologic agents that may present a substantial hazard to public health if improperly managed.
- Any other material that, in the determination of the facility infection control staff, presents a significant danger of infection because it is contaminated with, or may reasonably be expected to be contaminated with, etiologic agents.

Knowledge of process means the ability of the generator to characterize waste on the basis of the chemical materials from which the waste was derived or the process by which the waste was generated. It also means being able to verify the characterization with the documented procedures used and data accumulated during the waste-generation process.

Low-level waste is waste containing radioactivity distinguishable from background levels that is not classified as high-level waste, transuranic waste, spent nuclear fuel, or byproduct material, as defined in DOE Order 5820.2A. At LBNL, low-level waste is divided into several different categories, described in LBNL PUB-3092, *Guidelines for Generators to meet HWHF acceptance requirements for Hazardous, Radioactive, and Mixed Wastes at Berkeley Lab*.

Mecial waste, according to Federal and California laws, refers to three general types of waste generated in research laboratories and patient treatment areas:

- Biohazardous (including infectious and biological).
- Sharps (devices with sharp edges capable of piercing or cutting the skin).
- Waste generated or produced as a result of the diagnosis, treatment, or immunization of humans or animals; in research on humans or animals; or in the production or testing of biologicals.

Mixed medical waste is any mixture of medical and nonmedical waste, with the following exceptions:

- Waste that is **both medical/biohazardous and hazardous** is considered to be hazardous waste and is subject to hazardous waste regulations.
- Waste that is **both medical/biohazardous and radioactive** is considered to be radioactive waste and is subject to radioactive regulations.
- Waste that is **medical/biohazardous, hazardous, and radioactive** is considered to be mixed waste and is subject to both hazardous and radioactive waste regulations.

Mixed waste is any radioactive waste that is also a hazardous waste.

A **Radioactive Materials Area (RMA)** is an area where the potential exists for contamination due to the presence of unencapsulated or unconfined radioactive materials or an area that is exposed to beams or other sources of particles (neutrons, protons, etc.) capable of causing activation.

A **Satellite Accumulation Area (SAA)** is an area in an individual laboratory, shop, or other facility designated by the generator for the accumulation of waste, not to exceed 208 liters (55 gallons) of hazardous waste or 0.95 liter (1 quart) of extremely or acutely hazardous waste. The area must be at or near the point of waste generation and under control of the person generating the waste.

Sharps are devices having acute rigid corners, edges, or protuberances capable of piercing or cutting the skin.

Transuranic wastes are any wastes that, without regard to source or form, are contaminated with alpha-emitting transuranium radionuclides (elements 93 and higher) with half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay. Radium sources and U-233 are also considered to be transuranic wastes. Radioactive waste with quantities of transuranic radionuclides in concentrations of 100 nCi/g of waste or less is considered to be low-level waste and not transuranic waste.

A **Waste Accumulation Area (WAA)** is an officially designated area for the accumulation and storage of large quantities of hazardous waste.

20.7 STANDARDS

Hazardous Waste and Nonradioactive Portion of Mixed Waste:

- 42 U.S.C. 6901 et seq., Resource Conservation and Recovery Act (RCRA)
- Federal Facility Compliance Act (FFCA)
- 40 CFR Sections 260–279, Hazardous Waste; 761.1, PCBs
- 29 CFR 1910.120 Training
- 29 CFR 1910.1001, Asbestos Hazardous Waste Control Law, Hazardous Waste Control Law
- California Health and Safety Code, Section 25100 et seq.
- 22 CCR Section 66260.1 et seq. (and all permits pursuant)
- Disposal Site Waste Acceptance Criteria
- FFCA Order for LBNL HWCA 95/96-016, Site Treatment Plan for Mixed Waste
- Berkeley Municipal Code, Chapter 11.52, Hazardous Materials Management as applied to generator areas

Radioactive Waste and Nonhazardous Portion of Mixed Waste:

- 49 CFR 173, 177 (DOT), Packaging, Shipping, Carrier Loading
- Disposal Site Waste Acceptance Criteria
- DOE Order 5820.2A, Chapter II, Chapter II, Transuranic Waste excluding 3.j (QA); Chapter III, Low-Level Waste excluding 3.i (QA), Chapter IV, Accelerator Produced Radioactive Material excluding 3.b (QA); Chapter V, Decommissioning Facilities excluding 3.e (QA)

Medical Waste:

- 42 U.S.C. Section 6992 et seq., Medical Waste Tracking Act of 1988, Subtitle J, Solids Waste Disposal Act (RCRA)
- 29 CFR 1910.1030, Bloodborne Pathogens Standard
- California Health and Safety Code, Sections 25020.5–25090.6, California Medical Waste Management Act

20.8 REFERENCES

- PUB-3092, *Guidelines for Generators to Meet HWHF Acceptance Requirements for Hazardous, Radioactive, and Mixed Wastes at Berkeley Lab*, latest revision
- PUB-3093, *Guidelines for Management of Waste Accumulation Areas (WAAs) at Berkeley Lab*, latest revision
- PUB-3095, *Medical and Biohazardous Waste Generator's Guide*, latest revision

Chapter 21

RADIATION SAFETY

Revised December 1997

Reviewed by: Gary H. Zeman 12-11-97
Date

Approved by: Dale McGraw 12/15/97
EH&S Division Director
Date

CONTENTS

Chapter 21

RADIATION SAFETY

21.1 POLICY

It is Berkeley Lab policy that all types of radiological work activities will be conducted in accordance with applicable federal law and DOE requirements. This is achieved by adherence to Berkeley Lab policies set forth in this manual and the related programs and procedures implemented by the Radiation Protection Group (RPG). RPG communicates to line management the specific work requirements applicable to individual facilities and projects through authorization documents such as

- Safety Analysis Documents (SADs),
- Activity Hazard Documents (AHDs),
- X-ray Machine Safety Documents (XSDs),
- Radiological Work Authorizations (RWAs),
- Radiological Work Permits (RWPs), and
- Sealed Source Authorizations (SSAs).

Line managers are accountable for implementation and compliance with these radiation safety requirements as they apply to their facilities. RPG personnel provide support by performing the appropriate hazard evaluations, developing the applicable radiation safety authorization documents, and providing all necessary field support services. These field services include hazard evaluation, surveys and radiation monitoring, dosimetry, bioassay, instrumentation, and oversight of work activities.

The Radiation Safety Committee (RSC), which is appointed by and reports to the Laboratory Director, is responsible for advising LBNL management on all matters related to occupational and environmental radiation safety. The RSC reviews and recommends approval of radiation safety policies. The scope of its actions will generally be in issues of broad institutional concern and impact, or areas of potential high consequence either in terms of safety or institutional needs. The RSC must also provide a forum to ensure that important radiation safety issues receive appropriate, balanced, and expert review before being acted upon by the Environment, Health, and Safety Division.

Violations of this policy may result in restrictions from radiological work and/or disciplinary actions by line management. Serious violations of the policy, which are knowingly and willfully committed, may result in civil penalties or criminal prosecution as determined by applicable federal agencies.

RADIOLOGICAL WORK MAY BE STOPPED BY A WORKER THROUGH LINE MANAGEMENT, LINE SUPERVISION, OR THE RADIOLOGICAL CONTROL MANAGER IF RADIOLOGICAL CONTROLS ARE INADEQUATE OR ARE NOT BEING IMPLEMENTED.

21.2 SCOPE

This policy covers all aspects of the use, control, and storage of radioactive materials, radiation-generating devices, and exposure to ionizing radiation. It applies to all Berkeley Lab employees, contractors, and subcontractors acting on behalf of Berkeley Lab. This includes both on-site and off-site activities.

21.3 RADIATION PROTECTION PROGRAM

21.3.1 GROUP ORGANIZATION

Radiation Protection Group (RPG)

The core RPG at Berkeley Lab within the Environment, Health & Safety Division consists of health physicists (HPs), technologists, radiological control technicians (RCTs), and administrative support staff. The following programs have at least one health physics supervisor and one or more RCTs assigned.

- Radiological Work Authorizations
- Radiological Work Permits
- Radioactive Material Transportation
- Sealed Source Program, NIMMSS Program
- Radiation-Producing Machine Program

Other programs carried out by RPG are Radiation Protection Training, ALARA, Quality Assurance, and Regulatory Affairs.

Within the RPG, the Radiation and Analytical Measurements Laboratory (RAML) has health physicists and technical specialists performing instrument calibration, dosimetry services, and radioactive material analyses.

Qualification by the American Board Health Physicists or National Registry of Radiation Protection Technologists is encouraged. Some RPG personnel have certification by these organizations.

One-time projects, such as facility decommissioning, will be supervised by permanent staff, but may also utilize contract employees. Contract employees must have the same qualifications as permanent employees.

The Radiological Control Manager (RCM) supervises the health physicists leading these programs and may adjust reporting relationships as needed. The RCM reports to the Director of the Environment, Health & Safety Division.

Additionally, there are health physicists, RCTs, and other technical staff who perform duties in the areas of radiological environmental protection and radioactive waste disposal. These operations reside in other EH&S groups, with a matrix tie to the RCM.

21.3.2 SERVICE CONTACTS

EMERGENCIES	7911
Minor spills	5251
Accelerator Health Physics	5597
Administration (all services)	7652
Dosimetry Office/Bioassay	7497
Instrument repair and calibration	7617
Nuclear Material Representative	7141
Radiation Authorization/Work Permits (new uses, changes)	7736
Radiation Monitoring (requests for monitoring, release)	7652
Radiological Control Manager (RCM)	6626
Sealed sources	7141 or 7609
Training	7658
Transportation for radioactive materials	6228
X-Ray Safety Officer (monitoring and authorization)	5256
Regulatory Affairs	6424
RAML	4499

21.4 RADIOLOGICAL WORK AUTHORIZATION AND PERMIT PROGRAMS

The system of controlling work in areas with actual and potential radiological hazards is based on the issuance of a written authorization in the form of a Radiological Work Authorization (RWA) or a Radiological Work Permit (RWP). This program is designed to keep personnel radiation exposures as low as reasonably achievable by providing administrative control of job activities involving radiation and by ensuring that adequate safety precautions are taken in areas with radiological hazards. Based on an analysis of the project's hazards, requirements such as dosimetry, bioassay, engineering controls, user and EH&S surveys, instrumentation, and protective equipment will be specified. Routine assessments will be made by the RPG to determine compliance with the requirements and to assess laboratory radiological conditions. Periodic reports will be sent to the principal investigator (PI) or the work leader (RWP), as appropriate.

ALL USES OF RADIOACTIVE MATERIAL AT LBNL MUST BE IN ACCORDANCE WITH AN APPROVED AUTHORIZATION OR PERMIT.

A permit or authorization may be terminated by division management or by the RCM in response to repeated or serious violations of the requirements.

21.4.1 RADIOLOGICAL WORK AUTHORIZATION

The RWA program authorizes the use of radioactive material. If only sealed sources are to be used, a Sealed Source Authorization (SSA) will be issued. The SSA is handled identically to the RWA process. See Section 21.10.12 for more information regarding sealed sources.

RWAs are issued for activities that are considered long-term projects under routine radiological conditions. The RWAs specify the quantitative limits on amounts of radioisotopes and radiological conditions acceptable at the specified work areas. An approved RWA is valid for a year (2 years for an SSA).

THE RWA WILL SPECIFY THE LIMITATIONS OF ITS USE. MATERIALS EXCEEDING THE RWA LIMITATIONS SHALL NOT BE USED OR ORDERED UNTIL THE RWA IS AMENDED TO INCLUDE THEM.

Prior to the use of radioactive material, the PI shall obtain the approvals of the RCM and the cognizant Division Director.

RWA Application

It is the responsibility of the PI to request an RWA when radioactive material is to be obtained for a project. The request shall be sent to the RPG. The request may be part of a more general application form for hazardous operations. The following shall be included:

- The department.
- The building.
- The rooms. Include a diagram or floor plan of the facilities to be used. The facilities are expected to be adequate for use of the materials proposed. Benches are to be covered with impervious coatings. Likewise, floors are to be properly sealed or covered if unsealed radioactive materials will be handled. Indicate how materials will be secured against unauthorized removal.
- The name and title of the applicant. The applicant shall be the supervisor or the PI.
- The names and titles of all other personnel participating in the project. All personnel named to work with radioactivity or radioactive materials shall have submitted a completed LBNL Radiation Worker Form RL-6583 to EH&S and have been issued proper dosimetry prior to radiation work. Training requirements shall also be met prior to work with radioactive materials or radiation-producing machines. See Section 21.8, *Radiation Safety Training*, later in this chapter.
- The isotopes and amounts to be used.
  - Radioisotopes. Identify each isotope separately.
  - Chemical and physical forms.
  - The maximum quantity to be used per experiment, the frequency of experiments, the maximum quantity to be obtained per order, the maximum to be possessed at any time, and the anticipated total annual use.
- The delivery point (room number) for radioactive shipments.
- Proposed uses. Briefly outline the procedures to be followed regarding the radioactive materials used, and describe the procedure to be followed in sufficient detail to permit a radiation safety evaluation to be made. Include plans for handling and storing radioactive materials, care of radioactive animals, disposal of radioactive wastes, or any other applicable radiation safety issues. Note potential problems such as mixed waste production and the possibility of facility contamination.
- Protective equipment, e.g., fume hoods, glove boxes, safety equipment, shielding, etc.
- Survey instruments that are available for personnel protection.

Review and Processing of RWA Applications

After review and discussions with the PI, RPG will prepare an RWA that will be returned to the PI for acceptance and review by the project staff and Division Director. The PI will then return the RWA to RPG for review and approval by the RCM and the ALARA Committee, as required by EH&S Procedure 707. Once approved, RPG will assign an RWA number, which will be used on all subsequent correspondence, procurement orders, and surveys.

Upon receipt of the approved RWA, it is filed in the Radioisotope Journal.

The RWA approval will generally be valid for one year (two years for an SSA). The expiration date will be noted on the approved RWA document. Near the end of the approval period, RPG staff will contact the PI to update the application and renew the authorization. All projects are reviewed annually by RPG.

Amendments to RWA

To amend an RWA to include changes involving radionuclides, ordering or possession limits, rooms of use, or significantly altered research protocols, etc., submit a memo to RPG. The memo should briefly identify the changes to be addressed. Unchanged items may be referenced from the former application. Amendments shall be signed and approved by RPG before work begins under the new conditions.

Termination or Moving of a Project (RWA)

The PI is to notify RPG at least 30 days before changing laboratory facilities or terminating a project. All radioactive sources are to be properly transferred or disposed of. Line Management is responsible for ensuring that rooms, facilities, and apparatus used by the project are decontaminated so that, when measured by RPG, they meet the standards for Uncontrolled Areas. When surveys have been completed, RPG personnel will remove signs from the rooms and equipment and will terminate the RWA, if appropriate.

Procurement of Radioisotopes

Only radioactive material authorized by an approved RWA or SSA may be procured. See Section 21.10.5, *Procurement of Radioactive Material.*

Records

- **Radioisotope Journal**

Each project group shall maintain a Radioisotope Journal in which pertinent records are filed in a readily retrievable manner. This journal shall be accessible to all persons who work with radiation sources under the project. The journal shall also be available for inspection at any time during normal working hours, and the project staff should know where such records are kept. The journal shall be a consolidated record containing all relevant items and shall be kept in one or more volumes at one location. Journal binders will be furnished by RPG.

The journal shall include, but is not limited to, the following records:

- Authorization
  - A copy of the current RWA
  - A list of persons authorized to use radioactive materials
  - Usage protocols.

- Accountability
  - Daily Usage Logs, showing each receipt, use, disposal, and transfer of radioactive material
  - Quarterly Inventory Summaries
  - Room radiation survey records
- Training
  - Records of on-the-job training, listing specific radioisotope protocols, training dates, and attending personnel
  - Records of EH&S training
- Incident Reports
  - Spills
  - Overexposures
  - Losses of materials
- Miscellaneous
  - Correspondence with RPG
  - Notices and memoranda distributed by RPG
- Radiation Surveys (see Section 21.7)
  - User surveys and RPG surveys

- **Daily Usage Logs**

A Daily Usage Log sheet will be attached to each shipment of radioactivity at the transportation office. Users are required to complete this sheet by making entries each day when the material is used. The sheets are to be maintained in the Radioisotope Lab.

- **Logs of Sealed Source Usage**

Sources shall be kept in a central location and shall be properly inventoried. When sources are removed to other authorized locations, the log shall indicate this along with the date of removal and the name of the authorized user. Sources shall be moved by RPG unless otherwise authorized. Sources being used in experiments shall be secure, properly shielded, and labeled with the radionuclide, activity, and date.

- **RWA Performance Evaluation**

Compliance surveys of authorized projects will take place routinely by RPG at a frequency based on hazard level (weekly or monthly). Findings will be reported to the PI and maintained at RPG and at the authorized location. The current survey reports are to be posted at the use site. Compliance evaluation and follow-up is described in Appendix A.

21.4.2 RADIOLOGICAL WORK PERMIT

RWPs are issued for an nonresearch projects or tasks that, upon review by EH&S, require measures to protect personnel, the public, or the environment from radioactive contamination or radiation exposure. The RWP informs workers of the radiological controls and entry requirements for a specific work activity and is valid only for the duration of the project. The RWP must be completed, approved, and posted prior to performing any work where radiological concerns exist.

RWP Application

A memo or form is to be sent to RPG requesting an RWP. It is the responsibility of the work leader to ensure that an RWP is in place prior to the start of the work. To initiate the process, provide the following information to RPG:

- **The work leader.** This individual is responsible for the work authorized by the RWP and will provide functional oversight. Indicate a contact phone number.
- **Personnel.** These include personnel authorized to perform work on the project. Include employee numbers and radiological training information.
- **A detailed job description.** Include the purpose of the work, special skills or equipment required, and an outline of the tasks to be performed. List all if the locations where the work will take place.
- **Hazards information.** Provide any information available about any and all hazards that may be associated with the project.
- **Waste disposal and material release.** Detail the waste that will be generated and the disposition plans for both waste and project materials. Indicate which materials or equipment will be released after the job is done.

Review and Processing of RWP Applications

Upon receipt of the RWP request, RPG will review the information and list in the RWP the necessary radiation safety measures required for the specific work activity. A final RWP document will be prepared by RPG per EH&S Procedure 705, which will include:

- The RWP number
- The date of the document, the date to start work, and the RWP expiration date
- Locations covered by the RWP
- A project description
- A project contact and telephone extension
- The work leader and telephone extension
- Radiological conditions

- Posting, signage, and barriers
- RPG and EH&S coverage and surveillance
- Time or exposure limits
- Number and frequency of surveys for radioactivity
- Radiation detection instrumentation to be used at the jobsite
- Air sampling
- Criteria for the release of equipment and material from the worksite
- Dosimetry
- Bioassay
- Minimum training
- Emergency procedures
- Personnel authorized to work under the RWP
- ALARA concerns.

The RWP is to be approved and signed by the facility contact, work leader, Radiological Control Manager (or designee), and the EH&S Project Coordinator. Each of the "Authorized Personnel" must read and initial the RWP prior to the start of work. A copy of the completed RWP is to be posted at the access to the applicable work area. Any change in the scope of work or authorized personnel must be immediately reported to the EH&S project coordinator.

Oversight

Throughout the course of the RWP work, RPG staff will document the radiological conditions and the conduct of work in accordance with the terms of the RWP. This information will be recorded on the RWP Inspection Report form, which lists each of the compliance items on the RWP.

Closeout

At the conclusion of the work activity, an RWP Closeout Report will be completed by the EH&S Project Coordinator. A summary of all surveys, air sampling, contamination, incidents, dosimetry results, worksite status, and violations will be included. The Closeout Report will also identify lessons learned, which may be used as a training tool for future projects.

21.5 PERSONNEL RADIATION MONITORING

21.5.1 RADIATION EXPOSURE LIMITS AND CONTROLS

LBNL has established administrative control levels below Federal dose limits. (See Tables 21.1 and 21.2.) Prior to exceeding any control level, written authorization is required from the appropriate level of management, as indicated in Table 21.2.

Table 21.1. Federal Exposure Limits

Type of Exposure	Annual Limit
Radiological worker: whole body (internal + external)	5 rem
Radiological worker: lens of eye	15 rem
Radiological worker: extremity (hands, feet, arms below the elbow, and legs below the knees)	50 rem
Radiological worker: any organ or tissue (other than lens of eye) and skin	50 rem
Declared pregnant worker: embryo or fetus	0.5 rem in 9 months
Minors and students (under age 18): whole body (internal + external)	0.1 rem
Visitors* and public: whole body (internal + external)	0.1 rem

*Applies to visitors who have not completed training.

Table 21.2. LBNL Administrative Control Levels

Maximum Annual Dose Equivalent (mrem)					
Level	Whole Body	Skin and Extremity	Lens of the Eye	Any Organ or Tissue	Approvals Required
1	100*	1,000*	500*	1,000*	Line manager, RCM
2 (Facility control level)	500	10,000	500	5,000	RCM, Deputy Director for Operations
DOE control level	2,000	N/A	N/A	N/A	DOE Program Secretarial Official

*Exceeding these dose equivalents may be authorized as part of the LBNL RWA/RWP program.

Work activities that may result in annual dose equivalents above these levels should be reviewed to ensure that adequate ALARA practices have been implemented.

The initial administrative control level was based on the historically low doses received at LBNL.

The RPG should initiate an investigation of any abnormal or unanticipated personnel exposure exceeding 100 mrem or any uptake resulting in greater than 100 mrem committed effective dose equivalent (CEDE). The investigation should include a description of the circumstances and corrective actions to prevent recurrence.

If the Level 2 (or higher) administrative control level of this plan is exceeded without approval, the involved workers should be restricted from Radiological Areas. The RPG should immediately initiate a review of the incurred exposure. The review should include an investigation of the circumstances and list corrective actions to prevent recurrence. The involved workers should not enter Radiological Areas until the incurred exposure is investigated and further exposure is properly approved.

21.5.2 RADIATION WORKERS

In general, dosimetry will be required for all accelerator and X-ray-generating device users and for users of radioactive material that are likely to receive more than 100 millirems/year whole-body dose. Specified internal and external dosimetry requirements are listed in the controlling work safety document [Activity Hazard Document (AHD), RWP, RWA, or X-Ray Machine Safety Document (XSD)].

An investigation will be performed if there is any unplanned exposure exceeding any of the administrative control levels.

The federal annual occupational dose limits may be exceeded under certain emergency situations, such as in life saving or protection of major property, depending on risk-benefit considerations. The potential for this type of emergency at LBNL is very remote. The LBNL Radiological Control Manual addresses this area in greater detail.

21.5.3 WORKERS UNDER 18 YEARS OLD

No one under 18 years old should be employed in, or be allowed to enter, a Radiation Area or work with radioactive material where they can receive a total of more than 0.1 rem (1 mSv) per year from both internal and external doses. This age limit applies to all workers at the Laboratory, including employees, guests, students, and contractors. All requirements of the external and internal dosimetry programs and the RWA/RWP program also apply.

21.5.4 DECLARED PREGNANT WORKERS

No declared pregnant worker may receive more than 0.5 rem (5 mSv) during the nine-month gestation period. The Laboratory has established a Declared Pregnant Worker Policy, which prescribes responsibilities for the worker and the Laboratory. Contact RPG for details.

21.5.5 NONEMPLOYEES AND VISITORS

The dose equivalent received by members of the public during direct onsite access shall not exceed 0.1 rem (1 mSv) per year based on the sum of both internal and external doses. In all cases, radiation exposures should be maintained as low as reasonably achievable (ALARA).

Contract personnel are the responsibility of their employers and are obligated by contract to comply with all pertinent DOE and LBNL safety and health regulations and requirements, including restrictions on personnel under 18 years of age.

21.5.6 RADIATION DOSE REPORTS

Personnel in the dosimetry program receive a report of their annual dose equivalent as required by the 10 CFR 835.

21.5.7 AREA MONITORING DOSIMETERS

In order to minimize the number of areas requiring the issuance of personnel dosimeters and to demonstrate that the doses outside Controlled Areas for radiation protection are negligible, the RPG is responsible for establishing and maintaining a comprehensive area dosimetry program.

Contact RPG if questions arise regarding placement or results of area dosimeters.

21.5.8 EXTERNAL DOSIMETRY PROGRAM

All radiation workers exposed to external ionizing radiation will be issued a dosimeter as required by the RWA, RWP, XSD, or AHD.

Thermoluminescent dosimeters (TLDs) are considered the primary dosimeters at LBNL. Any other dosimeter is supplemental.

NOTIFY THE RPG IMMEDIATELY IF NONOCCUPATIONAL RADIATION EXPOSURES OCCUR TO A DOSIMETER.

The RPG provides extremity dosimeters for personnel who have the potential to receive an extremity dose significantly higher than the whole-body dose. Personnel will be issued and shall wear extremity dosimeters as required by their RWA or RWP. The dosimeters shall be returned to the RPG Dosimetry Office for evaluation.

Pocket dosimeters (self-reading, gamma indication) shall be worn as specified by the RWA, RWP, or AHD. Self-reading pocket and electronic dosimeters, called supplemental dosimeters, are worn simultaneously with the primary dosimeter.

All radiation workers shall wear their dosimeters as required and are encouraged to wear their dosimeters at all times when at the Laboratory. The preferred location for wearing a dosimeter is the upper torso, where it will give the best estimate of the whole-body dose equivalent. The dosimeter shall not be worn during nonoccupational activities, such as when undergoing medical or dental X-rays, nuclear medical procedures, radiation therapy, or air travel.

Laboratory personnel, both staff and guests, who might receive radiation exposures while working at other facilities will be issued dosimeters by the other facilities. The LBNL dosimeter shall not be used to monitor occupational radiation exposures at other facilities.

EXPOSURES RECEIVED AT OTHER FACILITIES MUST BE REPORTED TO THE RPG.

Compliance with External Dosimetry Requirements

Personnel are responsible for following Laboratory procedures and for returning their dosimeters as prescribed. Supervisors are responsible for enforcing this procedure. Personnel who do not return their dosimeters during the prescribed period will receive a written reminder, as will their division safety coordinator.

Continued failure to return the dosimeters will result in notification of the appropriate division director, and the worker will be removed from any radiation work until an evaluation of the employee's work practices has been completed.

Replacement costs of lost or damaged dosimeters and their holders will be charged to the worker's program account.

21.5.9 INTERNAL DOSIMETRY PROGRAM

The hazard analysis in the RWA/RWP process will determine the risk of internal intake of radioisotopes and whether internal dosimetry is required. The dose limits for internal radiation are based on the standards listed in the "Internal Dosimetry Technical Bases." Laboratory policy requires that all Controlled Areas be kept as free as possible of airborne radioactivity and contamination.

The program to monitor internal radiation dose equivalents to Laboratory employees is administered by the RPG. Line management supervisors are responsible for ensuring compliance with the program requirements.

The internal dosimetry program consists of in-vitro (body fluid) and in-vivo (whole-body counting) analyses. Workers who require internal dose monitoring shall submit samples and have whole-body counts as scheduled.

Compliance with Internal Dosimetry Program Requirements

An employee who does not submit the requested in-vitro samples or complete the in-vivo analysis as required will receive a written reminder, as will the division safety coordinator. Continued noncompliance will result in notification of the appropriate division director, and the worker will be removed from any radiation work until an evaluation of the employee's work practices has been completed.

21.6 ALARA PROGRAM

21.6.1 ALARA PROGRAM OVERVIEW

Title 10 of the Code of Federal Regulations, Section 835.101(c), requires that there be a formal documented program at LBNL that is designed to assure that radiation exposures are maintained as low as is reasonably achievable (ALARA). The primary mechanisms for training personnel, monitoring the workplace, controlling work activities, and maintaining radiation exposures ALARA are implemented through the authorization system, worker awareness, and RPG monitoring (individual and area) and surveillance activities. Oversight of the ALARA Program is provided by the Radiation Safety Committee (RSC) in conjunction with the RCM.

The elements of the ALARA Program include the following:

- Commitment of all levels of management and the work force at LBNL to the ALARA Program,
- Training including ALARA concepts for of all managers and workers involved in radiological operations,
- Appropriate methods of maintaining occupational exposure ALARA integrated into planning, design and procedures,
- Comprehensive audits conducted periodically and reported to the highest management levels, and
- Documentation of ALARA activities maintained to demonstrate compliance.

The following sections describe implementation of the elements.

EH&S policies, programs, and procedures spell out specific management and employee responsibilities. However, the people who have the most important role in reducing exposure, waste, and environmental effluents are the workers that use radioactive materials and radiation-producing devices. For each job involving exposure to radiation or radioactive material, each worker is responsible for understanding the job requirements, the radiological control measures, and ALARA practices. Workers and their managers are responsible for being aware of and understanding the radiation hazards in the workplace.

Techniques for reducing exposures include the use of distance, time, and shielding and the use of proper engineering controls such as glove boxes.

The authorization program provides a mechanism for the RCM to assess work and devise and implement controls designed to limit exposure. The RSC has an oversight role in that they review authorizations, develop ALARA goals, assess progress toward those goals, and conduct independent ALARA reviews when deemed necessary. The RSC also reviews ALARA Design Review and ALARA Work Reviews, which are described in the following paragraphs.

21.6.2 ALARA DESIGN REVIEW PROGRAM

Each new facility or operation utilizing radiation is subjected to reviews prior to any commitment of any radiation work. LBNL follows formal review processes that culminate in reports such as SAD, AHD, RWA, or RWP. Design and control measures are specified in the authorization basis for each facility or work process (SAD, AHD, RWA, RWP)

ALARA design review is incorporated into planning for new facilities to ensure that design features and administrative controls for new facilities are selected and evaluated to meet regulatory requirements and keep radiation exposures to workers, the public, and the environment as low as reasonably achievable. The primary methods used shall be design features such as containment, ventilation, and shielding. Administrative controls must only be used as supplemental methods of decreasing radiation exposures. Where the use of design features are impractical, administrative controls and procedural requirements shall be used to maintain exposures ALARA. When appropriate, ALARA optimization methods for selecting design alternatives will be used (only if collective exposure for a facility is expected to exceed 1 rem per year). The design objectives shall be to maintain accessible exposure rate levels to as far below 0. 5 millirem per hour average and maximum individual occupational exposures to as far below 20 per cent of the applicable limits as reasonably achievable. Control measures must provide additional assurance that maximum exposures will not exceed limits and will be ALARA.

21.6.3 ALARA WORK REVIEWS

ALARA work/experiment reviews assess radiological impacts, determine optimum radiological controls, track the effectiveness of controls, and document lessons learned. ALARA work planning is commensurate with the relative risks associated with the activity. ALARA reviews shall be determined by assessments through the work authorization process.

The review should be conducted for all operations, practices, and procedures that involve the potential for high individual or collective dose equivalent. The ALARA review will be documented via the Authorization Renewal documentation and/or Observation of Experiment Review.

21.6.4 DOSIMETRY REVIEWS

The Radiation Protection Group (RPG) routinely reviews periodic dose reports from the Dosimetry Office. These reports are provided monthly (nominally) and indicate the doses for all individuals that received positive dosimetry readings. This review helps ensure that ALARA measures are being effective and allows any dose that appears not to be ALARA to be raised to the appropriate management personnel. Additionally, the Dosimetry Office notifies the RPG of any individual dosimetry (internal and external) results that exceed predetermined alert level thresholds as soon as the result is deemed reliable. When appropriate, the individual is contacted to verify that the dose received reflects the level of radiological work performed. When necessary, recommendations are made regarding the reasons for exposure and methods of exposure reduction.

21.6.5 ALARA REPORTS

The RPG prepares periodic reports for the RSC summarizing ALARA information and work activities. These reports may include information such as:

- results of dose investigations
- results of ALARA reviews
- cumulative radiation exposure
- reportable radiological occurrences
- information on the number of personnel exceeding predetermined dosimetry alert levels.

Information contained in these reports is provided to the RPG staff, the RCM, the RSC, and other levels of Laboratory management, as needed.

RPG maintains a workplace monitoring program to ensure that contamination, dose equivalents, and the concentrations of airborne radioactivity in areas occupied by people do not exceed specified limits and that ALARA practices are followed. Radiation surveys shall be performed by radiation users and RPG.

21.7 RADIATION SURVEYS

21.7.1 RADIATION SURVEYS BY USERS

Radiation users shall conduct periodic radiation and contamination surveys to ensure that the safety controls are adequate. This involves surveying the work area, all work surfaces, the floors, the equipment, and the personnel. This should be done with portable equipment before, during, and after work that may change the radiological conditions of the work area. In areas where materials could be dispersed, causing contamination, wipe samples shall be taken and analyzed on a suitable instrument. Positive results must be documented and reported to RPG.

Formal, documented surveys shall be performed by radiation users in accordance with provisions of the controlling AHD, SAD, RWP, or RWA. The following information shall be recorded for both wipe and meter surveys: name, date, time, instrument, LBNL serial number, calibration date (due), instrument background or control sample data, and results. Results should be linked to a map or diagram of the area. Survey results shall be kept in the Laboratory Journal or equivalent that is available for inspection by RPG. Maps and survey forms are provided to each project by the RPG.

RPG shall be notified of radiation levels that could cause significant personnel exposure (>100 mrem/hr) or any unusual radiation fields. Corrective actions and rechecks shall be documented. Additionally, notification is required if laboratory spaces cannot be decontaminated immediately or if contamination exceeds the limits in Table 21.4 (see Section 21.10.11).

21.7.2 RPG MONITORING

Routine Surveys

Routine radiological contamination and radiation level surveys will be made by RPG on a schedule that is commensurate with the radiological hazard and the potential for a change of conditions. Radiation users will be notified of survey results and corrective actions, if required.

Decommissioning Surveys

Radiation surveys will be performed to decommission areas that are to be released for unrestricted use, such as nonradioactive work, construction, or maintenance. EH&S shall be notified at least 30 days in advance of project termination so that arrangements may be made for decontamination, decommissioning, or both.

Release Surveys

Equipment or materials to be removed from areas where activation or contamination could occur shall be surveyed and tagged by RPG. In some cases (for induced materials only), qualified radiation users with special training can perform these surveys. In general, the areas requiring release survey of materials are the posted Radiological Material Areas and Accelerator Controlled Areas. An updated list of these areas is published and distributed regularly. Note that Transportation will not move this equipment unless it has been tagged. EH&S Procedure 708 controls this activity. (See Section 21.10.11.)

Special Surveys

RPG will survey areas upon request if contamination or excessive radiation levels are suspected. First-time, high-level operations will be monitored. Call RPG for service.

Workplace Monitoring

Workplace monitoring of radiation exposure is performed by placement of radiation detectors, when appropriate.

Airborne Monitoring

Continuous air sampling will be performed within areas where there is the potential for airborne radioactive contamination, based on an assessment of the operation via the RWA/RWP process. The controlling procedure is EH&S Procedure 713.1.

Environmental Monitoring

Monitoring of ventilation emissions and offsite radiation levels is performed by the Environmental Protection Group. See Chapter 11, Environmental Protection, for more details about that operation.

21.7.3 RADIATION DETECTION INSTRUMENTS

All radiation users are required to have appropriate, calibrated radiation detection equipment. RPG provides guidance in the selection of instruments in addition to distribution, calibration, and maintenance. These instruments are delicate and expensive. Individuals who use them shall be trained in instrument use and shall be familiar with their limitations. It is the responsibility of the user to obtain adequate instrument training, to maintain the equipment in working order, and to obtain calibration when required. A tag on the instrument will indicate when calibration is due. (Calibrations are annual.) The RPG Radiological Control Technician (RCT) will facilitate calibration exchange.

Table 21.3. Types of Instruments

Alpha proportional probe (usually LBNL manufacture)	A survey meter for detection of alpha emitters (^{239}Pu, ^{244}Cm, and ^{237}Np)
Thin-window Geiger probe (e.g., Ludlum model 44-9)	A survey meter for detection of medium- to high-energy beta-gamma emitters (^{35}S, ^{14}C, ^{32}P)
Solid-state scintillation probe (e.g., Ludlum model 44-2, 44-3)	A survey meter for detection of gamma emitters, such as ^{125}I, and accelerator-induced isotopes.
Dose-rate monitor (e.g., RSO-5)	An instrument, such as an ionization chamber meter, that measures photon or neutron dose rates.

All of the following steps shall be followed satisfactorily for the instrument to be used:

- RPG training is required for instrument users.
- Choose the instrument appropriate for the type of monitoring.
- Check the calibration.
- Check the battery.
- Perform a source check if instrument is so equipped. (The result shall be within the acceptable range.)

Take a background reading before performing the survey. For contamination surveys, make sure the probe is moved slowly enough and is close enough to the surface to detect the contamination. Record the results, if required. Specialized instrument training is available from RPG and is part of the radiation worker training course.

21.8 RADIATION SAFETY TRAINING

10 CFR 835 requires all employees to receive radiation safety training prior to occupational exposure in a controlled area at a DOE facility and that such knowledge be verified by examination. Nonradiation workers who are at risk of radiation exposure must take General Employee Radiation Training (GERT). Radiation workers must complete more comprehensive training. If training is required, it must be repeated every two years. If qualified, an individual may satisfy the training requirement by challenge examination.

Note: Under no conditions may an individual receive radiation exposure at LBNL without first having completed training.

21.8.1 GENERAL EMPLOYEE RADIATION SAFETY TRAINING

All new employees and participating guests intending to be working more than one month must complete General Employee Radiation Training within the first month of employment. This is usually included as part of Introduction to Health & Safety at LBNL. Radiation related information is included with EH&S information provided during the first day of employment. New employees complete a Job Hazards Questionnaire, which is reviewed by their supervisor and EH&S. Specific EH&S training is determined based on the answers to the Job Hazards Questionnaire.

21.8.2 RADIATION WORKER TRAINING

An employee shall successfully complete fundamentals training, hazard-specific, and site-specific training to become qualified as a radiological worker. A radiological worker is an individual who has the potential to receive an exposure of over 100 mrem/yr. At LBNL this includes personnel who handle radioactive material, who frequent accelerator controlled areas, or who are assigned personnel dosimetry. Prior to completing training, an individual may work under direct supervision of a qualified radiation worker if they have received GERT.

Different hazard-specific modules are required for laboratory, accelerator, and sealed source workers. Written exams are required for all training courses; practical exams are required for certain types of qualification. Requalification training is required every two years. Initial or requalification training may be completed by passing a challenge examination in lieu of classroom training, if properly qualified due to previous training and experience. Contact RPG Training for information regarding training requirements and test-out procedures. Employees completing radiation safety training at other DOE facilities may have fundamentals training waived if they provide proper documentation and satisfactorily complete LBNL site-specific training. Such documentation shall include the employee's name, the date of training, the specific topics covered, and certification by an appropriate official. Wallet-sized "Certificate of Core Radiological Training" cards are issued for this purpose. Radiation safety training may be scheduled by calling EH&S Training, ext. 7366.

21.8.3 CONTRACTORS

Contractors shall meet the same radiation safety training criteria as employees. It is therefore imperative that coordination with the Radiation Protection Group be made well in advance of target work dates so appropriate escorts or training may be arranged.

Additional Radiation training policies for General Employees, Radiation Worker, and RCTs can be found in EH&S procedure 790. Contact RPG for your specific training requirements.

21.9 CONTROLLED AREAS, POSTING, AND ACCESS

Certain areas at the Laboratory are designated as Controlled Areas in order to alert personnel to potential hazards from radiation or contamination. Controlled Areas are posted as such and may contain more hazardous Radiological Areas within them. In some cases, the Radiological Area and the Controlled Area have the same boundary, and both postings appear together. Within Controlled Areas, Radiological Areas are identified by signs bearing the universal radiation symbol and the words "Radiation Area," "High-Radiation Area," "Very-High-Radiation Area," "Contamination Area," "High-Contamination Area," or "Airborne Radioactivity Area." Another area, called a Radiological Material Area (RMA) or Radiological Storage Area (RSA), which may be inside or contiguous with a Controlled Area, is less hazardous than a Radiological Area, but the name indicates that radioactive materials are used or stored within it. These areas are defined in the glossary.

21.9.1 ACCESS REQUIREMENTS

Before entering any Controlled Area, workers shall find out from the local area supervisors, the main control room at an accelerator, or EH&S the location and nature of potential radiation hazards in order to ensure proper radiation safety. Personnel shall never attempt to enter a Radiological Area without permission and without being fully familiar with the operational safety rules for that particular facility. Radiological worker or GERT training is required before entry to a radiological area. These rules are included in the facility's AHD, which can be obtained from the facility's building manager or from RPG.

21.9.2 ENTRY-CONTROL PROGRAM

An appropriate entry-control program shall be established for any Radiological Area. The level of control shall be consistent with the degree of hazard. Signs and barricades, control devices (e.g., locks) on entrances, conspicuous visual or audible alarms, or administrative procedures shall be used as appropriate to control personnel entry into restricted areas. For High-Radiation Areas, the entry-control program shall include at least one of the following:

- Control devices on each entrance or access point that automatically prevent entry when the radiation level is above 1.0 rem (0.001 Sv) per hour or prevent operation of the radiation source.
- A control device that energizes a conspicuous visible and/or audible alarm that warns anyone entering the area of the radiation level and informs RPG personnel of the entry.
- Locked entry ways, except during periods when access to the area is required, with positive control over entry and with radiation surveys made for the initial entry and periodically as necessary.
- Control devices that automatically generate conspicuous audible and/or visible alarms before operation of the radiation source to permit evacuation of the area or that prevent operation of the source when anyone is in the area.

The AHD, RWA, or RWP will specify which controls are necessary in each case. (See Section 21.11.4, *Accelerator Radiation Protection Interlock Systems.*)

No access is permitted to Very-High-Radiation Areas, which are controlled by interlocks.

21.10 RADIOACTIVE MATERIALS SAFETY

Users wishing to begin using radioactive materials should contact RPG to receive guidance in applying for a Radiological Work Authorization (see Section 21.4, *Radiological Work Authorization and Permit Programs*). Operations involving radioactive materials are restricted to those buildings (or areas within buildings) designated by EH&S for such use. Such operations shall be carried out only by qualified radiological workers and in accordance with the requirements of the RWA or RWP.

All chemical and mechanical operations on radioactive material shall be designed to prevent the spread of radioactive contamination out of the radiological work area and to reduce radiation exposure to levels that are ALARA. Each proposed use of enclosures or fume hoods shall be reviewed in advance by RPG with respect to the amount of radioactive material to be used and the type of operation. Before any change in use of radioisotopes, Radiation Production shall be consulted so that the safety controls and procedures can be re-evaluated and the RWA can be amended and approved.

21.10.1 RADIOLOGICAL ASSISTANCE

Radiological assistance normally is available Monday through Friday, 8 a.m. to 5 p.m. Assistance outside these hours is available but shall be arranged at least one week in advance. This is especially important during the Christmas–New Year shutdown. Call RPG, ext. 7652. Normally, a Radiological Control Technician will be assigned to each area where radioactive materials are used. Generally, radiation safety services and information may be obtained through the RCT.

21.10.2 SAFE WORK PRACTICES

Workers who are assigned a personnel dosimeter shall wear their dosimeters when in the Controlled Areas.

When working with radioactive material, employees shall check for personnel contamination before, during, and after work. See Section 21.7.

Mouth pipetting, eating, drinking, and smoking are prohibited in an RMA.

Do not pour liquid radioactive waste into sanitary drains unless specifically authorized. If this is done by accident, notify RPG immediately.

Air sampling requirements and locations will be specified in the RWA document. Notify RPG if there is any malfunction of air sampling equipment.

When leaving any radioisotope work area, employees shall check for personal contamination by using a hand and foot counter or by thorough monitoring with the appropriate survey meter.

All equipment and materials in a Radiological Material Area shall be monitored and tagged prior to removal.

Enclosures and containers housing radioactive material shall be labeled with a "Radioactive Materials" label showing the date and amount of radioactive material.

Follow contamination control practices when working with dispersible radioactive material:

- Wear appropriate protective clothing.
- Remove gloves when leaving the immediate work area.
- Use absorbent, impervious surfaces.
- Use a tray or other suitable secondary containment when dispensing or storing liquids.
- Use unbreakable secondary containers when transferring material between work locations.

Reduce the radiation dose by using time, distance, shielding, and engineering controls effectively.

When work is finished, dispose of and store materials and equipment properly.

21.10.3 ENGINEERED SAFETY ENCLOSURES

Safety enclosures are required for radiation use, based on the activity and dispersibility of the radioisotopes. These enclosures must meet specific engineering design requirements; notify EH&S whenever a new installation or modification of a safety enclosure is planned. The RWA or RWP hazard assessment will determine whether enclosures are required.

Fume Hoods

Fume hoods are designed to protect the operator by providing directional air flow. Since fume hoods are not typically filtered, they are not adequate for operations that might result in significant releases of radioisotopes to the atmosphere. For such operations, enclosures such as glove boxes shall be used. The Environmental Protection Group determines the allowable release for each RWA or RWP.

A lab coat, disposable gloves, and other appropriate attire shall be worn at all times when working at a hood or wherever a chance of contamination exists.

If radioactive material shall be kept in a hood for short periods, it shall be safely packaged and well shielded, and RPG shall be notified of its location. For storage for more than a month, the material should be given to RPG for safe storage in the pit-room facilities at Building 70. A warning tag or sticker identifying the radioactive isotope, its level of activity, the date, etc., shall be affixed in a prominent location outside the hood. RPG can advise on proper shielding of gamma emitters.

Flammables, explosives, and pyrophoric materials shall never be stored in hoods containing radioactive materials.

Acids, solvents, and heat sources can damage the inside surfaces of hoods, making any needed decontamination difficult. Always use protective coverings, such as sheet plastic, absorbent paper, or heat-resistant materials, as working surfaces.

The sliding front window of a fume hood protects against splashing chemicals and unexpected reactions and controls air velocity at the front of the hood. The recommended minimum air velocity of 100 fpm is achieved by matching the arrow on the side of the vertical sash with the arrow on the frame.

Periodically, hood ventilating systems shall be shut down for maintenance or repair. Before any hood ventilating system is shut down, the occupants of the room must be notified. The hood sash shall be in its most closed position during shutdown, and a sign stating "CAUTION: HOOD OUT OF SERVICE. DO NOT USE" shall be placed on the front of the hood. This sign shall remain in place until service is restored, at which time the occupants of the room shall be notified.

Construction & Maintenance requires that the PI or supervisor render the hood as free as possible of radioactive and chemical contamination before hood repairs or modifications are begun. Duct work shall be checked by RPG personnel prior to any maintenance.

NEW HOOD INSTALLATIONS SHALL MEET CURRENT STANDARDS FOR DESIGN. CONTACT INDUSTRIAL HYGIENE REGARDING REQUIREMENTS.

Glove Boxes

The basic glove box consists of an enclosure maintained by a manifold system at a negative pressure with respect to the room. Four types of glove boxes are used at the Laboratory:

- Basic boxes, referred to as "Berkeley boxes"
- Lead-shielded boxes, called "junior caves"
- Inert-atmosphere boxes
- Vacuum-line boxes, called "piano boxes."

The radioisotope contents and the approximate level of radioactivity inside the glove box shall be posted in a prominent location on the front of the box.

Glove boxes shall always be adequately ventilated; the ball indicator in the flow meter, mounted on the nonradioactive side of the high-efficiency filter on every box, shall stay above the black line inscribed on the face of the flow meter. Exhaust-manifold control-box alarms occasionally go off because of power interruptions or malfunctions. Should this occur, immediately notify RPG. Never turn the control box off, and never disconnect a glove box from an exhaust manifold.

Box gloves and glove "O" rings shall be checked visually and by instrument survey for holes and deterioration before each use of the box. If gloves or "O" rings need replacing, call RPG. Surgical gloves shall be worn while using box gloves. Sharp objects inside the glove box shall be placed in protective containers to prevent accidental puncture of gloves.

Box "pass-outs" and "pass-ins" shall be done only by properly trained personnel or with the assistance of RPG.

The amounts of flammable liquids or gases used in ordinary glove boxes shall be small enough to prevent the buildup of explosive concentrations. Special fire extinguishers for use on glove box fires are available from EH&S and shall be located near any glove box containing flammable material.

Never use a shielded glove box ("junior cave") until the radiation level inside the cave has been checked with the appropriate survey meter.

Check gloved hands for contamination when removing them from the box. Check hands and feet for contamination after working in a glove box and when leaving the work area.

Glove boxes are designed to resist earthquake damage and shall be secured to prevent tipping.

21.10.4 RADIOACTIVE WASTE

More detailed information regarding radioactive waste is given in Chapter 20, Hazardous Waste Disposal. Researchers and line management are responsible for compliance with waste requirements. All waste generators must complete Waste Generator Training. Radioactive waste is to be collected in approved containers with properly filled-out inventory tags. Waste must be segregated by physical and chemical form according to EH&S instructions. Sharps must be placed in protective containers, and biohazardous waste must be deactivated. Animal and tissue waste must be kept frozen until pickup.

Generation and accumulation of radioactive waste, especially mixed waste (radioactive plus hazardous) must be minimized. Do not overfill waste containers, as this can cause area contamination.

It is especially important that radioactive waste be properly characterized. A waste log should be maintained so that the tag can be filled out accurately. Researchers and line management are responsible for compliance with waste requirements. Waste cannot be picked up unless appropriate conditions are met.

21.10.5 PROCUREMENT OF RADIOACTIVE MATERIAL

Purchase of radioactive materials is done via blanket order or purchase order.

The following steps should be taken when ordering radioactive materials:

- Always check your Work Authorization (RWA or SSA) to ensure that you are authorized to receive the material (isotope, activity, and chemical form). Contract EH&S if you need to revise your RWA or SSA.
- Always tell the vendor (Amersham, ICN, IPL, etc.) to put your RWA or SSA authorization number on the Packing List which comes with each shipment. This information may be included as part of the "Attention" or Berkeley Lab address.

- When ordering material on a Berkeley Lab requisition/purchase order, be sure that the procurement paperwork has three things: "radioactive" box checked; the statement "Distribution A" included in large letters; and your RWA or other EH&S authorization.
- When receiving small amounts (limited quantities) of radioactive materials, especially from other researchers/facilities, include "ATTENTION: RADIATION PROTECTION GROUP, B75-113," in addition to the information listed above.

All vendor receipts must be accompanied by a packing list (copy), which will indicate the EH&S has surveyed the package for contamination. Receipts of unsealed materials will also be accompanied by a Daily Use Log and will require an authorized user to sign for receipt. If any package containing radioactive materials is delivered by an other means, contact your RCT or Health Physicist immediately.

For sealed-source purchases, see Section 21.10.12, *Radioactive Sealed Source Procedures.*

21.10.6 TRANSPORTATION AND SHIPMENT OF RADIOACTIVE MATERIAL

REMOVAL OF ANY RADIOACTIVE MATERIAL FROM THE LABORATORY PREMISES WITHOUT WRITTEN PERMISSION IS PROHIBITED. THE DIRECTOR'S OFFICE HAS GIVEN THE ENVIRONMENT, HEALTH & SAFETY DIVISION (AND THE PROPERTY MANAGEMENT DEPARTMENT, AS INDICATED) THE AUTHORITY TO GRANT SUCH PERMISSION.

All incoming and outgoing shipments of radioisotopes shall be made by RPG Transportation unless special authorization is obtained.

ONLY GOVERNMENT VEHICLES MAY BE USED FOR TRANSPORTATION OF RADIOACTIVE MATERIALS, INCLUDING SEALED SOURCES.

Generally, there are six types of transfers, each of which require different procedures for approval. They involve transfers to:

- Other DOE prime contractors
- DOE general-type contractors
- Foreign countries

- Universities or other educational institutions
- Commercial firms
- Governmental agencies.

A person wishing to ship or transfer radioactive materials from the Laboratory shall fill out a Hazardous Material Request for Shipment, available from the EH&S Transportation Office. At least 5 days' notice is required. After receiving approval for the shipment, the material shall be given to the EH&S Transportation Office, ext. 6228, for proper packaging, record keeping, and shipment.

Transfer of radioactive materials outside of immediate LBNL control involves potential financial liability and personal hazard problems, in addition to possession of the required license. Moreover, these materials are the property of the U.S. government and must be accounted for in accordance with established procedures.

Inter-building transportation within LBNL of radioactive material or equipment is made by RPG Transportation, except for low-level, well-contained items. See EH&S Procedure 750, Revision 1, for requirements regarding onsite transportation of radioactive materials.

21.10.7 STORAGE OF RADIOACTIVE MATERIAL

Radioactive materials that are not being used (exclusive of material that has become radioactive by bombardment with neutrons or charged particles, called "induced radioactive material," covered separately below) shall be stored securely in an area designated Radioactive Storage Area or Radiological Material Area. Examples include:

- The pit-room (70-147A) storage facility operated by RPG.
- A building or room locked during off hours that is an RMA or RSA.
- Lockable, fire-retardant Berkeley boxes or air-filtered cabinets designed to be earthquake resistant.

Radioactive research equipment that is too large to be stored at the Laboratory can be stored at Warehouse 903 (in Berkeley), provided that:

- The equipment is properly labeled and stored in a designated area.
- The level of radiation at the surface of the package does not exceed 0.5 mrem/hr.
- There is no removable contamination.
- The package has been monitored and tagged by RPG.

Unsuitable storage areas include bench tops, desk drawers, fume hoods, and wooden cabinets or lockers.

21.10.8 HANDLING OF INDUCED RADIOACTIVE MATERIALS

Induced radioactive material is material that has been made radioactive by bombardment with primary or secondary particles from accelerators or other sources.

Guidelines regarding induced radioactive material are as follows:

- Do not allow induced radioactive material that you are not using to accumulate. Contact RPG for proper disposal.
- When an item is removed from a Radiological Material Area (such as an accelerator cave), it is surveyed by trained and authorized personnel. If it is determined to be radioactive (see Section 21.10.11, *Release of Material from Controlled Areas*), it shall be labeled or tagged as such or placed in a delineated, labeled "RSA" within the Controlled Area.
- Items with removable contamination shall be marked as such and wrapped.
- Items with radiation levels above 0.5 mrem/hr at the surface shall be marked with a radiation label.
- Induced material shall not be moved out of the Controlled Area at LBNL accelerator facilities without a proper release tag.
- Any work to be performed on induced material shall be covered by an RWP or RWA. Notify Radiation Protection well in advance of such work to prevent delays while a hazards analysis is conducted and a permit or authorization issued.

21.10.9 NUCLEAR MATERIALS

Nuclear materials are accountable materials. They are ^{6}Li, ^{237}Np, ^{228}Th, ^{232}Th, ^{241}Am, ^{243}Am, ^{247}Bk, ^{248}Cf, deuterium, tritium, and all isotopes of curium, plutonium, and uranium.

These materials shall be stored in a locked location when not being used. They shall be auditable at any time. No nuclear material may be transferred from one user to another without approval by the RPG Nuclear Material Representative.

21.10.10 DECONTAMINATION OF RADIOACTIVE EQUIPMENT

Articles that are of sufficient value to make recycling economical can be given to EH&S for decontamination. The RPG will determine whether decontamination is feasible. Proper packaging and identification of these items shall be done by a RPG representative. Glove boxes, hoods, and other enclosed work areas may be decontaminated in place by RPG personnel. Contaminated clothing and other personal items shall be decontaminated by RPG before they can be removed from the Laboratory. In general, RPG should be contacted before cleaning any equipment that is contaminated greater than the Table 21.4 levels (see Section 21.10.11).

Decontaminated equipment will be released to the user when no radioactive residue can escape into the air or be transferred by contact and when there is no hazard from external radiation levels.

21.10.11 RELEASE OF MATERIALS FROM CONTROLLED AREAS

Potentially contaminated material to be released from certain Controlled Areas shall be surveyed by trained and authorized personnel to assure the absence of contamination. Areas requiring a release survey include any area where material may have become activated by an accelerator or contaminated by radioactive material. The list of areas requiring surveys is routinely updated, and it includes all areas with unsealed radioactive material and all accelerator beam access areas.

Contact RPG for release surveys or questions regarding applicability. Transportation will not pick up material from these areas unless it has been monitored and tagged.

Release Surveys

These surveys are generally performed by RPG. In some cases (for induced material), the monitoring may be conducted by other specially trained individuals. Release monitoring procedures are specified in EH&S Procedure 708. Contamination levels shall be surveyed by direct monitoring and swipe testing and shall be below the limits in Table 2-3 of the LBNL Radiological Control Manual. Some selected limits from the table are given in Table 21.4.

Table 21.4. Selected Contamination Limits

Nuclide	Removable Dpm/100 cm^2	Total (Fixed+Removable)
U-natural, U-235, U-238	1,000	5,000
Transuranics (alpha)	20	500
Th-natural, Th-232, SR-90, Ra-223, Ra-224, I-125, I-126, I-131, I-133	200	1,000
Beta-gamma (some exceptions)	1,000	5,000
Tritium	10,000	10,000

Material that has induced activity shall be surveyed externally. Samples are removed for analysis on a case-by-case basis, as specified by RPG.

Release to Controlled Areas

Material and equipment determined to have volume activity or surface activity exceeding release limits may be released to other Controlled Areas. The material must be properly labeled, and appropriate procedures and authorizations must be in place at the new location. Equipment with removable contamination above release limits can only be transferred to an authorized Contamination Area. All contaminated equipment and materials must be monitored and transferred by EH&S, unless specific authorization is given by the Radiological Control Manager.

21.10.12 RADIOACTIVE SEALED SOURCE PROCEDURES

A sealed source is radioactive material encapsulated or plated in such a way that it will not be released under normal conditions. RPG is responsible for approving all procurement and use of radioactive sealed sources. EH&S Procedure 711 specifies the appropriate procedures.

Administrative controls for sealed source use have been implemented using the RWA concept. If no unsealed materials are authorized, a Sealed Source Authorization (SSA) is used. If both sealed and unsealed materials are authorized, an RWA is used.

Source Custodian, Authorization

Each sealed source shall be assigned to a source custodian who will be responsible for it. Source custodians will be LBNL employees unless otherwise authorized in writing by the Radiological Control Manager. There will be an SSA or RWA issued to the source custodian that lists all sources in the custodian's possession, their use and storage locations, and all precautions and conditions of use. (See Section 21.4, *Radiological Work Authorization and Permit Programs*, for more information about the RWA process.)

Requests for new sources shall be initiated through RPG. If possible, an existing LBNL source should be used. If a new one is to be purchased, RPG shall approve the purchase order. A new or amended RWA or SSA shall be issued.

Transfer of Sources

Any radioactive source coming on site shall be delivered to the EH&S Transportation Office, as with other radioactive material. When the source arrives, RPG will test it for integrity, assign an inventory number (sealed-source identification number), and enter it into the radioactive material database. The source custodian will sign the RWA or SSA, accepting responsibility for the source.

If a source is to be moved to a use or storage location not on the RWA or SSA, Radiation Protection shall be notified to amend the authorization and assist in the transfer.

ALL OFFSITE TRANSFERS SHALL BE THROUGH RPG. A LEAK TEST IS REQUIRED PRIOR TO TRANSFER.

Source Possession Procedures

Sources shall be kept in properly labeled, secured, shielded areas. Conditions of use and storage are specified in the RWA or SSA and in EH&S Procedure 711. It is the responsibility of the source custodian to make the source available to RPG for semiannual leakage testing. Any source found to be leaking over limits shall be repaired or disposed of through RPG. Wear gloves and use caution when handling fragile sources. Notify RPG if there is any suspicion of source damage.

ANY SOURCE NOT IN CURRENT USE SHALL BE RETURNED TO RPG FOR STORAGE.

Source custodians are responsible for maintaining the integrity of sealed sources. When a new source is purchased, information from the manufacturers regarding handling, useful lifetime, etc., shall be given to RPG. The source custodian shall ensure that fragile sources are checked for leakage after each use or transfer and notify RPG of any contamination detected. A sealed source log that lists the location and current user of each source shall be maintained by the custodian. An entry shall be made whenever the source is removed from storage.

Training

All users of sources shall have training commensurate with radiation hazards. EH&S Radiation Worker training is generally required. (See Section 21.8, *Radiation Safety Training*.) Sealed source custodians are responsible to ensure on-the-job training regarding the unique hazards of sealed sources is performed and documented.

21.11 ACCELERATOR RADIOLOGICAL SAFETY

21.11.1 GENERAL

Every accelerator shall have a current Activity Hazard Document and/or Safety Analysis Document (SAD) before startup of operations. This AHD specifies details of the accelerator radiological control program and safety programs and defines the safety envelope. Help in preparing the AHD or SAD is available from EH&S. Procedures specified in the AHD shall be followed. Additional safety analysis is required by the primary DOE order for accelerators, DOE Order 5480.25.

The EH&S accelerator radiological control program consists of the following functions:

- Consulting with operations personnel, experimenters, and monitoring personnel
- Designing and reviewing shielding and other safety systems and reviewing AHDs
- Training operations and monitoring personnel
- Monitoring area radiation
- Dosimetry
- Reviewing and assessing radiological safety concerns of research projects.

Experimenters and operations personnel shall consult with an accelerator health physicist before planning new facilities or operations. Failure to consult Health Physics in the planning stage may result in costly delays. Operations shall be designed and conducted in such a way that personnel cannot be overexposed during "worst case" conditions and normal operational exposures are below administrative levels.

Before any operation is begun at any LBNL accelerator or ion source, a radiation survey shall be carried out by Health Physics. Surveys shall be carried out whenever radiological conditions might change and at least once per month during routine operations.

Interlocks and warning devices shall be checked and systems serviced (and the task documented) by the operating groups at intervals not to exceed six months. See the following section for guidance regarding interlocks.

All accelerator workers shall be assigned appropriate dosimeters and have radiological worker training. (See Section 21.5, *Personnel Radiation Monitoring*, and Section 21.8, *Radiation Safety Training*.)

21.11.2 INDUCED ACTIVITY

Accelerator beams can produce induced radioactivity in components and equipment that are in close proximity to the beam. Materials removed from these areas shall be characterized as to activity and radiation levels.

Items may not be removed from the accelerator Controlled Areas for unrestricted release until a release radiation survey and tagging have been performed per EH&S Procedure 708. Only Health Physics and specially trained and designated personnel may perform such surveys.

21.11.3 OCCUPANCY OF BEAM ENCLOSURES

LBNL policy requires radiation safety interlock systems at particle accelerators to protect personnel from accidental exposure to hazardous levels of radiation. Interlocks shall be addressed in the AHD.

Occupancy of a beam enclosure while the beam is directed to that area is not normally allowed unless specifically permitted in the basic facility AHD. Entrances to such enclosures shall be interlocked to the beam permissive-logic control system for safety. Overriding these safety mechanisms for purposes of convenience or expedience is not permitted.

Experiments shall be designed so that electronic or mechanical means are incorporated to monitor and to adjust the apparatus remotely if necessary.

If occupancy is required, a variance to this policy shall be requested from the facility manager. Such variances shall be requested far enough in advance to allow sufficient time for review—as much as several weeks. The request shall be written by the experimenter as a Special AHD, which shall include the following:

- Explain the need for such a variance. Mere convenience or expedience is not sufficient.
- Show why other methods cannot be used to avoid the need for a person to be in the enclosure with the beam on.
- Include alternate means to ensure equivalent degrees of safety and adequate provisions for monitoring radiation levels and personnel exposures.
- Include provisions to ensure that the beam will not deviate so as to increase radiation levels in the enclosure. A study shall be made of possible fault conditions that might lead to higher-than-anticipated radiation fields in the enclosure or in other occupied areas.
- Include full details of work to be done and precautionary measures to be taken during this mode of operation.
- Establish a short-term expiration date beyond which it will no longer be valid.

The Special AHD shall be approved by the people who approved the original AHD and the EH&S accelerator health physicist. The accelerator operators shall be informed of the provisions of the Special AHD and understand their authority and responsibility during the variant operation.

Any work in a Radiation Area or handling of radioactive material, whether the beam is operating or not, will require a Radiation Work Permit or a Radiation Work Authorization. See Section 21.4, *Radiation Work Authorization and Permit Program*, for more details about this program. RPG shall be contacted well in advance of new operations to prevent delays while hazards are assessed and the appropriate document issued.

21.11.4 ACCELERATOR RADIATION PROTECTION INTERLOCK SYSTEMS

General

Interlock systems protect personnel from accidental exposure to potentially high levels of radiation by excluding personnel from High-Radiation or Very-High-Radiation Areas. This section covers basic considerations governing the proper selection, design, and operation of a radiation warning and access control system that are essential to the safe operation of a particle accelerator.

This section, in conjunction with the pertinent sections of the LBNL Work Smart Standards, the current edition of the National Electrical Code (NEC), and other pertinent sections of PUB-3000, will apply to all particle accelerators owned or operated by LBNL that are capable of causing personnel to exceed federal dose limits. In case of conflict, the more stringent rule will apply unless this section explicitly states otherwise.

The intent is to give the general methods of system design that achieve the desired protection, not to give specific safety system requirements.

This section does not address protection from induced radiation or airborne radiation or the handling of radioactive material. Only prompt radiation, both primary and secondary, is covered.

Philosophy of Interlocking

Interlocking systems shall be individually designed to meet the requirements of individual accelerators and experimental areas. The common purpose of all interlocking systems is to provide adequate, effective, and reliable protection to personnel against inadvertent exposure to excessive radiation. This means that the interlocking system shall have the following qualities:

- The system shall be fail-safe.
- The system shall be redundant.
- The system shall be testable.

Principles of Interlocking Networks

• Fail-Safe Network

A fail-safe network is one in which the most likely failure modes (see *Points of Consideration* below) leave the protection system in a safe state. For example, should a single protection device fail (owing to electrical power failure, material fatigue, electrical overload, etc.), the network shall provide personnel protection in this failed condition.

• Redundant Systems

A redundant system is one in which no single failure will render the system unsafe. A redundant system shall have two or more completely separate networks doing the same task of interlocking the system. Redundancy can be achieved by using parallelism, overlapping, or a combination of both. Redundancy improves the system's overall reliability.

- **Parallelism**

Components, portions of the network, or the entire network can be parallel. Both paths in parallel systems have identical functions and are interchangeable. They sense the same parameters, act on information in the same way, and produce outputs that independently achieve the same result. The status of each path shall be displayed separately for the paths to be considered parallel.

- **Overlapping**

Overlapping systems, like parallel systems, shall produce at least two independent outputs that achieve the same results; however, overlapping systems have differing components, portions of networks, or entire systems. Overlapping systems sense different inputs, do logical functions differently, or take action in a different manner. Individual systems may overlap only partially, so that some modes are covered by some systems but not others. As long as each possible condition is covered by two or more systems, everything is overlapped. Overlapping tends to reduce vulnerability to systematic design flaws and failures.

- **Testable Systems**

Periodic system testing and verification are important factors for safe operation. A test shall verify that all protective elements in the system function properly. The test shall also verify that the system works as expected and prove that improperly executed operations do not lead to an unsafe condition. System design shall be such that unintentional acts by personnel do not defeat the interlock system. The system should also resist unauthorized attempts to defeat it, but not to the point that its complexity makes testing or repair difficult.

When system testing is complete, a functional test shall be performed and verified to ensure that any action that was done to enable testing has been rescinded. Additional functional tests shall be conducted at least once every six months.

- **Visibility**

The status of every input and output of the interlocking network should be displayed continuously. This facilitates the procedure of testing the system and spotting failures as they occur. It also helps the users keep track of the radiation safety situation.

- **Self Checking**

An advanced interlocking system may contain additional self-checking circuitry that detects disagreement between redundant systems. Each test exercise shall result in the system's being in a safe state.

Designing an Effective Interlock System

By definition, an interlock system ensures mutual exclusion of personnel and radiation in High-Radiation and Very-High-Radiation Areas. Requirements for an accelerator interlock system are based on a case-by-case evaluation of the radiation hazards. With this evaluation done, configuration and design of the interlock system can begin. The effectiveness of interlocking is largely dependent upon the choice of controlling and sensing devices.

The process of designing an effective interlock system consists of the following steps:

- Identify all the primary radiation- and access-controlling devices (beam plugs, power supplies, doors, etc.) and their status indicators. The status of each controlling device shall be derived by sensing the state of the device itself, not from the command to the device.
- Identify all sensing devices that sense radiation or the possible presence of personnel (beam monitors, door switches, pressure pads, motion detectors, etc.).
- Identify measurable secondary phenomena that, owing to some physical law, always occur with a given primary phenomenon for possible use by backup systems (neutron monitors, etc.).
- Using the information gathered in the preceding steps, select the primary and possible backup controls and sensors.
- Having identified the radiation- and access-controlling devices and the sensing devices, determine the design of the logic to effectively carry out the required operation. Remember to use each component in a fail-safe manner.

Design Requirements

Interlocks are normally composed of electrical or mechanical devices that operate automatically when personnel inadvertently attempt actions that would bring them in contact with hazardous levels of radiation. An interlock shall consist of inputs from controlling or measuring devices, a logic network, and outputs to radiation-limiting and access-controlling devices. In addition, the design shall embody a clear understanding of what to interlock (and what inputs to use) to achieve the required protection without hampering or defeating normal operations.

- **General Design Requirements**
  - Allow for ease of planning and performing experiments and support work, giving full consideration to prevention of accidents.
  - Prevent accidental exposure to hazardous levels of radiation in Controlled and Uncontrolled Areas.
  - Maintain continual surveillance and evaluation of potentially hazardous conditions in Controlled and Uncontrolled Areas, and provide methods of warning personnel of the potential hazard in these areas.

- Ensure that interlock circuits are fail-safe and that redundant systems are incorporated.
- Reduce reliance on procedures for personnel protection, and help enforce the timely and correct implementation of procedures.
- Ensure that interlocks are not used as the normal on-off control function.
- Ensure that warning devices are activated only when a hazard exists.
- Incorporate audible alarms that have a sweeping tone rather than a fixed frequency or a bell.
- Require the use of highly reliable components.
- Provide separate protected rights of way and enclosures for all personnel radiation protection interlock systems, to achieve a greater level of system integrity.
- Ensure that redundant interlocks activate separate safety devices.
- Incorporate reliability, operability, and maintainability.
- Interlocks and access controls shall not prevent personnel from exiting Controlled Areas.

- **Specific Design Requirements**
  - In all High-Radiation and Very-High-Radiation Areas, situate emergency cutoff devices within easy reach, and make sure they are clearly identified. Such devices shall have positive identification as to their operation and shall require an overt act to reset.
  - Audio and visual warning signals shall activate at least one minute before accelerators are turned on.

For more details, see *Points of Consideration* below.

Interlock Bypassing Requirements

Any temporary modification (such as a temporary defeat for testing) made to a radiation interlock system shall be carefully documented and approved by authorized personnel as specified in authorizing documents (AHD, XSD etc.). The temporary modification shall be removed and the interlock operation verified when the need for it no longer exists.

- Any particle accelerator interlock bypass shall be approved by the second level of supervision above the person requesting or installing the bypass.
- Only properly trained personnel shall be allowed to install and remove an interlock bypass.
- Interlock bypasses shall be documented on the appropriate schematics or checklist and shall be logged.
- A notice of an installed bypass shall be displayed in the central control room.
- A notice of an installed bypass shall also be so displayed that anyone who enters an area affected by the bypass and who relies on the bypassed interlock will be properly informed that a safety device has been disabled.

- All interlock bypasses shall be removed when no longer needed and, in general, should not be installed for more than two weeks. If more time is required, a permanent solution shall be implemented.
- When an interlock bypass is removed, the restored state of the system shall be documented on the schematics or checklist and shall be logged.
- Verification that the interlock bypass has been removed and that the interlock system has been restored to its original functional state will be performed by a second qualified individual. After this verification has been completed, the notices of an installed bypass will be removed, and a logbook entry documenting the removal will be made.

Computers and Logic Controllers

Many devices fall into this category (e.g., computers, programmable controllers, and fixed logic assemblies). While their use is not recommended in conjunction with safety interlocks, computers and logic controllers are used to monitor, time, evaluate, enable, disable, and control accelerators. These are complex interlock systems, requiring special design evaluation. Additionally, when computer and logic controllers are used in safety interlock systems for other than secondary monitoring and control, the system design will be subject to an additional peer review. This ad hoc peer review committee will be appointed by the appropriate Division Director and shall include the RCM and one or more individuals recommended by the Electrical Safety Subcommittee of the Safety Review Committee.

- Computers and logic controllers used in personnel radiation protection interlock systems shall be dedicated to this task. They shall not be used in multifunction service.
- Two identical systems that use the same software or hardware are vulnerable to common logical errors and do not qualify as a redundant system.
- All systems shall employ software and/or hardware, such as watchdog timers and sequences, that will ensure that the system is working and functioning in a normal manner, so far as can be determined.
- A computer or logic controller may enable the accelerator, but it shall not be able to turn on the accelerator without a specific act by the operator.
- A safety review group composed of qualified personnel shall review and approve all installations and alterations.
- Software and hardware protective mechanisms should be implemented to inhibit accidental or unauthorized alteration of the software.
- Access to system components shall be restricted to personnel authorized to use and maintain the system. Every effort shall be made to prevent deliberate or inadvertent alterations of the logic systems. Protective logic mechanisms shall remain functional after power interruptions.
- Special attention shall be paid to the environment in which the system resides. These environment than other devices.

Operations and Administration

Accelerators that require a radiation interlock system shall have an AHD Manual that defines the procedures to be used by operating personnel with respect to the accelerator interlock systems.

- Maintenance, functional testing, and complete testing schedules shall be incorporated in the AHD and shall be in accordance with the appropriate DOE orders.
- The AHD shall also include search and clear procedures.
- All searches shall be conducted by properly trained personnel.
- For limiting access to specific areas of an accelerator, barricades and ropes shall be used only temporarily.

Points of Consideration

- The most likely failure modes for relays and switches are failure of the contacts and failure of the device to activate.
- The most likely failure mode for solid-state devices is for the device to have a short circuit.
- The most likely failure mode for cables is for the cable to be severed or unplugged.
- For areas that temporarily change from Uncontrolled Areas to Controlled Areas, provide a two-stage automatic warning system to reduce the need for human interaction.
- When using TTL digital logic or relays in safety chains, the general rule is to use either negative logic or normally open contacts for circuits that enable.
- When using TTL digital logic or relays in safety chains, the general rule is to use either positive logic or normally closed contacts for circuits that disable.
- For situations in which several AHD procedures need to be implemented, provide hardware interlocks that require the procedures to be implemented in proper sequences and within a reasonable time.
- Avoid the use of solid-state devices in safety chains. Give special attention to failure analysis and to the more complex circuits employed.
- Consider the environment in which parts and equipment are to function.

21.12 X-RAY-MACHINE SAFETY

21.12.1 GENERAL

The major portion of this section gives general requirements for all X-ray equipment at LBNL. Specific requirements are given for X-ray machines, which are classified as analytical (open and enclosed beam), portable, therapeutic, diagnostic, or photoemissive. Safety requirements for these X-ray machines are based on ANSI Standard N43.2 and the appropriate sections of the National Council for Radiation Protection (NCRP) Reports numbers 102 and 49.

This policy establishes responsibilities, specific authorization of users, and requirements for X-ray machine operation and maintenance. Logbooks shall be used to keep records of operation and maintenance. Interlocks, where required, shall be redundant and fail-safe. An X-Ray Machine Safety Document shall be written by the X-ray System Supervisor for each X-ray machine and approved by the Radiation Protection Group. The Radiation Protection Group can supply guidance and examples for writing this document.

Variances from the general safety policies for specific operational cases are reviewed by the X-Ray Safety Officer and, in the case of routine use, approved only by the LBNL Radiation Safety Committee. This requires the operator to evaluate and explain the need for a variance and offer alternate provisions to achieve the equivalent degree of safety assurance.

The X-Ray Safety Officer periodically reviews these policies, revises them as necessary, and continually reviews the quality of the X-ray safety program.

21.12.2 RESPONSIBILITY

The X-ray System Supervisor has the prime responsibility for auditing to ensure compliance with policies.

The responsibilities of the individual worker are the following:

- Each worker shall immediately report to the Radiation Protection Group any suspected exposure to an X-ray beam.
- Each worker shall, upon the instruction of a qualified expert or responsible supervisor, follow the recommendations and instructions drawn up in the interest of radiation protection.
- Each worker shall use the protective devices provided.
- Each worker shall bring to the attention of those in charge any defect or deficiency in radiation protection devices and procedures.

The X-Ray Safety Officer is responsible for managing the X-ray safety program. The X-Ray Safety Officer advises on, and monitors compliance with, LBNL regulations.

21.12.3 X-RAY MACHINE SAFETY DOCUMENT

All X-ray machines shall have the most recent XSD readily accessible to certified X-ray users. This XSD shall contain at least the following:

- The name of the person responsible for the unit (system supervisor)
- A list of authorized users
- A list of authorized instructors
- A list of authorized maintenance personnel

- An emergency or problem call list
- Equipment descriptions and parameters
- Descriptions of safety features
- Specific operating procedures
- Specific alignment procedures, as applicable
- Copies of appropriate standards and policies, as provided by RPG.

These XSDs shall be prepared by the X-ray system supervisor with consultation from the Radiation Protection Group. The X-ray system supervisor shall review the XSD as frequently as changes in the program necessitate, but at least every 5 years. During this review, the X-ray system supervisor shall review the XSD and submit to the X-Ray Safety Officer any changes to be made or else indicate that there have been no changes.

The XSD shall also be reviewed when any item listed above changes, except for the list of authorized users, instructors, or maintenance personnel.

21.12.4 SYSTEM SAFETY ANALYSIS

All X-ray machines shall undergo a System Safety Analysis as follows:

- For new units, before operation
- For working units, at intervals no longer than 5 years or upon modification
- For out-of-service units, before being brought back into service.

A System Safety Analysis shall be performed by qualified personnel designated by LBNL Management and shall consist of at least the following:

- Identification of modifications to the safety systems made since the last analysis, if any, and approval of the changes
- Verification, update, or production of schematic diagrams of the safety systems
- Assessment of potential equipment failure modes and their possible consequences, with emphasis on the failure modes of interlocks and other safety devices
- Review/preparation of the detailed protocol for routine maintenance testing of safety devices
- Preparation of a written report of the findings of the analysis together with recommendations for action, if any. Copies shall be given to the X-Ray Safety Officer, who will distribute them to the X-ray system supervisor.

21.12.5 INTERLOCKS AND INDICATORS

All X-ray machines shall have interlocks and indicators as specified in applicable standards (NCRP 102 and ANSI N43.2), unless exempted for its specific machine classification in this manual or by variance.

Specific requirements are as follows:

- Redundant interlock chains or mechanical shutters, either of which should prevent the emission of X-rays from the X-ray tube. It is recommended that a signal from a fail-safe area radiation monitor be part of one of these interlock chains.
- A bistable indicator that gives a positive indication that high voltage is applied to the X-ray tube. This indication shall be incorporated into an interlock chain in a fail-safe manner, or another bistable indicator that gives a positive indication that high voltage is not applied to the X-ray tube shall be used.
- A key-controlled switch that controls the main power to the X-ray generator. Furthermore, actuation of this switch shall not by itself cause high voltage to be applied to the X-ray tube. It shall not be possible to remove the key while this switch is in the "ON" position. Access to this key shall be controlled. There should be as few copies of this key as possible, and those copies should be numbered and assigned. When not being used, these keys shall be locked up. This requirement should be relaxed in cases where access to the room in which the X-ray-machine is located is both limited and controlled at all times.

In addition, it is recommended that each X-ray machine have an audible, attention-catching, and reliable or fail-safe indication of when high voltage is applied to the X-ray tube and the interlock chain has not been satisfied.

21.12.6 OVERRIDE OF X-RAY SAFETY SYSTEM INTERLOCKS

Interlocks on X-ray equipment vary. Portable and medical diagnostic X-ray systems have few, if any, interlocks. Therapeutic X-ray machines, which are usually configured as a walk-in irradiator, and cabinet X-ray machines are usually extensively interlocked, and these interlocks need only be overridden for service or system testing. Analytical X-ray machines are also extensively interlocked; often, overriding of these interlocks is necessary for alignment.

The need to override interlocks for service operations is left to the judgment of the authorized service personnel. These personnel are specified in the XSD for each X-ray machine. Unusual override requirements for unique service situations shall be brought to the attention of the X-Ray Safety Officer, who will decide what alternate provisions will be required (if any) to continue with the service operation.

On analytical X-ray machines, there is the additional need to override interlocks for system alignment. Override is provided by a toggle or key switch. The type of switch needed is determined by the degree of access control at a given X-ray machine and the stability of its user population. Having a small, relatively stable community of users and good access control allows toggle switch overrides. In other situations, as determined by the X-Ray Safety Officer, key switches are required.

When an override is necessary for alignment, an audible alarm is required as an alternate means of indicating that the beam is on and the shutter is open. This alarm serves

- To constantly remind the user of the state of the X-ray beam, and
- To discourage leaving the machine in this state for extended periods.

The XSD for an analytical X-ray machine will state when and how this override should be used. When alignment override is required, authorized personnel are designated in the XSD.

The X-Ray Safety Officer may also find it necessary to operate an x-ray machine with interlocks overridden. This is allowed under terms and provisions as determined sufficient for assured safe operation by the X-Ray Safety Officer and without further consultation.

Overriding of interlocks is never allowed for routine use.

21.12.7 POSTING

Posting of warning signs and labels shall be in accordance with current standards and with the recommendations of the X-Ray Safety Officer.

21.12.8 RECORDS

All X-ray machines are controlled items, requiring complete property management accountability records.

All X-ray machines shall have a User's Logbook located near the machine and a Maintenance Logbook. The User's Logbook shall be used to record the following information:

- The user's name,
- The experiment or procedure performed,
- The number of exposures,
- The techniques used,
- The approximate time of use,
- The date of use,
- Any suspected abnormalities noted in machine operation,
- The name of the responsible person to be notified of the above abnormality, and
- User leakage surveys (for analytical X-ray machines only).

All notifications of suspected machine abnormalities shall be answered in the Maintenance Logbook. All maintenance work on X-ray-machine is considered a use of that equipment and shall be entered in the User's Logbook, with a reference to the location of a more detailed entry in the Maintenance Logbook.

The Maintenance Logbook is used to record the following information:

- The maintenance person's name and employer (if other than LBNL),
- The reason for maintenance (should refer to the User's Log entry of the noted abnormality),
- Specific problems noted during maintenance (need not be entered into the User's Log),
- Repairs performed (If modification is performed, give the date of written approval from the X-Ray Safety Officer),
- The time and date of maintenance operation, and
- The signature of the maintenance person (indicates a certification that the machine is in normal working order, including all interlocking and fail-safe devices, and that circuitry and construction is in strict accordance with original manufacture plus approved modifications).

The User's Logbook and the Maintenance Logbook may be combined if deemed appropriate by the X-ray system supervisor. This combined logbook shall be located near the machine, as would a User's Logbook, and shall contain all information required for both logbooks.

All records of radiation exposure to users will be maintained by RPG.

21.12.9 PROPERTY MANAGEMENT

All requisitions for X-ray machines shall be reviewed by the X-Ray Safety Officer. Such equipment is controlled and should not be removed from inventory while still under Laboratory authority. Removal from inventory for purposes of disposal, transfer of ownership, or any other reason shall have prior approval of the X-Ray Safety Officer. Any suspected loss of inventory accountability of X-ray machines shall be reported to the X-Ray Safety Officer, who will assist in a prompt investigation. All movements of X-ray machines shall be recorded by means of an Equipment Movement Record and have prior approval of the X-Ray Safety Officer.

All inventory information for X-ray machines (plus that for electron microscopes) shall be made available in the form of a computer readout, arranged in order of location, upon request of the X-Ray Safety Officer. In addition, the computer search information shall be complete and exclusive of superfluous items.

21.12.10 DOSIMETRY

Users of X-ray equipment who are required to be monitored for radiation exposure shall properly and continuously wear appropriate personal radiation dosimeters supplied by the Personal Dosimetry Office.

Because of the low penetrating nature of X rays, personnel dosimeters shall be worn on the side of the body facing the X-ray equipment, at the level of the X-ray beam, and outside all clothing. The X-Ray Safety Officer or the Dosimetry Office should be consulted regarding proper use of personnel dosimeters.

21.12.11 RADIATION SAFETY SURVEYS

All X-ray machines shall have a radiation safety survey performed by the X-Ray Safety Officer or designee at least once a year for machines in active use and upon startup of machines that have been removed from service. Additionally, each analytical X-ray machine shall have an area monitoring device that continuously surveys the general environment (see area monitors below).

In addition, all X-ray machines shall have a radiation safety survey performed

- Upon installation but before regular use,
- After a repair operation that could have caused a change in the condition of shielding or safety protection devices,
- After any repairs or maintenance that could affect the performance of a medical diagnostic machine, and
- Upon request.

To supplement these major surveys, the X-ray system supervisor for analytical equipment shall spot check the X-ray machine at least every six months for radiation leakage.

All surveys and spot checks involve machine usage and therefore shall be entered in the User's Log as such.

21.12.12 ROUTINE SAFETY MAINTENANCE

The X-ray system supervisor is responsible for ensuring that X-ray machine safety systems are checked at the intervals specified in the System Safety Analysis. This interval is usually six months. A technician can be assigned by the Radiation Protection Group to perform this service, which may be charged to the program. If the X-ray system supervisor prefers to have his or her own personnel perform the safety check (and this is allowed by the Routine Testing Protocol), then he or she shall submit to the X-Ray Safety Officer for approval the names, organizations, and qualifications of the people who will perform the safety check. Safety system testing shall be in accordance with the Routine Testing Protocol established as part of the System Safety Analysis.

The Completion of Routine Maintenance form and the Routine Testing Protocol checklist shall be filled out and sent to the X-Ray Safety Officer. A notation of findings and action taken shall also be included.

21.12.13 MODIFICATIONS

All modifications to X-ray-generating systems shall have the prior approval of the X-Ray Safety Officer. Modifications affecting the safety or interlock system will require a new System Safety Analysis.

21.12.14 USE CONTROL

Only authorized users should use X-ray machines. To prevent unauthorized use, each X-ray machine shall be controlled as specified in Section 21.12.5, *Interlocks and Indicators.*

21.12.15 USER TRAINING

To become an authorized X-ray machine user, a person shall complete LBNL's X-ray Machine Safety course (EH&S 410) and receive machine-specific training. The machine-specific training is conducted by an instructor named in the X-ray Machine Safety Document. This training shall include specific machine operation and an introduction to the function and meaning of each safety feature and to basic radiation hazards and cautions. Additional courses should be required as appropriate. Written certification of training signed by both trainee and instructor shall be submitted to the X-Ray Safety Officer before the trainee can be approved to use the X-ray machine.

To ensure continued awareness of procedures for machine operation, users shall be recertified whenever the safety aspects of the XSD are changed, when a user has not used the machine for more than one year, and at the discretion of the X-ray system supervisor or X-Ray Safety Officer.

Routine recertification shall be done every two years.

21.12.16 INSTRUMENTATION

A radiation survey meter with appropriate energy response characteristics should be used frequently to monitor for leaks around analytic and portable X-ray machines. In addition, a fixed Geiger-Mueller or ionization-type monitor of fail-safe design is required. This monitor could also be incorporated into the safety interlock chain as noted above in Interlocks and Indicators.

21.12.17 SHIELDING

All X-ray machines shall be shielded for stray radiation according to the direction of the X-Ray Safety Officer, with reference to prescribed standards and within the prescribed practice of ALARA.

21.12.18 NEW INSTALLATIONS

New installations of X-ray machines shall not be operated without prior approval of the X-Ray Safety Officer and performance of a System Safety Analysis. An XSD shall also be in place. Therefore, it is strongly advised that the X-Ray Safety Officer be consulted while the installation is still in the planning stage so that he or she can review requirements such as shielding, interlocks, and safety devices.

21.12.19 X-RAY MACHINE CLASSIFICATIONS AND SPECIFIC SUPPLEMENTAL REQUIREMENTS

Analytical X-Ray Equipment

Analytical X-ray machines are classified into two types:

- Enclosed-beam X-ray systems
- Open-beam X-ray systems.

The definitions of these terms are contained in ANSI N43.2, subsections 5.2.1.1, 5.2.1.2, and 5.2.2.3.

The classification of enclosed-beam X-ray systems includes X-ray diffraction and X-ray fluorescence equipment that meets the specifications in ANSI N43.2. In addition, all cabinet X-ray units are considered enclosed-beam X-ray systems.

The classification of open-beam X-ray systems includes all X-ray diffraction and X-ray fluorescence equipment not meeting the requirements for enclosed-beam X-ray systems.

In all cases, first consideration and effort shall be given to making a system meet the requirements of an enclosed system. Approval to use an open-beam X-ray system is handled as a variance.

This equipment shall be surveyed for stray radiation every six months and whenever any changes are made to the experimental setup that could compromise shielding effectiveness. More frequent surveys would constitute good practice and are encouraged.

Portable X-Ray Equipment

Portable X-ray equipment presents particular hazards due to its flexibility of use and therefore must be used more carefully. Extra caution and awareness of beam orientation and the location of personnel in the vicinity of the X-ray machine are essential.

The following specific provisions are required for portable X-ray generators:

- Fail-safe, obvious, and prominent visual indications that X rays are being generated
- Interlocks, if possible; however, the nature and use of X-ray machines often precludes interlocks
- Periodic surveys for stray radiation (also conducted whenever any changes that could compromise shielding effectiveness are made to the experimental setup)
- A key-controlled power switch on each unit
- Adherence to all NCRP standards applicable to portable X-ray machines.

Additionally, reliable audio indication that X rays are being generated should be provided.

Diagnostic X-Ray Equipment

Medical diagnostic equipment safety is described in NCRP Reports numbers 102 and 49. Since long exposures at high outputs are generally impossible with such units, interlocking is inappropriate; however, all such equipment shall have a reliable, audible indicator that signals the production of X rays.

The XSD for this equipment shall state whether the X-ray machine complies with state and federal regulations for use on humans. Any X-ray machine to be used on humans shall be found by the X-Ray Safety Officer to comply with these regulations before such use commences, unless specifically exempted by the Human Use Committee.

All diagnostic X-ray installations shall, if possible, have a light outside the room that indicates when the X-ray control unit is energized and when X rays are being produced. (A "rotor on" indication will suffice for the "X ray on" indication.) These lights shall be fail-safe or redundant. Furthermore, they shall be positioned and labeled so that their presence and meaning are obvious.

Photoemission X-Ray Spectrometers

These X-ray systems do not, by design, emit X rays beyond the contiguous internal vacuum. They are, therefore, not within the scope of these regulations and are exempt from them. The X-Ray Safety Officer shall, however, survey them for X-ray leakage on request and shall be kept informed of their location.

21.12.20 VARIANCES

If it is impossible or highly impractical to adhere to any safety standard, the X-Ray System Supervisor should request, in writing, a variance. This request will be reviewed by the X-Ray Safety Officer and referred, with comment/recommendation, to the LBNL Radiation Safety Committee for consideration.

All requests for variances will be evaluated on an individual basis and shall demonstrate:

- A definite need for variance
- Alternate safety devices or procedures that will ensure an equivalent assurance of safety.

Variances for service are described above.

The LBNL X-Ray Safety Officer may operate, or direct the operation, of any X-ray machine in variance of these requirements but shall have in place alternate provisions, deemed by his professional judgement, to provide equivalent assurance of safe operation.

The above provision may also be used to allow X-ray system supervisors, in concert with the X-Ray Safety Officer, to run one time unusual operations without the need for a formal variance which would be required if such use were routine. Usually such operations will be constantly monitored and directly supervised by the X-Ray Safety Officer.

All requests for variances from DOE-prescribed regulations require specific DOE approval.

21.13 IRRADIATOR SAFETY

An irradiator consists of a high-activity, sealed radioactive source housed in a shielded, interlocked chamber. Samples are inserted or brought into the chamber for exposure to radiation; then the chamber is closed and the source is moved remotely to the irradiation position. In general, the same safety requirements that apply to enclosed X-ray machines also apply to irradiators. In addition, an SSA will be required. The SSA incorporates requirements of the AHD by reference.

21.13.1 RESPONSIBILITY

The irradiator supervisor has the prime responsibility for compliance with safety requirements.

The responsibilities of the individual worker are as follows:

- Each worker shall, upon the instruction of a qualified expert or responsible supervisor, follow the recommendations and instructions drawn up in the interest of radiation protection.
- Each worker shall use the protective devices provided.
- Each worker shall bring to the attention of those in charge any defect or deficiency in radiation protection devices and procedures.

The X-Ray Safety Officer, a member of the Radiation Protection Group, is responsible for monitoring and assisting with compliance with LBNL regulations.

21.13.2 ACTIVITY HAZARD DOCUMENT

All irradiators shall have the most recent AHD readily accessible to authorized users. This AHD shall contain at least the following:

- The name of the person responsible for the unit (system supervisor)
- A list of authorized users
- A list of authorized instructors
- A list of authorized maintenance personnel
- An emergency or problem call list
- Descriptions of safety features
- Specific operating procedures
- Copies of appropriate standards and policies, as provided by RPG.

The AHDs shall be prepared by the irradiator supervisor with consultation from the Radiation Protection Group. The irradiator supervisor shall review the AHD as frequently as changes in the program necessitate, but at least every 5 years. During this review, the irradiator supervisor shall review the AHD and submit to the X-Ray Safety Officer any changes to be made or else indicate that there have been no changes. The AHD shall also be reviewed when any item listed above changes, except for the list of authorized users, instructors, or maintenance personnel.

21.13.3 IRRADIATOR SYSTEM SAFETY ANALYSIS POLICY

All irradiators shall undergo a System Safety Analysis as follows:

- For new units, before operation
- For working units, at intervals no longer than 5 years or upon modification
- For out-of-service units, before being brought back into service.

A System Safety Analysis shall be performed by qualified personnel designated by LBNL Management and shall consist of at least the following:

- Identification of modifications to the safety systems made since the last analysis, if any, and approval of the changes
- Verification, update, or production of schematic diagrams of the safety systems
- Assessment of potential equipment failure modes and their possible consequences, with emphasis on the failure modes of interlocks and other safety devices
- Review of the detailed protocol for routine maintenance testing of safety devices

- Preparation of a written report of the findings of the analysis, together with recommendations for action, if any. Copies shall be given to the X-Ray Safety Officer, who will distribute them to the irradiator supervisor.

21.13.4 RADIOLOGICAL WORK AUTHORIZATION

All irradiators shall have an RWA issued by the Radiation Protection Group. The RWA shall include the following information:

- The system supervisor's name, telephone number, mail stop, and division
- Any specific safety precautions
- References to the AHD, PUB-3000, and the RCM
- Emergency telephone numbers
- A list of authorized users.

For more information on the RWA process, see Section 21.4, *Radiological Work Authorization and Permit Programs*.

21.13.5 INTERLOCKS AND INDICATORS

All irradiators shall have fail-safe interlocks and indicators as specified in applicable standards. See Section 21.11.4, *Accelerator Radiation Protection Interlock Systems*, for guidance.

21.13.6 POSTING

Posting of warning signs and labels shall be in accordance with current standards and with the recommendations of the X-Ray Safety Officer. "High-Radiation Area" signs are required.

21.13.7 RECORDS

All irradiators are controlled items, requiring complete property management accountability records.

All irradiators shall have a User's Logbook located near the machine and a Maintenance Logbook. The User's Logbook shall be used to record the following information:

- The user's name
- The experiment or procedure performed
- The number of exposures or exposure duration
- The approximate time of use
- The date of use
- Any suspected abnormalities noted in machine operation

- The name of the responsible person to be notified of the above abnormality
- User radiation surveys.

All notifications of suspected abnormalities shall be answered in the Maintenance Logbook. All maintenance work is considered a use of that equipment and shall be entered in the User's Logbook, giving a reference to the location of a more detailed entry in the Maintenance Logbook.

The Maintenance Logbook is used to record the following information:

- The maintenance person's name and employer (if other than LBNL)
- The reason for maintenance (may refer to the User's Log entry of the noted abnormality)
- Specific problems noted during maintenance (need not be entered into the User's Log)
- Repairs performed (If modification is performed, refer to the date of written approval from the X-Ray Safety Officer)
- The time and date of maintenance operation
- The signature of the maintenance person (indicates a certification that the machine is in normal working order, including all interlocking and fail-safe devices, and that circuitry, construction, and shielding is in strict accordance with original manufacture plus approved modifications).

The User's Logbook and the Maintenance Logbook may be combined if deemed appropriate by the irradiator supervisor. This combined logbook shall be located near the machine, as would a User's Logbook, and shall contain all information required for both logbooks.

All records of radiation exposure to users will be maintained by RPG.

21.13.8 PROPERTY MANAGEMENT

All requisitions for irradiators shall be reviewed by the X-Ray Safety Officer. Such equipment is a controlled item and may not be removed from inventory while still under Laboratory authority.

21.13.9 DOSIMETRY

All users of irradiators shall properly and continuously wear appropriate personal radiation dosimeters supplied by the Dosimetry Office. Dosimetry will be specified by the RWA.

21.13.10 RADIATION SAFETY SURVEYS

All irradiators shall have a radiation safety survey performed by the X-Ray Safety Officer or designee at least once a year for machines in active use and upon startup of machines that have been removed from service. Additionally, each irradiator shall have an area monitoring device that continuously surveys the general environment.

In addition, all irradiators shall have a radiation safety survey performed:

- Upon installation but before regular use
- After a repair operation that could have caused a change in the condition of shielding or safety protection devices
- Upon request.

To supplement these major surveys, the irradiator supervisor or designee shall spot check the irradiator at least every six months for radiation leakage.

All surveys and spot checks require use of the irradiator and therefore shall be entered in the logbook.

21.13.11 ROUTINE SAFETY MAINTENANCE

The irradiator supervisor is responsible for ensuring that irradiator safety systems are checked at the intervals specified in the System Safety Analysis report. This interval is usually six months. A technician can be assigned by the Radiation Protection Group to perform this service, which may be charged to the program. Safety system testing shall be in accordance with the Routine Testing Protocol established as part of the System Safety Analysis.

The "Completion of Routine Maintenance" form and the Routine Testing Protocol checklist shall be filled out and sent to the X-Ray Safety Officer. A notation of findings and action taken shall also be included.

21.13.12 MODIFICATIONS

All modifications to any irradiator shall be described in a System Safety Analysis and shall have the prior approval of the X-Ray Safety Officer.

21.13.13 USER TRAINING

To become an authorized irradiator user, a person shall complete EH&S 430 and receive installation-specific training. The installation-specific training is done by an instructor named in the AHD.

To ensure continued awareness of procedures for machine operation, users shall be recertified whenever the safety aspects of the AHD are changed, when they have not used the machine for more than one year, and at the discretion of the irradiator supervisor or X-Ray Safety Officer. Recertification shall be done at least every two years.

21.13.14 INSTRUMENTATION

A radiation dose-rate meter should be used to monitor radiation levels. A fixed monitor shall be installed inside or at the entrance to the irradiation chamber that is connected to the interlock system.

21.13.15 SHIELDING

All irradiators shall be shielded according to the direction of the X-Ray Safety Officer, with reference to prescribed standards and within the prescribed practice of ALARA.

21.13.16 NEW INSTALLATIONS

New irradiators may not be operated without prior approval of the X-Ray Safety Officer and performance of a System Safety Analysis. An AHD and an RWA shall also be in place. Therefore, it is strongly advised that this officer be consulted while the installation is still in the planning stage so that he or she can review requirements such as shielding, interlocks, and fail-safe devices.

21.14 PROCEDURES FOR EMERGENCIES INVOLVING RADIOACTIVE MATERIAL

CALL 7911 FOR ANY EMERGENCY

21.14.1 REPORTING AN EMERGENCY

- Call 7911. (See other options below for reporting minor events.)
- Stay calm; speak clearly.
- Give your name and the location of the emergency.
- State the nature of the emergency (radiation, chemical, personal injury).
- Describe the severity.
- Relay other potential hazards (exposures, flammables, high voltage).
- Stay in the area until help arrives, if possible.

21.14.2 SUSPECTED RADIOACTIVE CONTAMINATION TO PERSONNEL OR AN AREA

- Evacuate personnel to a safe area. Isolate and deny entry to contaminated area.
- Detain all evacuees to avoid spreading contamination and for evaluation by EH&S.
- Call 7911 for help or

- If there is a minor spill or contamination, the event can be reported via 5251 (EH&S), or 6015 (Fire Department nonemergency number).
- Do not attempt decontamination of the equipment or work area.
- Preserve the scene.

21.14.3 SUSPECTED RADIOACTIVE CONTAMINATION TO PERSONNEL, OR TO AN AREA, AND AN INJURY

- Immediately call 7911. Report injury and possible radioactive contamination.
- Apply first aid. First aid can be rendered to the level to which the aid giver is trained.
- Avoid moving the victim if possible. Weigh the risk of moving the victim against the risk of potential exposure.

21.14.4 SKIN CONTAMINATION

- Call 7911 for help or
- If there is a minor spill or contamination, the event can be reported via 5251 (EH&S), or 6015 (Fire Department nonemergency number).
- Do not try to decontaminate a wound.
- Gently wash the skin with mild soap and water, using absorbent paper to collect the washing liquid.
- Do not use solvents or abrasive cleaners.
- Do not redden or abrade the skin.

21.14.5 RESPONSIBILITIES

All Employees

- Be familiar with your emergency plan.
- Know your evacuation route.
- To evacuate, use stairs, not the elevator.
- Note the locations of emergency showers and eyewashes, fire pull boxes, and fire extinguishers.

Supervisors

- Emergency shutdown procedures for hazardous operations must be posted in a safe and conspicuous location.
- Post and maintain a current emergency call list.
- Conduct pre-work reviews, including emergency responses.
- Address emergency issues in planning and design processes.

For further details see Chapter 9, *Emergency Management*.

21.14.6 INVESTIGATION

All emergency incidents will be investigated by RPG, and a report relating to causes, prevention, actions taken, results of clean-up and testing, lessons learned, etc., will be prepared. Incidents that must be reported pursuant to DOE Order 232.1A, *Occurrence Reporting,* include overexposures, personal clothing or skin contamination, contamination outside a Controlled Area, and violations of procedures. These incidents have reporting deadlines and must be categorized immediately. More serious occurrences will have a report prepared by an RSC investigation committee. The committee will consist of line management and a qualified representative of RPG.

21.15 RESPONSIBLE PARTIES

21.15.1 RADIATION WORKERS

All radiation workers must:

- Follow the safety requirements outlined in their Authorization.
- Report unsafe conditions or abnormal radiological occurrences to their supervisor and to RPG.
- Ensure that their training qualifications are current and appropriate for the work activities and equipment that they use or may be expected to use in abnormal situations.
- Consult their supervisor or RPG whenever questions arise.
- Maintain Radioisotope Journals, logs, and Inventory Summaries with accurate and timely data entries that reflect current work practices.
- Wear dosimetry properly and participate in the bioassay program as required by their RWA. Workers shall be prompt in exchanging dosimeters and providing bioassay samples.
- Monitor and minimize their own radiation exposure through good ALARA work practices.
- Monitor for contamination at every reasonable opportunity, and document surveys as required.

- Minimize waste. Keep waste segregated, properly stored, characterized, and documented. See Chapter 20, *Hazardous Waste Disposal*, for additional guidelines.
- Strive to find and implement new "good work practices" to minimize their dose, waste, and effluents.
- Practice good housekeeping in the laboratory to minimize accidents and mishaps.

21.15.2 SUPERVISORS AND PRINCIPAL INVESTIGATORS

Supervisors and PIs shall:

- Stop work when unsafe conditions exist.
- Report unsafe conditions or abnormal radiological occurrences to RPG.
- Ensure that all radiation work is within the scope of an approved authorization document.
- Promptly request new or amended RWAs when radiological conditions or changes are first identified.
- Ensure that RWA and RWP safety requirements and conditions are being met.
- Ensure that Radioisotope Journals, logs, and Inventory Summaries are being properly maintained and reflect current work practices.
- Frequently monitor their employees' radiation doses and working environment in order to establish good ALARA work practices.
- Ensure that laboratory safety equipment and instruments are adequate for the work being performed.
- Schedule appropriate training and on-the-job training to keep worker qualifications current.

21.16 GLOSSARY

Activation is the process of producing a radioactive material by bombardment with neutrons, protons, or other nuclear particles.

An **administrative control level** is a numerical dose constraint established at a level below the regulatory limits in order to administratively control and help reduce individual and collective doses.

An **airborne radioactivity area** is any area where the concentration of airborne radioactivity above natural background exceeds or is likely to exceed 10% of the derived air concentration (DAC) value. The DAC values are given in Appendices A and C of 10 CFR 835.

The **Radiation Safety Committee (RSC)** is responsible for advising LBNL Management on all matters related to occupational and environmental radiation safety. The RSC shall provide oversight to the Radiation Protection Program (RPP), including the ALARA program.

The **annual limit on intake (ALI)** is the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. The ALI is the smaller value of intake of a given radionuclide in a year by the reference man (ICRP Publication 23) that would result in a committed effective dose equivalent of 5 rem (0.05 sievert) or a committed dose equivalent of 50 rem (0.5 sievert) to any individual organ or tissue.

As low as reasonably achievable (ALARA) describes an approach to radiological management and control that aims to keep exposures (individual and collective) to the work force and to the general public at levels as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. As used in this manual, ALARA is not a dose limit but a process that has the objective of attaining doses as far below the applicable controlling limits as is reasonably achievable.

Background radiation is radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear materials); and global fallout as it exists in the environment from the testing of nuclear explosive devices. Background radiation does not include radiation from source, byproduct, or special nuclear materials.

The **becquerel (Bq)** is the International System (SI) unit for activity of radioactive material. One becquerel is that quantity of radioactive material in which one atom is transformed per second or undergoes one disintegration per second.

A **bioassay** is an internal dosimetry test used to determine the kinds, quantities, concentrations, and in some cases the locations of radioactive materials within or excreted from the human body. This process includes whole-body and organ counting as well as urine, fecal, and other specimen analysis.

A **bistable indicator** is an indicator that has only two positions: on or off.

Calibration is the process of adjusting or determining one of the following:

- The response or reading of an instrument relative to a standard (e.g., primary, secondary, or tertiary) or to a series of conventionally true values.
- The strength of a radiation source relative to a standard (e.g., primary, secondary, or tertiary) or to a conventionally true value.

A **containment device** is a barrier, such as a glove box or fume hood, for inhibiting the release of radioactive material from a specific location.

A **Contamination Area** is an area where ambient contamination levels are more than those specified in Table 21.4. (See *Release of Material from Controlled Areas* in Section 21.10 *Radioactive Materials Safety*.)

In a **contamination survey**, swipes or direct instrument surveys are used to identify and quantify radioactive material on personnel, on equipment, or in areas.

A **continuous air monitor (CAM)** is an instrument that continuously samples and measures levels of airborne radioactive materials on a "real-time" basis and has alarm capabilities at preset levels.

A **Controlled Area** is any area to which access is managed in order to protect individuals from exposure to radiation or radioactive materials. Individuals who enter Controlled Areas, without entering Radiological Areas, are not expected to receive a total effective dose equivalent of more than 0.1 rem (0.001 sievert) in a year.

Controlled Items, as designated by the Laboratory's Property Management, are items that shall be kept under inventory control, regardless of value.

A **dead-man switch** is a switch that must be continually held in position in order for equipment to operate; i.e., the release of the switch stops the operation.

A **declared pregnant worker** is a woman who has voluntarily informed her employer in writing of her pregnancy and the estimated date of conception.

Decontamination is the process of removing radioactive contamination and materials from personnel, equipment, or areas.

A **deep dose** is the dose equivalent from external radiation determined at a tissue depth of 1 cm.

The **derived air concentration (DAC)** is the airborne concentration equal to the ALI divided by the volume of air breathed by an average worker for a working year of 2000 hours (assuming a breathing volume of 2400 m^3).

A **dose** is an amount of energy deposited in body tissue because of radiation exposure. Various technical terms, such as dose equivalent, effective dose equivalent, and collective dose, are used to evaluate the amount of radiation an exposed worker receives. These terms are used to describe the differing interactions of radiation with tissue as well as to assist in the management of personnel exposure to radiation.

> An **absorbed dose (D)** is the energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. The units of absorbed dose are the rad and the gray (Gy).
>
> A **collective dose**, measured in person-rem, is calculated by summing the dose to each person in a group of interest. For example, if 12 workers each have 1 rem, then the collective dose is 12 person-rem.

A **committed dose equivalent ($H_{T,50}$)** is the dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by a person during the 50-year period following the intake.

A **committed effective dose equivalent ($H_{E,50}$)** is the sum of the products of the weighting factors and the committed dose equivalents applicable to each of the body organs or tissues irradiated ($H_{E,50}=\Sigma W_T H_{T,50}$).

A **dose equivalent (H_T)** is the product of the absorbed dose in tissue, the quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and the sievert (S_V).

An **effective dose equivalent (H_E)** is the sum of the products of the dose equivalents (H_T) and the weighting factors (W_T) applicable to each of the body organs or tissues irradiated ($H_E = \Sigma W_T H_T$).

A worker's **lifetime dose** is the person's total occupational exposure over his or her lifetime, including external and committed internal doses.

A **total effective dose equivalent (TEDE)** is the sum of the effective dose equivalent for external exposures and the committed effective dose equivalent for internal exposures. The deep-dose equivalent to the whole body may be used as the effective dose equivalent for external exposures.

The **weighting factor** represents the ratio of the total stochastic (cancer plus genetic) risk resulting from irradiation to tissue to the total risk when the whole body is irradiated uniformly.

The **whole-body dose** is the sum of the annual deep dose equivalent for external exposures and the committed effective dose equivalent for internal exposures.

Dose assessment is the process of determining the radiological dose and the uncertainty included in the dose estimate through the use of exposure scenarios, bioassay results, monitoring data, source term information, and pathway analysis.

Engineering controls are components and systems used to reduce airborne radioactivity and the spread of contamination by using piping, containments, ventilation, filtration, or shielding.

An **exclusion area** is an area defined by a qualified expert as one that all personnel should be restricted from entering during operation of an accelerator.

Extremities include hands, feet, arms below the elbow, and legs below the knee.

Being **fail-safe** means having the property that any single failure causes a sequence of events that always results in a safe situation.

A **fail-safe design** is one in which all single-component failures of indicators or safety systems (that can reasonably be anticipated) cause the equipment to fail so as to maintain personnel radiation safety. For example, if a light indicating "X ray on" fails, the production of X rays shall be prevented; similarly, if a shutter-status indicator fails, the shutter shall close.

Fixed contamination is radioactive material that cannot be readily removed from surfaces by nondestructive means, such as casual contact, wiping, brushing, or washing.

Frisking is the process of monitoring personnel for contamination. Frisking can be performed with hand-held survey instruments or automated monitoring devices.

General Employees are all DOE or LBNL employees, subcontractors, and participating guests.

The **Gray (Gy)** is the SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule per kilogram (100 rads).

A **High-Contamination Area** is an area where ambient contamination levels are higher than 100 times those specified in Table 21.4.

A **high-efficiency particulate air (HEPA) filter** is a extended, pleated medium dry–type filter with (1) a rigid casing enclosing the full depth of the pleats, (2) a minimum particle removal efficiency of 99.97% for thermally generated monodisperse DOP smoke particles with a diameter of 0.3 µm, and (3) a maximum pressure drop of 1.0 inch w.g. when clean and operated at its rated airflow capacity.

A **High-Radiation Area** is any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.1 rem (0.001 Sv) in one hour 30 cm from the radiation source or from any surface that the radiation penetrates.

An **irradiator** is a sealed radioactive material that has the potential to create a radiation level exceeding 500 rad (5 grays) in 1 hour at a distance of 1 meter.

Mixed waste is waste containing both radioactive and hazardous components as defined by the Atomic Energy Act and the Resources Conservation and Recovery Act, respectively.

Low Activity Source (LAS) Authorizations allow use or transfer of very small quantities of radioactive material, provided that a project does not possess more than ten such quantities. Compliance with regulations and other provisions of EH&S programs is required.

Occupational dose is the dose received by a person during employment in which the person's assigned duties involve exposure to radiation and to radioactive material. An occupational dose does not include doses received from background radiation, from medical procedures, from voluntary participation in medical research programs, or as a member of the public.

Personal protective equipment is equipment such as respirators, face shields, and safety glasses that is used to protect workers from excessive exposure to radioactive or hazardous materials.

Personnel dosimeters are devices such as film badges and thermoluminescent dosimeters (TLDs) designed to be worn by a single person for the assessment of his or her dose equivalent.

Personnel monitoring describes systematic and periodic estimates of radiation doses received by personnel during working hours. The term is also used for the monitoring of personnel, their excretions, their skin, or any part of their clothing to determine the amount of radioactivity present.

The exposure of an embryo or fetus to radiation is known as **prenatal radiation exposure**.

The operation of any accelerator will result in radiation called **prompt radiation**, as distinguished from induced radioactivity. Prompt radiation stops as soon as the accelerator is turned off.

A **qualified expert** is a person having the knowledge and training to measure ionizing radiation, to evaluate safety techniques, and to provide advice on radiation protection needs as determined by LBNL Management.

The **rad** is a unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs per gram or 0.01 joules per kilogram (0.01 gray).

A **Radiation Area** is any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.005 rem (0.05 mSv) in one hour 30 cm from the radiation source or from any surface that the radiation penetrates.

A **Radiological Work Authorization (RWA)** is an authorization for use of radioactive materials in long-term projects having stable radiological conditions. Precautions, limits of use, and requirements are specified.

A **Radiological Work Permit (RWP)** is a permit that identifies radiological conditions, establishes worker protection and monitoring requirements, and contains specific approvals for specific radiological work activities. The Radiological Work Permit serves as an administrative process for planning and controlling radiological work and informing the worker of the radiological conditions. A permit for construction or demolition work in a Radiological Material Area is one example.

A **Radiological Material Area (RMA)** is an area or structure where radioactive material is used, handled, or stored.

A **Radiological Storage Area (RSA)** is a structure or designated area in which radioactive material is stored.

A **radioactive material** is any material, equipment, or system component determined to be contaminated or suspected of being contaminated. Radioactive material also includes activated material, sealed and unsealed sources, and material that emits radiation.

Radiography is the nondestructive examination of the structure of materials by using a radioactive source, x-ray machine or accelerator.

A **radiological posting** is a sign or label that indicates the presence or potential presence of radiation or radioactive materials.

Radiological work is any work that requires the handling of radioactive material or requires access to Radiation Areas, High-Radiation Areas, Contamination Areas, High-Contamination Areas, or Airborne Radioactivity Areas.

A **radiological worker** is a worker whose job assignment requires work on, with, or in the proximity of radiation-producing machines or radioactive materials AND has the potential of being exposed to more than 0.1 rem (1 mSv) per year, which is the sum of the dose equivalent from external irradiation and the committed effective dose equivalent from internal irradiation. A radiological worker may also be referred to as a "radiation worker" or a "rad worker."

Release to Uncontrolled Areas is the release of material from administrative control after confirming that the residual radioactive material meets the guidelines in DOE Order 5400.5.

The **rem** is a unit of dose equivalent. The dose equivalent in rem is numerically equal to the absorbed dose in rad multiplied by a quality factor, a distribution factor, and any other necessary modifying factor (1 rem = 0.01 sievert).

Removable contamination is radioactive material that can be removed from surfaces by nondestructive means, such as casual contact, wiping, brushing, or washing.

Radioactive material that is contained in a sealed capsule, sealed between layers of nonradioactive material, or firmly fixed to a nonradioactive surface by electroplating or other means is called a **sealed source.** The confining barrier prevents dispersion of the radioactive material under normal, and most accidental, conditions related to use of the source.

A **Sealed Source Authorization (SSA)** authorizes possession and use of sealed sources. Precautions, limits of use, and other requirement are specified.

The **sievert (Sv)** is the SI unit of any of the quantities expressed as a dose equivalent. The dose equivalent in sievert is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rem).

Techniques are instrument use parameters employed during an X-ray exposure, e.g., kV, mA, mAs, sec, filter, distance, field size, etc. (Not all parameters are, of course, applicable to all types of X-ray machines.)

An **Uncontrolled Area** is any area where access is not restricted and the effective dose equivalent received by any member of the public resulting from exposure during direct on-site access does not exceed a limiting value of 0.001 sievert (0.1 rem) in any year.

An **unusual occurrence** is a nonemergency occurrence that has significant impact or potential for impact on safety, environment, health, security, or operations. Examples of the types of occurrences that are to be categorized as unusual occurrences are listed in DOE Manual 232.1A.

A **Very-High-Radiation Area** is any area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in one hour 1 meter from a radiation source or from any surface that the radiation penetrates.

An **X-ray accessory apparatus** is any portion of an X-ray installation that is external to the radiation source housing and into which an X-ray beam is directed for making X-ray measurements or for other uses.

The X-ray tube and that portion of an X-ray system that provides the accelerating voltage and current is the **X-ray generator.**

An **X-ray system supervisor** is a person having administrative control over an X-ray machine and so designated in the X-ray Machine Safety Document for that machine.

21.17 STANDARDS

- 10 CFR 835, *Occupational Radiation Protection at Department of Energy Facilities*
- DOE Order 232.1A, *Occurrence Reporting and Processing of Radiological Protection for DOE Activities*
- DOE Order 5480.25, *Safety of Accelerator Facilities,* Paragraphs 9d-j, 10, and 11
- DOE Order 5400.5, *Radiation Protection of the Public and the Environment*

21.18 RELATED PUB-3000 CHAPTERS

- *Emergency Management* (Chapter 9)
- *Environmental Protection* (Chapter 11)
- *ES&H Documentation and Approvals* (Chapter 6)
- *Hazardous Waste Disposal* (Chapter 20)
- *Occurrence Reporting* (Chapter 15)

21.19 REFERENCES

- American National Standards Institute (ANSI) N43.2, *Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment*
- American National Standards Institute (ANSI) N43.1 *Radiological Safety in the Design and Operation of Particle Accelerators*
- DOE Notice 441.1, *Radiological Protection for DOE Activities*
- NCRP Report No. 102, Medical X-Ray, Electron Beam and Gamma-Ray Protection for Energies Up to 50 MeV
- NCRP Report No. 49, Structural Shielding Design and Evaluation for Medical Use of X-Ray and Gamma-Ray Energies up to 10 MeV
- "Internal Dosimetry Technical Bases" (LBNL internal document)

21.20 APPENDICES

- Appendix A. RWA Performance Evaluation

APPENDIX A. RWA PERFORMANCE EVALUATION

RWA Performance Evaluation

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Compliance checks will be performed during routine (weekly or monthly) surveys of the RMAs. Findings will be reported to the PI and documented in the RWA files. Three levels of noncompliance findings have been established. Safety-significant findings (Level 3) require review by the Radiation Safety Committee.

LEVEL 1 (Minor). RWA Project PI's will be notified directly of all Level 1 findings. The project has 30 days to correct those findings requiring action. If the same noncompliance item is identified during the next monthly RPG survey, the finding is elevated to a Level 2.

1. Proper protective clothing not worn while handling radioactive material.
2. Radiological waste containers not labeled indicating isotope disposed within. Benchtop containers are to be labeled indicating the isotope, date, and approximate amount disposed.
3. User surveys not documented or performed at the required frequency. Survey maps and associated LSC output and User Checklists are to be completed and filed in the Radioisotope Lab Journal.
4. "Daily Use Logs" not completed. The logs are to be used to indicate the amount of material removed from each stock vial and the amount disposed of as waste or held in long-term storage.
5. Authorized radionuclide possession limit exceeded.
6. Posting and labeling of RMAs or RSAs not correct or missing.
7. TLD or bioassay sample not provided in a timely manner.
8. OJT forms not maintained as required. Completed job-specific training forms are required for unsealed isotope users, as well as x-ray machine and sealed source users.
9. Transfer of radioactive material or sealed source to an authorized project not properly documented. Daily use logs are to accompany the transfer of unsealed material. Transfer of a sealed source requires documentation in the sealed source use log and notification of the source custodian.

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LEVEL 2 (Major): RWA Project PI's, Division Director, and users will be notified directly of all Level 2 findings. The project has 30 days to correct those findings requiring action. If the same noncompliance item is identified during the next monthly RPP survey (< 30 days), the finding is elevated to a Level 3.

1. Level 1 (minor) findings not corrected within 30 days of notification.
2. Five or more Level 1 findings identified within the same month.
3. Personnel contamination, contamination outside an RMA, or on the floor within the RMA not reported to the RPG.
4. Dosimetry not worn during work with radioactive material, as required by the RWA.
5. Exposure above administrative limits without prior approval.
6. Receipt/purchase of material greater than the currently authorized vial limit.
7. Food, drink, or smoking in an RMA or RSA.
8. Unsupervised work with radioactive material or use of radiation-producing machines (including x-ray machines) without required radiation safety training.
9. OJT training not provided to new radiation workers, sealed source, or x-ray machine users.
10. Transfer of radioactive material, sealed sources, or x-ray equipment to unauthorized projects.
11. Use of facilities for radiological work not authorized in the RWA.
12. Release of contaminated materials/equipment for unrestricted use without prior authorization.
13. Safety interlock violation that would not under normal circumstances lead to an exposure greater than 5 rem.

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LEVEL 3 (Serious—Safety Significant). The RWA PI and Division Director will be notified of all Level 3 findings. RWA suspension is at the discretion of the Radiological Control Manager. A review by the Radiation Safety Committee is required prior to reinstating the RWA.

1. Level 2 (major) findings not corrected within 30 days of notification.
2. Five or more Level 2 findings identified within the same month.
3. Failure to control clear and present danger to worker health and safety, e.g., worker exposure above regulatory limits (5 rem, whole body; 50 rem, skin or extremity; and 15 rem, eye).
4. Reportable occurrences or noncompliance with 10CFR835 that have safety significance and/or are due to willful carelessness or negligence.
5. Falsification of surveys or records.
6. Willful, unauthorized violation of an interlock system used for radiological safety that has potential for a radiation exposure in excess of limits specified in 10CRF835, whether or not such an exposure occurs. An example is operation of a facility with a nonfunctioning interlock system or entry into high radiation areas without having performed an adequate survey.
7. Willful, unauthorized release of radioactive material or contaminated articles off site that poses a realistic potential for exposure of the public to levels or doses exceeding the annual dose limit for members of the public.

Chapter 22

RESEARCH WITH HUMAN AND ANIMAL SUBJECTS

Revised December 1997

Henry Stauffer 12/15/97

R.C. Bally 12/12/97

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Date

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EH&S Division Director
Date

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Chapter 22

RESEARCH WITH HUMAN AND ANIMAL SUBJECTS

PART I: RESEARCH WITH HUMAN SUBJECTS

22.1.1 POLICY

It is the policy of the Laboratory to implement the principles and regulations formulated by the Department of Health and Human Services (DHHS) for research projects involving human subjects.

22.1.2 LBNL SUPPORT ORGANIZATIONS

- Human and Animal Regulatory Committees Office
- Human Subjects Committee

22.1.3 IMPLEMENTATION

It is the responsibility of the Laboratory to maintain an agreement by which Laboratory projects may be reviewed and certified in accordance with DHHS principles and regulations. Investigators are responsible for safeguarding the welfare, privacy, and rights of human subjects who take part in their research experiments and for observing both the letter and the spirit of the DHHS regulations.

22.1.3.1 HUMAN SUBJECTS COMMITTEES

The Laboratory has a long-standing agreement with the UC Berkeley **Committee for Protection of Human Subjects (CPHS)** to review and certify Laboratory projects. CPHS is an Institutional Review Board with DHHS Multiple Project Assurance #M-1349.

The Berkeley Lab **Human Subjects Committee (HSC)** is responsible for pre-reviewing and approving all Laboratory projects. Requests for approval go to the Berkeley Lab HSC and not to the CPHS on campus.

22.1.3.2 HUMAN SUBJECT INVOLVEMENT

All proposed research projects that involve human subjects in any way must be reviewed to determine risk. Human subject involvement includes:

- The use of human-derived data or cultures of human cells.
- Projects in which the investigator is the only subject.
- Information sought indirectly such as through observation.
- Information sought directly through an interview or questionnaire.
- Collaborative studies in which materials or information are collected at another institution and sent to researchers at the Laboratory.
- Requests from third parties for information concerning the individuals in question, whether through access to files or data banks or through direct inquiry.
- Donation of tissues, organs, fluids, or other bodily material.
- Physical participation in an activity.

If the human subject involvement in a research project satisfies certain criteria, it may be declared exempt from further review. This does not mean that review of the project is not required. Human subject involvement must be documented for every project and grant application. It must be reviewed even if the proposed involvement appears to be similar to a previously approved project. Research involving vulnerable subjects always requires a full review.

22.1.3.3 REVIEW AND APPROVAL PROCEDURES

All research projects involving human subjects require prior review and formal approval by an Institutional Review Board. The purpose of this review is to determine whether subjects are at risk, whether the potential benefits of the research outweigh the risk, and whether adequate provision has been made to obtain informed consent. Risk is defined as exposure to the possibility of harm, whether physical, psychological, sociological, or other, to a participant in a research activity. Research is defined as a systematic investigation designed to contribute to scientific knowledge. This definition extends to pilot studies. Except in extraordinary cases, the researcher must obtain the informed consent of a subject to participate in research. Research involving vulnerable subjects requires special care in design and review.

PROJECTS THAT INVOLVE HUMAN SUBJECTS MUST NOT BE INITIATED UNTIL THE APPROPRIATE CPHS APPROVAL HAS BEEN RECEIVED.

Both the HSC and the CPHS meet monthly. The HSC meetings are scheduled for timely submission to the CPHS for its agenda deadline.

Human subject protocols should be submitted to the HSC two weeks prior to its meeting date. Final CPHS review generally takes about seven weeks from the time of submission.

Many funding agencies require that certification of human subjects approval be submitted with the grant proposal. The National Institutes of Health (NIH) allows a grace period of 60 days following the proposal submission date. Human subjects review should be requested when a research proposal is being prepared, since delays sometimes occur before final approval can be granted. Annual reviews are required for continuing projects.

22.1.3.4 AUTHORITY TO SUSPEND OR TERMINATE APPROVAL OF RESEARCH

Under the DHHS Assurance of Compliance for Protection of Human Subjects, the Laboratory, upon recommendation by the Committees, has the authority and the responsibility to suspend or terminate research that is not being conducted in accordance with CPHS decisions, conditions, and requirements or that has been associated with unexpected serious harm to subjects.

In the case of suspension of research, research shall not resume until the Committees have assurance that the appropriate corrective actions have been implemented.

The reporting requirements for issues and concerns that might involve suspension or termination of research are as follows: The CPHS must report information concerning noncompliance by Berkeley Lab research investigators, injuries to subjects, and unanticipated problems involving risk to the DHHS Office for Protection from Research Risks (OPRR). If the CPHS suspends or terminates approval of research, the Committee shall include a statement of the reason for the action and shall report the action promptly to the research investigator, the Berkeley Lab Director, and the OPRR. The Laboratory has an institutional responsibility to inform the DOE Human Subjects Program Manager and the Field Office. If the research is funded by DOE, the Laboratory must inform the appropriate Program Secretarial Office; if funded by a non-DOE agency or source, the Berkeley Lab Sponsored Projects Office must be informed.

CALL THE LBNL HUMAN AND ANIMAL REGULATORY COMMITTEES OFFICE AT (510) 486-5507 FOR INFORMATION ON HUMAN SUBJECTS RESEARCH.

22.1.4 STANDARDS

- 10 CFR Part 745, *The Common Rule for Human Subjects Research*
- DOE Order 1300.3, *Policy on the Protection of Human Subjects*
- DOE Order 4300.2C, *Work for Others*

22.1.5 REFERENCES

- *Protecting Human Subjects at the Department of Energy*, DOE Human Subjects Handbook
- *Guidelines of the Committee for Protection of Human Subjects*, Berkeley Campus (CPHS), September, 1996 (or most recent annual update)

PART II. RESEARCH WITH RADIOACTIVE DRUGS

22.2.1 POLICY

It is the policy of the Laboratory to implement the regulations and policies of the Food and Drug Administration for the use of radioactive drugs in human subjects.

22.2.2 LBNL SUPPORT ORGANIZATIONS

- Human and Animal Regulatory Committees Office
- Radioactive Drug Research Committee

22.2.3 IMPLEMENTATION

It is the responsibility of the Laboratory to review and approve protocols for the use of radioactive drugs in human subjects in accordance with Food and Drug Administration regulations and policies. Investigators are responsible for obtaining the appropriate approval to use a radioactive drug in a human subject prior to requesting protocol approval from the HSC. (See the section of this chapter on *Research with Human Subjects* for information on the HSC.)

22.2.4 RADIOACTIVE DRUG RESEARCH COMMITTEE

The Laboratory maintains a **Radioactive Drug Research Committee** (**RDRC**) in compliance with **Food and Drug Administration** regulations (21 CFR 363.1.) The LBNL RDRC is identified as RDRC #38. The RDRC meets quarterly or more often as required. In addition to its FDA-mandated responsibilities, the RDRC is required by the Laboratory to review the doses of all radiopharmaceuticals administered to human subjects at the Laboratory.

22.2.5 REVIEW AND APPROVAL

For approval purposes, a radiopharmaceutical falls into one of three classifications: experimental, under investigational new drug permit, or commercially available. Basic research involving human use of experimental radiocompounds must be approved by the Laboratory RDRC. Investigators are responsible for filing an **Investigational New Drug (IND)** application with the Food and Drug Administration for qualifying radiopharmaceuticals; such applications are not reviewed by the RDRC. Human subjects protocols involving the use of IND-covered or commercially available radiopharmaceuticals are not reviewed by the RDRC but are reviewed for human subjects approval as described in the section of this chapter on *Research with Human Subjects.*

Protocols calling for the use of an experimental radioactive drug in humans must be submitted at least 90 days in advance of the required approval date. The RDRC reviews the protocol to ensure that pharmacological and radiation doses lie within federal guidelines, that the radiation exposure is justified by the benefits of the research, and that the study meets certain other requirements in investigator expertise and radiation safety.

Protocols approved by the RDRC are automatically forwarded for human subjects approval as described in the section of this chapter on *Research with Human Subjects.*

Investigators using experimental radioactive drugs must additionally file form FDA 2914 quarterly with the RDRC.

CALL THE LBNL HUMAN AND ANIMAL REGULATORY COMMITTEES OFFICE AT (510) 486-5507 FOR INFORMATION ON RADIOACTIVE DRUG RESEARCH.

22.2.6 STANDARDS

- 10 CFR Part 745, *The Common Rule for Human Subjects Research*
- 21 CFR 361.1, *Radioactive Drugs for Certain Research Uses*
- DOE Order 1300.3, *Policy on the Protection of Human Subjects*
- DOE Order 4300.2C, *Work for Others*

22.2.7 REFERENCES

- *Guidelines of the Committee for Protection of Human Subjects*, Berkeley Campus (CPHS), September 1996 (or most recent annual update)

PART III: RESEARCH WITH ANIMALS

22.3.1 POLICY

It is the policy of the Laboratory that all research involving animals performed at or funded through the Laboratory shall be conducted in accordance with the Public Health Service's Policy on Humane Care and Use of Laboratory Animals.

22.3.2 LBNL SUPPORT ORGANIZATIONS

- Human and Animal Regulatory Committees Office
- Animal Welfare and Research Committee

22.3.3 IMPLEMENTATION

22.3.3.1 RESPONSIBILITIES

The Laboratory is responsible for:

- Complying with the Animal Welfare Act and other federal statutes and regulations relating to animals.
- Ensuring that all research involving animals is conducted in accordance with the Public Health Service's *Guide for Care and Use of Laboratory Animals.*
- Maintaining full accreditation of the Laboratory animal colony from the American Association for the Accreditation of Laboratory Animal Care (AAALAC).
- Maintaining an approved Assurance of Compliance (Assurance) with Public Health Service Policy on Humane Care and Use of Laboratory Animals with the Office for Protection from Research Risks (OPRR) of the NIH.

Investigators are responsible for:

- Following the procedures laid out in their approved animal use protocol, taking proper care of laboratory animals used in experiments, and maintaining full approval of their animal use protocols.
- Ensuring that all staff, students, or visitors using animals under their aegis are following an approved protocol and are properly trained to perform the procedures involved.
- Exercising extreme care in observing the letter and the spirit of the Assurance.

22.3.3.2 ANIMAL WELFARE AND RESEARCH COMMITTEE

The **Animal Welfare and Research Committee** (**AWRC**) was formed at the Laboratory in 1975 in accordance with federal statutes and regulations. The AWRC is an Institutional Animal Care and Use Committee with OPRR Multiple Project Assurance #A3054-01. The AWRC meets monthly, or more often, as required.

The AWRC is responsible for:

- Ensuring that all animal research conducted at LBNL complies with the Assurance.
- Reviewing all Laboratory projects involving animals at least annually.
- Reviewing all aspects of the animal care program and inspecting the animal colony and its satellite facilities at least twice a year.

22.3.3.3 PROTOCOL REQUIREMENTS

All research projects involving live vertebrate animals or vertebrate animal tissues or products require prior review and formal approval by the AWRC.

Researchers are responsible for submitting a complete animal use protocol to AWRC for experiments using live vertebrate animals.

The AWRC is responsible for determining whether the activity is in compliance with the following requirements:

- Procedures that involve live animals must avoid or minimize discomfort, distress, and pain to the animals, consistent with sound research design.
- Any procedure that may cause more than momentary or slight pain or distress to the animals must be performed with appropriate sedation, analgesia, or anesthesia. These measures must not be omitted unless there is justification for scientific reasons. If so, investigators are responsible for putting the justification in writing, including a description of the sources used to determine that no alternatives to this procedure exist.
- Animals that would otherwise experience severe or chronic pain or distress that cannot be relieved must be painlessly euthanized at the end of the procedure or, if appropriate, during the procedure.
- Investigators must explain the significance of the research and the need to use animals to achieve the stated research goals in terms understandable to a nonscientist. The proposed research must not duplicate existing data.
- The number of animals proposed for use in an experiment must be justified on the basis of sound research design.
- The living conditions of the animals must be appropriate for their species and contribute to their health and comfort. The housing, feeding, and care of the animals must be directed by a veterinarian or other scientist trained and experienced in the proper care, handling, and

use of the species being maintained or studied. All conditions should conform to the specifications of the *Guide for the Care and Use of Laboratory Animals.*

- Medical care for animals by a qualified veterinarian must be available on an as-needed basis.
- Personnel conducting procedures on the animals must be qualified and trained in those procedures.
- Knowledge of protocol procedures, Laboratory guidelines, and training must be documented on a Protocol Personnel Form.
- Investigators and their staff may be expected to demonstrate their skill or training in the presence of an AWRC representative.
- Methods of euthanasia used must be consistent with the recommendations of the Euthanasia Review Panel of the American Veterinary Medical Association (AVMA). These methods must not be omitted unless there is justification for scientific reasons. If so, investigators are responsible for putting the justification in writing.

22.3.3.4 SPECIAL USE PROTOCOLS

There are four **special use protocols** that may be obtained to allow limited animal use:

- Exempt
- Collaborative
- Shipping
- Facility use

Exempt protocols allow the acquisition and analysis of tissues from public sources such as abattoirs.

Collaborative protocols enable an investigator to acquire and analyze the tissues or products of experimental animals held by another investigator either at the Laboratory or at another institution.

Shipping protocols allow a Laboratory investigator to send animals to another facility.

Facility use protocols allow an investigator from another institution to use the specialized equipment available at the Laboratory.

Collaborative, shipping, and facility use protocols must be reviewed to ensure that the investigator from an outside institution is operating under a protocol approved by an institutional animal care and use committee with a current Assurance. In general, if an outside institution does not have a current Assurance, a full animal use protocol must be filed with the AWRC.

22.3.3.5 APPROVAL PROCEDURES

Requests for approval of projects involving animals must be submitted to the AWRC four weeks before the proposed use of the animals.

Many funding agencies require that certification of AWRC approval be submitted with the proposal. NIH allows a grace period of 60 days following the proposal submission date. To avoid delays in a grant proposal review and funding, certification of animal use protocol approval should be obtained by the time a proposal is submitted to the sponsoring agency.

PROJECTS THAT INVOLVE ANIMALS MUST NOT BE INITIATED UNTIL THE APPROPRIATE ANIMAL USE PROTOCOL HAS RECEIVED AWRC APPROVAL.

Annual reviews by the AWRC are required for continuing projects. The researcher holding the protocol is responsible for submitting renewals in a timely fashion, and for ceasing animal use under protocols which have expired.

All requisite forms and implementing procedures can be found in the *Berkeley Lab Guidelines for Vertebrate Animal Use* and are available through the AWRC office.

22.3.3.6 AUTHORITY TO SUSPEND OR TERMINATE APPROVAL OF RESEARCH

Under the Assurance to the National Institutes of Health (NIH), the Laboratory, upon recommendation by the Committee, has the authority and responsibility to suspend or terminate research that is not being conducted in accordance with AWRC decisions, conditions, and requirements. In addition, United States Department of Agriculture regulations stipulate that research activities may be suspended if the standards for animal welfare, care and housing, or mitigation of pain and distress are not being met.

In case of suspension of research, research shall not resume until the Committee has assurance that the appropriate corrective actions have been implemented.

The reporting requirements for issues and concerns that might involve suspension or termination of research are as follows. The AWRC must report information concerning noncompliance by research investigators to the NIH OPRR. If the AWRC suspends or terminates approval of research, the Committee shall include a statement of the reason for the action and shall report the action promptly to the research investigator, the researcher's Division Director, to Berkeley Lab Sponsored Projects Office, and to the OPRR.

CALL THE LBNL HUMAN AND ANIMAL REGULATORY COMMITTEES OFFICE AT (510) 486-5507 FOR INFORMATION ON ANIMAL USE APPROVAL.

22.3.4 STANDARDS

- 9 CFR, United States Department of Agriculture Animal Welfare Regulations
- 7 U.S.C1. 2131-2157, *The Animal Welfare Act*

22.3.5 REFERENCES

- *Guide for the Care and Use of Laboratory Animals,* U.S. Public Health Service
- *Berkeley Lab Guidelines for Vertebrate Animal Use*

PART IV: GLOSSARY

22.4.1 RESEARCH WITH HUMAN SUBJECTS

A human subject is a living person about whom a researcher obtains (1) data through intervention or interaction or (2) identifiable private information.

Informed consent is consent to participate in research based on a full and complete understanding of the research and any attendant risk.

An **Institutional Review Board** is a board or committee duly authorized by a federal assurance to review human subjects use.

Vulnerable subjects are subjects especially susceptible to coercion or undue influence (including but not limited to the mentally or physically infirm, children, the illiterate, prisoners and parolees, addicts, and the poor).

22.4.2 RESEARCH WITH RADIOACTIVE DRUGS

An **experimental radioactive drug** is a radioactive drug used to obtain basic information regarding the metabolism of the drug or regarding human physiology, pathophysiology, or biochemistry, but not intended for immediate therapeutic, diagnostic, or similar purposes.

An **investigational new drug** is a drug product for human use covered by an investigational new drug permit from the Food and Drug Administration.

A **radioactive drug** is any radioactive compound or isotope which is intended for use in humans.

A **Radioactive Drug Research Committee** is a committee duly authorized by the Food and Drug Administration to review the use of experimental radioactive drugs.

22.4.3 RESEARCH WITH ANIMALS

Animal use is the use of a live vertebrate animal or the product of a live vertebrate animal for research purposes.

An **Institutional Animal Care and Use Committee** is a committee duly authorized under federal regulations to review and approve animal use.

Chapter 23

SEISMIC SAFETY

Revised December 1997

Reviewed by: [signature] 12/9/97
Date

Approved by: [signature] 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 23

SEISMIC SAFETY

23.1 POLICY

23.1.1 POLICY STATEMENT

It is Laboratory policy to design and construct its physical plant and program facilities to prevent the loss of life and to minimize the risk of personal injury, program interruption, and property damage due to earthquakes.

23.1.2 GENERAL POLICY

The intent of these guidelines is to ensure that all Laboratory buildings, structures, program equipment, and heavy shielding are designed to resist a magnitude-7+ earthquake on the Hayward Fault or a magnitude-8.3 earthquake on the San Andreas Fault without collapse. (The occurrence of some structural and nonstructural damage is anticipated and accepted.)

Critical emergency facilities must be designed to remain functional during and after the design earthquakes specified above.

Enclosures and systems containing radioactive or other hazardous, dispersible materials (e.g., toxic, flammable, or infectious substances) must be designed to ensure confinement during and after the design earthquake specified above and to ensure that the acceptable risk, established during the AHD determination by the division, is not exceeded. These enclosures must be inspected by EH&S before any use.

All structural and nonstructural elements of normally unoccupied structures must be designed to prevent damage to building structures and enclosures containing radioactive or other hazardous, dispersible materials.

All structural and nonstructural elements of normally occupied structures must be designed for life safety.

23.1.3 PHYSICAL PLANT FACILITIES

All buildings must be structurally designed by, or under the supervision of, a structural engineer registered in the state of California.

All building projects must be designed on the basis of geological and geotechnical investigations used to establish foundation design values and to assess hazards from fault movement (e.g., landslides and ground motion). No building may be constructed over an active fault, and the proposed location of a building relative to an active fault must be reviewed and approved by the Seismic Safety Subcommittee.

Calculations, drawings, and specifications for buildings must be submitted to the Facilities Department for review before construction, and drawings must be signed and stamped with the registered engineer's seal.

All submissions must contain the following:

- A clear statement of the seismic design criteria used
- A clear description of the lateral-force-resisting system used

Structural design details must be emphasized to ensure a formal and complete lateral-force-resisting system that addresses soil–foundation interaction and ductile-inelastic behavior.

In accordance with the University Seismic Safety Policy dated May 17, 1988, all drawings and calculations for buildings must be formally peer reviewed by an independent, licensed structural engineer.

23.1.4 PROGRAMMATIC FACILITIES

Calculations, drawings, and specifications for programmatic equipment and structures must be approved by the Project Engineer. The Seismic Safety Subcommittee review process is described with the general design criteria for program facilities, below. The Seismic Safety Subcommittee may require that the program engage an outside consultant. Drawings and specifications for massive structures, such as concrete shielding and supports, that affect building elements must be reviewed by a licensed structural engineer.

The Laboratory must provide continuous field inspections during construction and appropriate special inspections as defined by the California Building Code (CBC). The Project Engineer will formally approve final acceptance of the completed project.

23.2 RESPONSIBILITIES FOR SEISMIC SAFETY

23.2.1 SEISMIC SAFETY SUBCOMMITTEE

The Seismic Safety Subcommittee of the LBNL Safety Review Committee is responsible for:

- Establishing LBNL seismic safety policy.
- Being aware of state-of-the-art developments in the seismic response of structures and using this knowledge in the performance of its functions.
- Reviewing the criteria and guidance for the design of structures and special LBNL equipment involving state-of-the-art seismic design issues where appropriate code or institutional criteria may not apply directly or may not exist or where specified in this chapter.

- Determining whether dynamic structural analyses using the LBNL Design Basis Earthquake are required or whether structural analyses based on the Uniform Building Code are sufficient.
- Conducting Seismic Design Review Meetings (see the *Seismic Safety Subcommittee* section in Chapter 1, *General Policy and Procedures*).

The Subcommittee will provide a Design Basis Earthquake (with time-history and spectral-response data) when dynamic analyses are required. The current LBNL Design Basis Earthquake to be applied is specified in *Strong Seismic Ground Motion for Design Purposes at the Lawrence Berkeley Laboratory* (LBNL-32364). The Seismic Safety Subcommittee does not establish risk levels on high-value equipment but, when requested by a program division, will recommend criteria for a given level of risk.

23.2.2 PHYSICAL PLANT FACILITIES

The Facilities Department is responsible for ensuring the seismic safety of physical plant facilities at LBNL, which are designed to comply with existing building codes and regulations.

23.2.3 PROGRAM EQUIPMENT AND SHIELDING

The parent division of a program is responsible for the seismic safety of program equipment and shielding. The Seismic Safety Subcommittee provides guidance to program personnel by conducting Seismic Design Review Meetings for shielding structures and for special LBNL equipment involving state-of-the-art seismic design problems. The Facilities Department may be consulted about the design of program equipment and shielding for seismic safety.

23.2.4 CONTAINMENT FOR RADIOACTIVE, INFECTIOUS, TOXIC, OR PYROPHORIC MATERIALS

EH&S is responsible for the review of the containment facilities for radioactive, infectious, toxic, or pyrophoric dispersible materials.

23.2.5 OPERATIONAL SEISMIC SAFETY

Each division director is responsible for his or her division's implementation of LBNL seismic safety policy. The Environmental Health and Safety Division (EH&S) performs routine operational seismic inspections to ensure that seismic safety programs are carried out.

23.2.6 EARTHQUAKE SAFETY INSPECTION PROGRAM

The Earthquake Safety Inspection Program is carried out periodically by the EH&S OSHA Inspection Team to ensure that industrial and research material, equipment, and hardware are restrained in place to avoid damaging motion resulting from seismic ground motion.

23.3 SEISMIC DESIGN CRITERIA FOR PHYSICAL PLANT FACILITIES

23.3.1 GENERAL

All structures and nonstructural elements of buildings at LBNL must be designed and constructed to withstand all lateral forces (such as wind and seismic forces) in accordance with the CBC and with the DOE's *Facility Safety* (DOE Order 420.1A), unless noted otherwise.

Seismic analysis of buildings and structures must conform with the static lateral force procedures described in CBC Section 2334, unless a dynamic lateral force analysis conforming to CBC Section 2335 is required by CBC Section 2333, by DOE Order 420.1, or by the Facilities Department Head, who is the LBNL-designated Class A member representative of the International Conference of Building Officials (ICBO).

In addition, all buildings and nonstructural components must be designed in accordance with the Facilities Department's *Design Management Procedures Manual* (RD3.22).

Parapets, interior or exterior ornamentation, and exhaust stacks that do not handle extremely toxic, radioactive, or pyrophoric materials are to be designed in accordance with CBC Section 2336.

23.3.2 BRACING AND ANCHORAGE FOR NONSTRUCTURAL ELEMENTS CONTAINING OR SUPPORTING TOXIC, INFECTIOUS, OR PYROPHORIC MATERIALS

These requirements apply to the seismic restraint of nonstructural elements or equipment containing or supporting dispersible extremely toxic, infectious, or pyrophoric materials such as arsine, phosphine, or bromine pentafluoride. The bracing and anchorage of these nonstructural elements located in the occupancies described in the CBC as Group H occupancies; Division 2, Pyrophoric; Division 6, Semiconductor Research Facilities; and Division 7, Toxic Material must conform to the design criteria given below for program facilities.

23.4 SEISMIC DESIGN CRITERIA FOR PROGRAM FACILITIES

23.4.1 GENERAL

When moving into or rearranging work areas, each division is responsible for providing anchorage for seismic resistance of nonstructural building elements (such as research equipment and systems and related vents, plumbing, ducting, electrical wiring and equipment, fixtures, furnishings, and material storage facilities). The seismic restraints must conform to the requirements of this chapter and to the California Building Code (latest version).

Practical Equipment Seismic Upgrade and Strengthening Guidelines (UCRL-15815) provides practical guidelines for implementing an equipment seismic strengthening and upgrading program.

Seismic protection must be provided to research equipment and shielding upon installation, and this protection must be maintained during major maintenance or reassembly.

Seismic Safety Subcommittee Design Review Meetings are conducted by a review committee and are normally convened at the request of the responsible user of the equipment or experiment. The review committee must consist of a majority of the members of the Seismic Safety Subcommittee, including the following:

- The Chairperson of the LBNL Seismic Safety Subcommittee, to act as chair of the meeting
- A structural engineer from the LBNL Facilities Department
- A member of EH&S with appropriate background
- In complex cases, a non-LBNL seismic engineering consultant

The project will be presented to the review committee by a professional member of the project's staff.

The Seismic Safety Subcommittee determines when a dynamic structural analysis based on the Design Basis Earthquake is required and when an equivalent static structural analysis is sufficient. When the use of the Design Basis Earthquake is required, the natural frequencies of the assemblage, representing 90% of the response of the assemblage, must be computed. The maximum stresses must also be shown. The analysis procedure used must be approved by the Seismic Safety Subcommittee.

The locations of heavy objects that are to be placed close to building structural members (columns, bracing, etc.) must be reviewed and approved by the Facilities Department. In certain instances, it may be undesirable to fasten heavy objects securely to a floor, because normal settlement may cause unacceptable warping or misalignment of sensitive elements. It is acceptable to supply the requisite restraint without initial hard contact by allowing a small movement before "motion stops" become effective.

In other instances, when the floor under a heavy object cannot withstand the horizontal earthquake force, it may be desirable to decouple the heavy object from the floor and allow an acceptable, but limited, horizontal motion. The motion must be limited to a few inches and must not permit the heavy object to injure personnel or obstruct an escape route. In all cases, upset (toppling or overturning) must be prevented.

Lateral restraint of stationary objects must be in accordance with the following general guidelines:

- If personnel can be exposed to a life-threatening injury by being struck or trapped by the lateral movement or upset (toppling, overturning) of any object from a seismic disturbance, the movement or overturning of the object must be prevented, without reliance on friction, when the object is subjected to a horizontal acceleration of 0.7g with 75% of the weight effective against overturning. If the object is provided with adjustments, it must resist 0.7g when the adjustments are in the most unfavorable positions. In this context, "stationary object" means an object such as a large detector, magnet, floor-mounted laboratory equipment, work bench, machine, surface plate, platform, or cabinet. Electronic racks and other portable equipment on wheels or casters must conform to the lateral restraint requirements of this section where they may pose a life safety hazard during a seismic disturbance.
- Where the maximum allowable stress and displacement in seismic restraining systems are not specified below, these criteria must be established by the Project Engineer and must be such that life-threatening lateral movement (relative to the support) or overturning will not occur during a horizontal acceleration of 0.7g.
- For equipment or other objects mounted on resilient stands or on floors of resilient buildings, the dynamic load during an earthquake may, because of amplification, greatly exceed the maximum ground acceleration. The Project Engineer must ensure that such stands have sufficient strength and ductility to withstand dynamic loads. Spectral analyses, using the LBNL Design Basis Earthquake (Ref. 23-1), must be used to determine the seismic horizontal acceleration.

23.4.2 RESTRAINT OF SYSTEMS CONTAINING HIGHLY TOXIC, INFECTIOUS, OR PYROPHORIC MATERIALS: DESIGN REQUIREMENTS

These requirements apply to the seismic restraint of systems containing highly toxic, infectious, or pyrophoric materials such as arsine, phosphine, or bromine pentafluoride. They also apply to the anchorages of stacks and ductwork handling highly toxic or infectious materials. Stacks and ductwork handling pyrophorics are exempt from these requirements provided a seismic sensor is installed that will stop gas flow at the gas bottle in the event of an earthquake.

The bracing and anchorage of program research equipment located in the occupancies described in the CBC as Group H occupancies; Division 2, Pyrophoric; Division 6, Semiconductor Research Facilities; and Division 7, Toxic Material must be designed and fastened to resist a lateral force of 2.0g or the force determined by spectral analysis based on the floor or surface on which the equipment is mounted. These seismic restraints must also comply with the allowable design stresses in the CBC and with the ICBO-recommended working loads for proprietary anchor bolts or expansion anchors using the lateral force defined in this paragraph or in *Tentative Provisions for the Development of Seismic Regulations for Buildings* (ATC 3-06), Chapter 8.3.2.

23.4.3 SEISMIC DESIGN CRITERIA FOR CONCRETE SHIELDING

General

The following requirements and guidelines apply to all LBNL concrete-shielding blockhouses, particle-beam shielding, and other structures consisting of large blocks. In view of the developing nature of seismic design philosophy, each concrete-shielding structure to be constructed, modified, or relocated must be reviewed in a Seismic Safety Subcommittee Design Review Meeting.

Whenever dispersible residual radiation (for example, the material used in a radioactive chemistry experiment) must be contained, more stringent safeguards are necessary, and EH&S must be consulted regarding the appropriate requirements.

All shielding structures must be designed to resist static lateral loads applied to the center of gravity from any horizontal direction. Shielding structures must be designed to resist the horizontal acceleration specified below. The intended system of restraint must be described in an Engineering Note containing the supporting calculations.

Elements of a shielding structure must be prevented from moving in any lateral direction with respect to one another by a positive physical interference, such as integral keys, metal plates with end stops, or their equivalent. This requirement does not include the shielding-to-floor interface. Chapter 11 of *The Seismic Safety Guide* discusses the design of concrete-shielding-block structures in detail.

The capacity of the floor to carry lateral loads must be determined. When the floor under a structure cannot withstand the horizontal earthquake force, it may be desirable to decouple the structure from the floor and allow an acceptable, but limited, horizontal motion. This decision must be made by the Project Manager and the Seismic Safety Subcommittee. In all cases, upset of the structure must be prevented. Engineering studies and shake-table tests can be conduced, if necessary, to determine optimal methods of absorbing the lateral load energy of concrete-shielding structures.

When limited horizontal motion of the structure with respect to the floor is permitted during a seismic disturbance, the structure construction must ensure that escape routes for personnel remain open.

Moment arms for resistance of concrete blocks against upset may be calculated with the guidelines shown in Fig. 23.1.

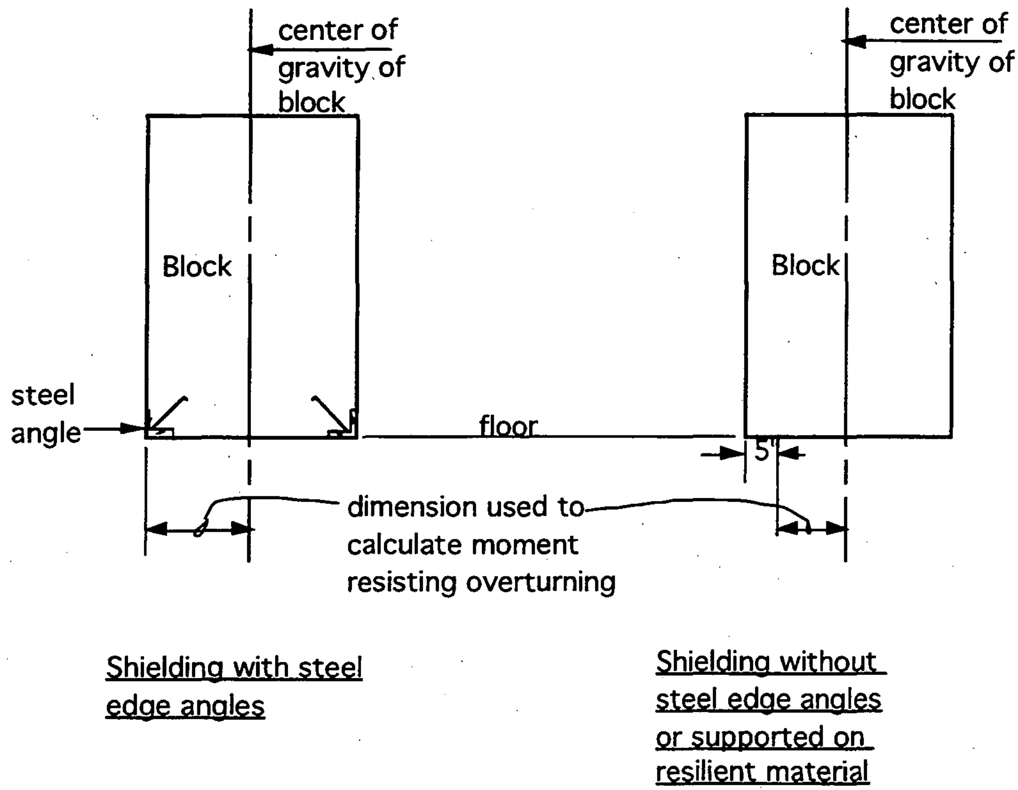

Fig. 23.1. Calculation of moment arms for the resistance of concrete blocks against upset.

The structural integrity of buildings and the continuity of plant services are Facilities Department responsibilities. If shielding is in contact with building elements or is so close that contact is likely during a seismic disturbance, or if shielding is supported, restrained, or braced from the building structure, then the Facilities Department must participate in and approve the design for the lateral restraint of the shielding. Buildings and shielding can be expected to have different motions in response to a seismic disturbance, and they should be made structurally independent whenever possible.

The best seismic defense for shielding is to unify an assemblage of blocks into a single integral structure by using keys, strap plates, tie rods, chains, etc.

Design Requirements

The shielding structure and components in the seismic restraining system must comply with the following design requirements.

When sliding can occur, friction forces between unsecured structures must not be used in these seismic calculations.

Nonductile Shielding Structures. Structures constructed of components or materials that fail in a brittle manner [i.e., are susceptible to sudden failure resulting from elastic (nonlinear) behavior] and that do not exhibit ample reserve strain-energy capacity are considered nonductile structures. One example is a structure made of nonductile reinforced concrete blocks held together with ductile metal attachments that are not configured, or do not have enough mass, to safely absorb the seismic strain energy in the structure. For nonductile structures and bracing systems, the design must be based on the following:

- The base shear must not be less than 0.7g.
- The dead load assumed for calculation of the resisting moment about the center of gravity must not exceed 0.65% of the weight.
- The maximum allowable stress in ductile structural elements must not exceed
  - 75% of the ultimate compressive strength, or the stresses permitted by the UBC, for concrete in bearing or compression. Requirements for reinforced concrete in shear, torsion, or flexure are given in *Building Code Requirements for Reinforced Concrete*.
  - 50% of the ultimate strength for welds.
  - 75% of the manufacturer's recommended ultimate load values, which have been established by testing, for proprietary anchor bolts or expansion anchors that depend on the concrete for their ultimate load capacities.
  - 75% of the ultimate strength for other structural elements.

Ductile Shielding Structures. Structures and their attachments and bracing constructed of materials that exhibit ductile inelastic (nonlinear) behavior at stresses beyond their yield points and that have ample reserve strain-energy capacity beyond their yield points are considered ductile structures. An example is a structure and its attachments made of structural steel having a configuration and mass of ductile metal sufficient to safely absorb the seismic strain energy in the structure. The designer should be aware that a ductile material can be configured in such a way as to result in a nonductile structure or attachment and should seek guidance from the Subcommittee early in the design process. For ductile bracing systems, the design must be based on the following:

- The base shear must not be less than 0.5g.
- The dead load assumed for calculating the resisting moment about the center of gravity must not exceed 75% of the weight.
- The maximum allowable stress in ductile structural elements must not exceed the elements' yield strengths at 0.5g.

23.4.4 SEISMIC DESIGN CRITERIA FOR RADIOACTIVE CONTAINMENT FACILITIES

Scope

Radioisotope control policies at LBNL have been developed to protect both the personnel and the environment at this site from unwarranted exposure to radioisotope hazards.

It is imperative that seismic design criteria be incorporated into normal radioisotope control policies to ensure complete protection of life and the environment.

Seismic design criteria for "critical" areas of containment must follow the guidelines set forth in the DOE's *Facility Safety* (DOE Order 420.1A).

Design Requirements

In Category 1 and 2 facilities, as defined in UCRL 15910, all critical items or equipment associated with critical areas of radioactive containment and special-hazards assemblies must be designed to withstand lateral forces in accordance with the foregoing requirements for concrete shielding. In Category 3 and 4 facilities, all critical items or equipment associated with critical areas of radioactive containment and special-hazards assemblies must be designed to the requirements in UCRL 15910. EH&S is responsible for determining the appropriate category of a facility.

Ground spectra guidelines, based upon a magnitude-7+ earthquake on the Hayward Fault, indicate a peak acceleration of about 0.7g at frequencies less than 10 Hz. Seismic design must be reviewed and approved by the Seismic Safety Subcommittee and EH&S.

The seismic stability of each irradiator unit, shielded radioisotope shipping container, or cask must be evaluated.

23.5 EARTHQUAKE SAFETY INSPECTION PROGRAM

23.5.1 SCOPE

Earthquake safety measures have been developed at LBNL to protect personnel in the event of a seismic disturbance. Sufficient protection is required to allow time for personnel to exit an endangered area without injury. All equipment, hardware, and objects inside and outside buildings must be adequately restrained or anchored to ensure that they do not block escape routes during seismic ground motion. The anchoring system must be analyzed to ensure that the primary support (floor, wall, etc.) is strong enough to support the restrained hardware and equipment during seismic motion.

23.5.2 IMPLEMENTATION AND FOLLOW-UP

The earthquake safety inspection program is carried out by the EH&S OSHA Inspection Team periodically as part of the overall yearly OSHA safety inspection program.

A report of OSHA deficiencies, including seismic deficiencies, is made after a formal inspection and is given to the division director of the inspected facility. A copy is sent to the Building Manager. The Maintenance and Operations Group of the Facilities Department or the sheet metal shop normally will perform the work of anchoring or restraining ordinary items such as shelves, bookcases, file cabinets, etc. The Architectural/Engineering Group of the Facilities Department is responsible for the design and construction of seismic restraints or anchors for any large-mass or special item that has a significant effect on the floor loading or on the building's structure. The responsible user must ensure that any seismic deficiencies are corrected.

23.5.3 NONSTRUCTURAL EARTHQUAKE SAFETY MEASURES

Some earthquake hazards that have been observed in buildings are listed below with recommended corrective measures:

- Bookcases three feet or more in height. Remove, shorten, or fasten these to walls or to the floor.
- File cabinets three feet or more in height. Remove or fasten these to walls or to the floor.
- Storage shelves and bins. Strap separate units together and fasten them to the wall at the top and to the wall or floor at the bottom.
- Install 3/4-inch lips or 10-mm heavy-duty bungee or equal elastic shock cord on book shelves four feet or more in height in situations where shelf contents could cause injury or block egress. The cord should be installed to be 50–60% longer than its length when unstretched. Make sure end hooks are fastened securely.
- Electronics racks. Fasten these to the floor or to walls.
- Electronics racks, tool cases, test equipment, etc. mounted on casters. At least two casters must have locking wheels. Chain or otherwise restrain all heavy mobile equipment when not in use. (This is not always practical—use good judgment.)
- Emergency battery or power-switching systems. Battery cells must be cushioned and restrained within their mounting racks.
- All gas-fired appliances, such as water heaters, space heaters, and furnaces, must be anchored to withstand a force of 0.7g applied laterally at the center of gravity. The appliances must be connected with a short (3-ft maximum), flexible gas line from the local supply valve to the appliance. This requirement applies to all new construction, and this change must be made to existing facilities when they are renovated or modified.
- Paper storage and other heavy items on shelves. Store heavy materials on the floor. When heavy items are stored on shelves or on top of bookcases or file cabinets, the storage surface must not exceed 3 feet in height.
- Glassware, chemical reagents, and other hazardous laboratory equipment. Store these in wall cabinets with secure door latches or in base cabinets. The method of attaching cabinets to walls must be approved by EH&S. Lips must be attached to the outside edges of shelves to prevent hazardous chemicals from sliding off. For general use, make lips of 1/8-inch-thick Plexiglas or equivalent material, 3 inches high.
- Secure personal computers and other expensive desktop equipment with Quakegrip, a Velcro product in stock at the LBNL storeroom.

- Lead bricks. Store loose lead bricks on the floor or on pallets in a reasonably distributed manner. The smallest base dimension should be at least one half the stack height. Bricks stacked or built into shielding walls must have containing frames securely anchored to prevent sliding and overturning.
- Heavy materials or equipment hanging on walls or stored on shelves or in bins. Such materials or equipment must be fastened to their supports. Fasten shelves and bins to prevent sliding and overturning. Store heavy items near floor level. Bins stored outside and near sloped areas should be placed away from the edge to minimize sliding and overturning.
- Trailers and temporary buildings. Anchors and supports must be used to resist vertical and lateral (wind or earthquake) forces. The Facilities Department is responsible for the design and installation of these anchors and supports.
- Emergency escape routes must be kept open, and measures must be taken to prevent blockage during an earthquake.

The above examples of hazards and solutions are general. Each situation merits special consideration to arrive at a practical and economic solution. Proper anchorage is the key to earthquake safety.

The EH&S Division and Facilities Departments are available to advise, make recommendations, and assist in arriving at solutions or in the preparation of job orders when required.

23.6 GLOSSARY

An **active fault** is a fault that has moved within the past 10,000 years. (This definition is mandated by statute in California.)

AHD is an abbreviation for "activity hazard document."

The **Design Basis Earthquake** is the maximum credible earthquake anticipated at the LBNL site.

A **ductile material** is one that exhibits considerable reserve strain energy beyond the yield point.

0.7g represents 70% of the force of gravity.

The **ICBO** is the International Council of Building Officials

A **nonductile material** is one that does not exhibit considerable reserve strain energy beyond the yield point and that characteristically fails in a brittle manner.

The **parent division** of a research program is the division sponsoring the program.

The **Project Engineer** is the engineer in responsible charge of a project or experiment related to a program.

A **stationary object** is any large detector, magnet, machine, work bench, cabinet, or piece of floor-mounted equipment.

23.7 STANDARDS

- DOE Order 420.1A, *Facility Safety*
- CAC Title 24 Building Standards

23.8 REFERENCES

- DOE Standard 1020, *Natural Phenomena Hazards Design and Evaluation Criteria for DOE Facilities*, April 1994
- DOE Standard 1022, *Natural Phenomena Hazards Site Characterization Criteria*, March 1994
- DOE Standard 1023, *Natural Phenomena Hazards Assessment Criteria*, January 1996
- Angliss, F.T., "Lateral Force (Wind and Earthquake) Design Criteria," in *Design Management Procedures Manual*, RD3.22, Rev.1, August 1996
- Angliss, F.T., Hernandez, P., and McClure, F.E., *Derivation of Seismic Lateral Force Coefficient*, Engineering Note M6947, February 1990
- *Building Code Requirements for Reinforced Concrete*, ACI 318-(Latest Version), American Concrete Institute, Detroit, Michigan
- *Design and Evaluation of DOE Facilities Subjected to Natural Hazard Phenomena*, UCRL-15910, U.S. Department of Energy, June 1990
- Newmark, N.M., "Response of Simple Structures to Earthquake Motions," Section 16.Z, in *Earthquake Engineering*, Robert L. Weigel, Ed., Prentice-Hall, 1970
- *Practical Equipment Seismic Upgrade and Strengthening Guidelines*, UCRL-15815, Lawrence Livermore National Laboratory, September 1986
- *Seismic Safety Manual*, UCRL-MA-125085, Lawrence Livermore National Laboratory, September 1996
- *Sliding Response of Rigid Bodies to Earthquake Motion*, LBL-3868, UC-11, Lawrence Berkeley Laboratory, September 1975
- *Strong Seismic Ground Motion for Design Purposes at the Lawrence Berkeley Laboratory*, LBL-32364, Lawrence Berkeley Laboratory, June 1992
- *Suspended Ceiling System Survey and Seismic Bracing Recommendations for Lawrence Livermore National Laboratory*, UCRL-15714, Lawrence Livermore National Laboratory, August 1985
- *Tentative Provisions for the Development of Seismic Regulations for Buildings*, ATC 3-06, Applied Technology Council, Palo Alto, CA, April 1984

Chapter 24

ENVIRONMENT, HEALTH & SAFETY TRAINING

Revised December 1997

Reviewed by: 12/12/97
Date

Approved by: 12/15/97
EH&S Division Director Date

CONTENTS

Chapter 24

ENVIRONMENT, HEALTH & SAFETY TRAINING

24.1 POLICY

It is LBNL policy, and the federal law requires, that all staff, participating guests, visitors, and others who perform work at, or for, LBNL receive appropriate training necessary to protect their health and perform work in a safe and environmentally sound manner. This training must include information regarding job hazards, possible health effects, and required work practices and procedures. The EH&S Training Program has been designed to meet the requirements of the Department of Energy and all other federal, state, and local regulatory agencies.

24.2 OBJECTIVES

The objectives of the EH&S Training Program are:

- To identify all required and recommended environment, health, and safety training.
- To assist line management in assuring satisfactory completion of pertinent EH&S training requirements.
- To provide mechanisms to ensure that such training is completed.
- To provide appropriate document systems to record all EH&S training.
- To ensure training-related records and reports are accessible for use by laboratory senior management and cognizant line management.
- To provide a mechanism to ensure continuous improvement with regard to the EH&S Training Program.
- To provide LBNL employees with knowledge and skills needed to perform work in a safe, healthful, and environmentally protective manner.

24.3 ORGANIZATION

The EH&S Training Program is a collaborative endeavor of the EH&S Division and line management. Line management provides job-specific training and ensures that training requirements are met. The EH&S Division provides training courses to meet regulatory requirements. Maintenance of the Lab-wide training data base system is shared by the EH&S Division, Information Systems and Services, and all other organizations that provide training.

EH&S training requirements should be included as part of each employee's training and development plan.

The EH&S Division publicizes its Training Program by distributing the quarterly publication *Environment, Health and Safety Education Course Information*, which describes courses scheduled for the following three months. The quarterly course announcement is also available electronically, on the LBNL EH&S Home Page-Training Section (http://www-ehs.lbl.gov/html/training .htm). In addition, on the last Friday of each month, *Currents* publishes a calendar of EH&S courses for the following month.

24.4 REQUIREMENTS

24.4.1 GENERAL

Completion of the required EH&S training courses will provide greater assurance that all LBNL personnel know the hazards associated with their jobs, understand the possible health and safety effects of exposure to those hazards, and know how to perform operations safely and in accordance with all environmental protection requirements.

Training requirements originate in DOE Orders, DOE regulations (10CFR), OSHA regulations (29CFR), EPA regulations (40CFR), Department of Transportation regulations (49CFR), the California Code of Regulations (Titles 8 and 22), LBNL's Operating and Assurance Program, and LBNL policies covering specific hazards.

Within six months after starting work at LBNL, personnel must address all pertinent EH&S training requirements associated with their job, as referenced in the training profile, unless specified elsewhere in other policies. In the absence of this assurance, the employee, participating guest, or visitor is allowed to work only under the direct supervision of an employee who has completed such training. A list of EH&S training is available via the LBNL EH&S Home Page-Training Section (http://www-ehs.lbl.gov/html/training.htm). Some training requires a medical examination and approval before certification is issued. Examples of training courses that require a medical examination are *Crane/Hoist Operator Training* and *Half- and Full-Face Mask Respirator Training*. Contact EH&S Training for more information on training requirements.

24.4.2 NEW EMPLOYEES AND PARTICIPATING VISITORS

All new employees and participating visitors must receive basic EH&S orientation information prior to commencing work at LBNL. This information may consist of a suitable combination of reading and video material, including *Health and Safety Handbook, Health and Safety Handbook for Subcontractors and Visitors*, or *Health and Safety for Visitors and Guests and Hazards Alert* video. Recognized site-specific orientation training for guests and visitors at user facilities (such as the Advanced Light Source) is sufficient and deemed as equivalent to institutional orientation programs. All new employees must then attend the course *Introduction to EH&S at LBNL* within the first month after starting work at LBNL. All participating visitors working at LBNL for more than one month must also attend. This course provides general safety orientation and training, including *Introduction to EH&S at LBNL* (EHS-10), *Hazard Communication for Employees* (EHS-392), and *General Employee Radiation Training* (EHS-405).

Additional training and certification are required for work involving special hazards. These training courses are identified for each individual by completing the Job Hazards Questionnaire (See Appendix A or EH&S Web Page-Training Section). Supervisors must follow established procedures for ensuring that data from the Job Hazards Questionnaire are entered into the Lab-wide training data base, the System for Training Assessment and Records (STAR). Toward this end, the Job Hazards Questionnaire is available on-line (via the EH&S Home Page-Training Section) for completion, submittal, and automated update of the LBNL training database. New employees and participating visitors who will be at LBNL for more than three months must complete the Job Hazards Questionnaire within the first month of employment. The STAR database then will generate an individualized Training Profile identifying EH&S training requirements and recommendations. For more information on specific EH&S training, please refer to the associated chapters in this manual, such as *Lasers*, *Lockout/Tagout*, *Radiation Protection*, or *Industrial Hygiene*.

24.4.3 RETRAINING AND RECERTIFICATION

Regulations and policy may require periodic retraining and recertification. Examples are the forklift and crane training program, which require recertification every three years, and the laser safety training program, which also requires retraining every three years. The individual's Training Profile will indicate when retraining is due, and if it is overdue.

24.4.4 COMPLETION OF TRAINING

Personnel must attend the entire training course and pass any examinations to receive credit. In some cases, such as the chemical safety training course, it is possible to take a written and/or practical examination in lieu of course attendance and receive course credit by passing the examination. Consult with course instructors or EH&S Training about this option.

In the event that a trainee fails a written or practical examination, the instructor should provide remedial instruction and the trainee must repeat the examination.

24.4.5 EH&S TRAINING FOR PERSONNEL AT OFF-SITE LOCATIONS

All LBNL employees working at off-site locations, including UC Berkeley-controlled spaces (i.e., Appendix J spaces), are required to adhere to ES&H training requirements as stipulated by any host institution. In the absence of such requirements or in the event training requirements are not deemed equivalent, LBNL requirements shall be completed. These requirements can be identified by completing the Job Hazards Questionnaire. In some cases, facility- or procedure-based safety training specific to the location will fulfill an LBNL training requirement. For example, training connected with hazardous waste handling or confined space entry, which covers specific procedures for an off-site facility, may be provided by the institution controlling the work space. Similarly, radiation safety training requirements may be site specific, depending on whether the facility is DOE- or University-controlled.

24.4.6 WAIVERS FOR EH&S TRAINING REQUIREMENTS

Under special circumstances, a waiver may be granted to a person who is normally required to complete a training course indicated on a Training Profile. For example, line management may exercise its judgment in waiving a training requirement for staff in a particular area where significant experience and proficiency is evident.

24.4.7 JOB-SPECIFIC TRAINING

Job-specific EH&S training can include on-the-job training (OJT), formal mentoring, hazard-specific training, or training given off-site by another facility or organization.

OJT is formal training conducted and evaluated in the work environment through interaction between line management and the employee. It is designed to teach the employee how to perform a task or operation and is often used to supplement general EH&S training. For example, once the employee has completed *Training for Hazardous Waste Generators* (EHS-604), the supervisor should then train the employee about the location of the local Satellite Accumulation Area and the procedures for handling hazardous waste in his/her laboratory or shop.

Hazard-specific training explains the specific health and safety hazards of an operation and must include information on health effects, risks, and proper means of protection. For example, the supervisor must provide training regarding the safe handling of specific chemicals in connection with the operations that the employee performs. Off-site training is often necessary to maintain competence in a specialized field and may be included as part of an employee's training and development plan.

It is highly recommended that job-specific training be planned, delivered, and documented in a manner similar to that of all other EH&S training. Written documentation that describes the training and the means to evaluate successful completion should be kept by the line organization that develops and provides the training. Such record keeping is a line management responsibility.

The requirements for identifying job-specific training may be included in the Job Hazards Questionnaire, in a section containing division or facility-specific questions. If these training requirements are not included in the Job Hazards Questionnaire, then line management must develop other methods to identify personnel needing the training.

Educational materials, such as videos, pamphlets, and fact sheets on specific hazards, as well as technical assistance, are available from EH&S to help line management design and deliver job-specific training.

24.5 DOCUMENTATION

24.5.1 SYSTEM FOR TRAINING ASSESSMENT AND RECORDS (STAR)

All EH&S training must be documented and retained in a readily accessible manner. The STAR database system provides a centralized means to capture pertinent EH&S training data. Data concerning courses include: course name, course code, instructor name(s), length of the course, retraining or recertification cycle, and class date. Data on students include: the participant's name, employee number, and examinations successfully passed. If the student fails to pass an examination, the student does not receive credit for the course until the examination is passed.

Individual employee training reports, including Training Profiles, are available through the LBNL Web Site, through the Integrated Reporting and Information System (IRIS-page www.iss.lbl.gov/cgi-vin/login). In addition, training records can always be requested from EH&S. Different types of training reports are available on the STAR menu. Users with a CSA account may access STAR and generate training reports by using the Toolkit in FOCUS. Documentation regarding STAR, as well as instructions concerning access, is available from the Information Systems and Services Department (ISS).

24.5.2 JOB HAZARDS QUESTIONNAIRE

All personnel, including managers, staff, and participating visitors working at LBNL for more than three months, are required to complete the Job Hazards Questionnaire (JHQ) to identify pertinent training requirements. New personnel must complete the JHQ within the first month after starting work at LBNL. It is recommended that personnel on-site for less than three months also complete the JHQ. A copy of the JHQ is included as Appendix A; a web version of the JHQ is available for data entry via the LBNL EH&S Home Page-Training Section (http://www-ehs.lbl.gov/html/training.htm).

The JHQ is a tool to help managers and supervisors identify which EH&S training requirements their employees must satisfy. The answers on the questionnaire lead to a series of training requirements/recommendations (known as the Training Profile) based on the work environment and hazards that may be encountered by an employee.

Subsequent to JHQ data entry for new staff and updated information associated with existing staff, supervisors and staff should engage in dialogue to assure the appropriateness of identified training requirements. Line management at this time can make the decision to add and/or delete requirements identified through the JHQ process. Such decisions can be based on demonstrated on-the-job training commensurate with the hazard, or satisfactory demonstration of equivalent training requirements through experience prior to employment at the Berkeley Lab. Line management is responsible for retaining supporting information in this regard and updating the database to reflect the appropriate training status; EH&S technical staff are available to offer assistance in this endeavor.

Such tracking of training requirements is the responsibility of line management. Each employee's JHQ must be reviewed and updated as appropriate, on an annual basis. In any event, the questionnaire will be updated when the nature of an employee's work environment and hazards change (i.e., significant change).

The divisions may use the JHQ to help personnel identify required or recommended job-specific training courses developed by line management. To facilitate this, a set of division-specific questions can be added. Contact EH&S, ext. 6571, for assistance in developing job- or division-specific training questions.

The employee or his/her supervisor may complete the employee's JHQ. However, it is the responsibility of the line supervisor to ensure appropriate review of the provided information takes place. For those employees who are matrixed to other divisions, the matrix supervisor must also review the information.

Once the data have been entered, the Training Profile can be generated. The Training Profile shows ES&H requirements and recommendations. If a requirement has been satisfied, the Training Profile shows when it was completed and when retraining or recertification is necessary. The Training Profile is a tool to enable line management to track completion of EH&S training requirements. The Training Profile is available as a report choice in the STAR database.

Completed and signed JHQs must be maintained in the division's files. The location of the resulting Training Profiles should be referenced in the appropriate Facility, Project, or Function Notebook(s). Documentation concerning the use of the JHQ is available from EH&S or from ISS.

24.6 EH&S COURSE APPROVAL

The EH&S Division has developed a procedure (EH&S Division Procedure 2.01, 12/5/95) for approving and evaluating EH&S training courses, as well as a policy on instructor qualifications. Contact EH&S (ext. 6571) for copies or for further information.

24.7 RESPONSIBLE PARTIES

The EH&S Training Program is the shared responsibility of the EH&S Division and the line management organization of LBNL. Individuals and groups must implement the following aspects of the EH&S Training Program:

24.7.1 EMPLOYEES/PARTICIPATING VISITORS

- Attend *Introduction to Environment, Health and Safety at LBNL,* which is the new employee health and safety orientation, within the first month after starting work at LBNL.

- Satisfy all EH&S training requirements within the first six months after beginning work at LBNL, unless specified differently in other policies.
- Are allowed to work only under the direct supervision of trained personnel until such training requirements are completed.

24.7.2 SUPERVISORS

- Complete, or have the employee complete, the Job Hazards Questionnaire to identify EH&S training requirements and recommendations. Review and update each employee's JHQ annually or more frequently based on significant changes in work assignment.
- Identify EH&S training requirements and other training needs specific to the job responsibilities, operations, and hazards to which their personnel may be exposed.
- Ensure that all personnel under their supervision satisfy pertinent training requirements.
- Provide job- and hazard-specific orientation and training for new personnel, and for all personnel whenever procedural changes or system modifications have an impact on safety. Maintain written documentation of all such training.
- Include EH&S training requirements in annual employee training plans and performance expectations and assess completion in annual performance and progress reviews.

24.7.3 MATRIX SUPERVISORS

- Identify EH&S training requirements and other training needs specific to the job responsibilities, operations, and hazards to which their personnel may be exposed.
- Review and sign completed Job Hazards Questionnaires.

24.7.4 DIVISION MANAGEMENT

- Identify any division-specific training requirements and provide such training.
- Enter training requirements data from the Job Hazards Questionnaire in the STAR database. Maintain signed JHQs in division files.
- Maintain records for job-specific and hazard-specific training and orientation in the STAR database.
- Provide staff time to attend required EH&S training.
- Assess supervisors' oversight of EH&S training completion in their annual performance and progress review.

24.7.5 EH&S TRAINING

- Assist line management in assuring satisfactory completion of pertinent EH&S training requirements.

- Oversee the EH&S Training Program, including design, implementation, and evaluation of the program.
- Review and assure content of EH&S training courses.
- Provide tools such as the Job Hazards Questionnaire to enable line management to meet EH&S training needs.
- Maintain documentation for all training courses provided by the EH&S Division, including records in the STAR database.
- Provide technical assistance to EH&S course instructors and to line management on their EH&S and job-specific training needs and program.

24.7.6 USER ADVISORY COMMITTEE

- Facilitates the design and implementation of an integrated EH&S training program to better serve LBNL customer needs and meet requirements for compliance and internal policy, using best management practice.
- Develops an improved communication infrastructure between LBNL staff and management levels that will guarantee effective and timely reporting on EH&S training issues.
- Promotes a greater understanding throughout the Laboratory community of EH&S training requirements and opportunities.
- Supports and encourages the LBNL staff efforts that integrate job performance standards with personal and collective safety considerations.
- Includes individuals from these LBNL groups:
  - DOE–Berkeley Site Office
  - Senior Staff Scientists
  - Division Safety Coordinators
  - Safety Review Committee Chairpersons
  - Environment, Health, and Safety Division
  - Building/Facility Supervisors
  - EH&S Course Instructors
- Functions as an advisory committee reporting to the EH&S Division Director on matters related to the continuous quality improvement of institutional EH&S training.
- Reviews background information and analyses of Lab EH&S training programs, policies, guidelines, and regulatory interpretations, and provides recommendations to the Deputy Director of Operations and EH&S Division Director on strategies to enhance efficacy, compliance, and relevance of training systems and programs to the Berkeley Lab community, enabling them to work safely.

24.8 STANDARDS

- 29 CFR 1910, *General Industrial Safety Orders*
- 29 CFR 1926, *OSHA Construction Standards*

24.9 RELATED PUB-3000 CHAPTERS

- *Electrical Safety* (Chapter 8)
- *Emergency Management* (Chapter 9)
- *Ergonomics* (Chapter 17)
- *Hazardous Waste Disposal* (Chapter 10)
- *Lasers* (Chapter 16)
- *Lockout/Tagout* (Chapter 18)
- *Occupational Safety* (Chapter 5)
- *Personal Protective Equipment* (Chapter 19)
- *Pressure Safety and Cryogenics* (Chapter 7)
- *Radiation Protection* (Chapter 21)

24.10 REFERENCES

- *Chemical Hygiene and Safety Plan*, PUB-5341, Lawrence Berkeley Laboratory, April 1992
- *Operating and Assurance Program Plan*, PUB-3111, Lawrence Berkeley Laboratory, July 1994
- Environment, Health and Safety Division Function Notebook

24.11 APPENDICES

- Appendix A. Job Hazards Questionnaire

APPENDIX A. JOB HAZARDS QUESTIONNAIRE

PAGE 1

EH&S TRAINING REQUIREMENTS:
JOB HAZARDS QUESTIONNAIRE

Employee/Guest Name: ______________________________ Date: ____________

Employee/Guest Number: ______________________________

Supervisor: ______________________________ Division: ____________

Matrix Supervisor: ______________________________ Matrix Div. ____________

***** Read each question carefully keeping in mind the section title *****

YES RESPONSES LEAD TO THE REQUIRED AND/OR RECOMMENDED COURSES INDICATED.

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____________GENERAL____________

A01 __Y __N Is the employee/guest working at LBNL on the main site, Donner, Calvin, 903, 934, 936 or 938 (not just on campus) for more that 30 days?

Required:	EHS0010	INTRODUCTION TO EH&S AT LBL
	EHS0392	HAZARD COMMUNICATION EMPLOYEE TRAINING
Recommended:	EHS0135	EARTHQUAKE SAFETY
	EHS0405	GENERAL EMPLOYEE RADIATION TRAINING

A02 __Y __N Was the employee/guest hired before January 1982, or is s/he a rehired retiree, who originally began work at LBNL before that date?

A03 __Y __N Does the employee/guest use a computer for more than an average of 4 hours/day?

Recommended:	EHS0060	ERGONOMICS FOR COMPUTER USERS

A04 __Y __N Does the employee/guest routinely enter posted "Controlled Areas" which are designated for radiation protection, but is NOT a radiation worker?

Required:	EHS0405	GENERAL EMPLOYEE RADIATION TRAINING
	EHS0406	GERT REFRESHER *

____________SPECIAL ASSIGNMENTS____________

B01 __Y __N Is the employee/guest a division Environment, Safety, and Health Coordinator?

Recommended:	EHS0060	ERGONOMICS FOR COMPUTER USERS
	EHS0067	OFFICE ERGONOMICS EVALUATORS TRAINING
	EHS0261	ELECTRICAL SELF-ASSESSMENT TRAINING
	EHS0348	CHEMICAL HYGIENE/SAFETY TRAINING
	EHS0604	HAZARDOUS WASTE GENERATOR TRAINING

* Indicates refresher courses.

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SPECIAL ASSIGNMENTS Continued

B02 __Y __N Is the employee/guest a member of the Division's self-assessment team, or the self-assessment coordinator?

Recommended:	EHS0261	ELECTRICAL SELF-ASSESSMENT TRAINING
	OAA0802	SELF ASSESSMENT INSPECTOR TRAINING

B03 __Y __N Is the employee/guest a Division Director or a Division designee for occurrence reporting?

Required:	EHS0800	OCCURRENCE REPORTING AND PROCESSING

B04 __Y __N Is the employee/guest a building manager or a member of the building emergency team?

Required:	EHS0116	FIRST AID-4HR-3YR CERTIFICATION
	EHS0123	CPR-3HR-2YR CERTIFICATION
	EHS0154	EMERGENCY TEAM TRAINING
	EHS0530	FIRE EXTINGUISHER SAFETY
Recommended:	EHS0135	EARTHQUAKE SAFETY

B05 __Y __N Is the employee/guest a member of the Lab-wide Emergency Command Center Team?

Required:	ECC0002	ECC ORIENTATION TRAINING

B06 __Y __N Does the employee/guest work in any environment other than an office, and/or directly supervise those who do?

*********** If no, please skip to the required signatures at the end and sign.
If yes, continue filling out the questionnaire.

RADIATION PROTECTION

C01 __Y __N Does the employee/guest work with unsealed radioactive material, sealed sources, operate an x-ray machine, or work at the 88" Cyclotron? (If no, skip to next section.)

C02 __Y __N Does the employee/guest work with unsealed radioactive material?

Required:	EHS0400	RADIATION PROTECTION-FUNDAMENTALS
	EHS0432	RADIATION PROTECTION - LAB SAFETY

C03 __Y __N Does the employee/guest work with sealed sources?

Required:	EHS0400	RADIATION PROTECTION-FUNDAMENTALS
	EHS0438	SEALED RADIOACTIVE SOURCE TRAINING

* Indicates refresher courses.

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____________________RADIATION PROTECTION______Continued______

C04 __Y __N — Does the employee/guest work at the 88" Cyclotron?

Required:	EHS0400	RADIATION PROTECTION-FUNDAMENTALS
	EHS0439	RAD PROTECTION-ACCELERATOR BEAMLINE

C05 __Y __N — Does the employee/guest generate radioactive and/or mixed waste that is stored in a designated and posted Satellite Accumulation Area (SAA)?

Required:	EHS0604	HAZARDOUS WASTE GENERATOR TRAINING
	EHS0622	RADIOACTIVE AND MIXED WASTE GENERATOR

C06 __Y __N — Does the employee/guest operate an x-ray machine, e.g., diffraction unit cabinet x-ray machine?

Required:	EHS0410	X-RAY MACHINE SAFETY

____________________CHEMICAL USE____________________

D01 __Y __N — Does the employee/guest handle/use hazardous chemicals (e.g., corrosive, flammable, reactive, toxic) or routinely work where these are present?

Required:	EHS0348	CHEMICAL HYGIENE/SAFETY TRAINING

D02 __Y __N — Does the employee/guest generate hazardous waste that is stored in a posted Satellite Accumulation Area(SAA) or Waste Accumulation Area(WAA)?

Required:	EHS0604	HAZARDOUS WASTE GENERATOR TRAINING

____________________PRESSURE SAFETY____________________

E01 __Y __N — Does the employee/guest use, or work on/with pressure systems involving compressed gases(EXCLUDING HOUSE AIR), vacuum systems, and/or cryogenics? (If no, skip to next section.)

E02 __Y __N — Does the employee/guest use compressed gases, up to 150 psi, that include components such as regulators, valves, tubing, or gauges (NO VESSELS)?

Required:	EHS0231	COMPRESSED GASES

E03 __Y __N — Does the employee/guest use pressure vessels, compressed gas systems > 150 psi, or pressure systems with liquid > 1500 psi?

Required:	EHS0230	PRESSURE SAFETY ORIENTATION

E04 __Y __N — Does the employee/guest use vacuum systems and/or cryogenics?

Recommended:	EHS0231	COMPRESSED GASES

* Indicates refresher courses.

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ELECTRICAL SAFETY

F01 __Y __N Does the employee/guest work in a research lab or shop area, but is NOT an electrician or electronics technician?

Required: EHS0260 BASIC ELECTRICAL HAZ AWARENESS: RESEARCH

F02 __Y __N Is the employee/guest an electrician or electronics technician?

Required: EHS0250 ELECTRICAL SAFETY/QUALIFIED ELEC WORKERS
Recommended: EHS0123 CPR-3HR-2YR CERTIFICATION

F03 __Y __N Is the employee/guest an electrician or electronics technician who serves as a required safety watch for hazardous electrical operations?

Required: EHS0123 CPR-3HR-2YR CERTIFICATION

LOCKOUT/TAGOUT

G01 __Y __N Does the employee/guest service, maintain, modify, or work on equipment where an unexpected release of energy is a possibility?

One Required: EHS0256 LOCKOUT/TAGOUT TRAINING - OSHA STANDARDS
EHS0257 LOCKOUT/TAGOUT - TRAINING BY SUPERVISOR

RESPIRATORY PROTECTION

H01 __Y __N Does the employee/guest use respiratory protection or directly supervise those who do? (If no, skip to next section.)

H02 __Y __N Does the employee/guest use a half or full-face respirator?

Required: EHS0310 RESPIRATOR TRAINING

H03 __Y __N Does the employee/guest have emergency response responsibilities where use of self-contained breathing apparatus (SCBA) may be necessary?

Required: EHS0315 SELF-CONTAINED BREATHING APPARATUS TRG

H04 __Y __N Does the employee/guest use an air-line supply respirator?

Required: EHS0312 AIR-LINE SUPPLY RESPIRATOR TRAINING

H05 __Y __N Does the employee/guest ONLY directly supervise users of respiratory protection, but does NOT use a respirator themselves?

Required: EHS0318 TRG FOR SUPERVISORS OF RESPIRATOR USERS

* Indicates refresher courses.

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MATERIAL HANDLING

I01 __Y __N Does the employee/guest operate cranes, hoists, and/or forklifts or is a designated trainer for those who do? (If no, skip to next section.)

I02 __Y __N Does the employee/guest operate a forklift?

Required:	EHS0225	FORKLIFT CERTIFICATION
	EHS0226	FORKLIFT RECERTIFICATION TRAINING *

I03 __Y __N Does the employee/guest operate cranes or hoists?

Required:	EHS0206	CRANE & HOIST OPERATOR TRAINING
	EHS0207	RECERTIFICATION (FOR CRANE EHS0206) *

I04 __Y __N Is the employee/guest a designated crane/hoist or forklift trainer?

Required:	EHS0208	HOIST, CRANE & FORKLIFT INSTRUCTOR
	EHS0209	RECERTIFICATION (FOR CRANE EHS0208) *

CONFINED SPACES

J01 __Y __N Does the employee/guest perform work in a confined space (e.g., tanks, ducts, trenches, underground vaults)?

Required:	EHS0275	CONFINED SPACE HAZARDS

J02 __Y __N Does the employee/guest use atmospheric testing instruments for confined spaces?

Required:	EHS0270	GAS DETECTOR INSTRUMENTATION

J03 __Y __N Does the employee/guest directly supervise those who perform work in a confined space?

Recommended:	EHS0275	CONFINED SPACE HAZARDS

OTHER HAZARDS: RESEARCH DIVISIONS

K01 __Y __N Does the employee/guest work for, or is matrixed to, a research division (AFRD, E&E, ESD, LSD, MSD, CSD, NSD, Physics, SBD, NERSC)? (If no, skip to next section.)

K02 __Y __N Does the emp./guest handle human blood/products, tissue cultures, spores, bacteria, viruses, or other possibly infectious material of human origin?

Required:	EHS0737	BLOOD BIOSAFETY & MEDICAL WASTE TRAINING
	EHS0738	BLOOD BIOSAFETY RETRAINING *

* Indicates refresher courses.

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______________OTHER HAZARDS: RESEARCH DIVISIONS______Continued______

K03 __Y __N Does the employee/guest operate a Class 3B or Class 4 laser (does not include laser printers or laser pointers)?

Required: EHS0280 LASER SAFETY

K04 __Y __N Does the employee/guest ONLY directly supervise a Class 3B or 4 laser user?

Recommended: EHS0280 LASER SAFETY

K05 __Y __N Does the employee/guest work at the Advanced Light Source (ALS)?

Required: ALS1001 SAFETY AT THE ADVANCED LIGHT SOURCE
EHS0405 GENERAL EMPLOYEE RADIATION TRAINING
EHS0406 GERT REFRESHER *

K06 __Y __N Does the employee/guest do field work at a site which may be contaminated with hazardous materials or is an uncontrolled haz waste site?

Required: EHS0652 HAZ WASTE OPS&ER TRAINING/40 HOUR
EHS0654 HAZ WASTE OPS&ER TRAINING/8HR REFRESH *

K07 __Y __N Does the employee/guest drive, transport, or package hazardous and/or radioactive materials?

Required: MAT0002 DOT HAZARDOUS MATERIALS TRANSPORT REGS
MAT0003 HAZARDOUS MATERIALS TRAINING RECERT. *

K08 __Y __N Does the employee/guest work in or occupy a high-noise area, where the average noise level is above 85 dBA (normal conversation is difficult)?

Required: EHS0285 HEARING CONSERVATION

K09 __Y __N Is the employee/guest the designated responsible person for a Waste Accumulation Area (WAA)?

Required: EHS0610 WASTE ACCUMULATION AREAS

K10 __Y __N Does the employee/guest weld, grind, sand, or work on painted surfaces where paint particles could become airborne?

Required: EHS0330 LEAD HAZARDS AWARENESS

K11 __Y __N Does the employee/guest melt lead in operations other than electronic soldering?

Required: EHS0330 LEAD HAZARDS AWARENESS

K12 __Y __N Does the employee/guest handle extensive amounts of lead bricks (more than 20 bricks per work shift)?

Required: EHS0330 LEAD HAZARDS AWARENESS

* Indicates refresher courses.

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OTHER HAZARDS: SUPPORT DIVISIONS

L01 __Y __N Does the employee/guest work for a support division (Operations, EH&S ICSD, Engineering, Facilities) and is not matrixed to other divisions? (If no, skip to next section.)

L02 __Y __N Does the employee/guest perform work on construction/renovation projects where contact with radioactive material or contamination is possible?

Required: EHS0420 SAFETY ORIENTATION

L03 __Y __N Does the employee/guest work at the Advanced Light Source (ALS)?

Required: ALS1001 SAFETY AT THE ADVANCED LIGHT SOURCE
EHS0405 GENERAL EMPLOYEE RADIATION TRAINING
EHS0406 GERT REFRESHER *

L04 __Y __N Does the employee/guest drive, transport, package, or sign manifests for hazardous and/or radioactive materials?

Required: MAT0002 DOT HAZARDOUS MATERIALS TRANSPORT REGS
MAT0003 HAZARDOUS MATERIALS TRAINING RECERT. *

L05 __Y __N Does the employee/guest work in or occupy a high-noise area, where the average noise level is above 85 dBA (normal conversation is difficult)?

Required: EHS0285 HEARING CONSERVATION

L06 __Y __N Does the employee/guest remove or disturb (i.e., machine, penetrate, or pulverize) asbestos-containing materials (e.g., floor tiles, roofing)?

Required: EHS0322 ASBESTOS WORKER TRAINING-EPA/OSHA
EHS0323 ASBESTOS WORKER REFRESHER - 8 HRS *

L07 __Y __N Does the employee/guest directly supervise workers who remove asbestos- containing materials?

Required: EHS0324 CONTRACTOR/SUPERVISOR ASBESTOS TRAINING
EHS0325 CONTRACTOR/SUPERVISOR ASBESTOS REFRESH *

L08 __Y __N Does the employee/guest do field work at a site which may be contaminated with hazardous materials or is an uncontrolled haz waste site?

Required: EHS0652 HAZ WASTE OPS&ER TRAINING/40 HOUR
EHS0654 HAZ WASTE OPS&ER TRAINING/8HR REFRESH *

L09 __Y __N Does the employee/guest operate GUN POWDER-Actuated fastening tools?

Required: EHS0242 POWDER ACTUATED TOOL TRAINING

* Indicates refresher courses.

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______OTHER HAZARDS: SUPPORT DIVISIONS______Continued______

L10 __Y __N Is the employee/guest a designated operator of a waste Fixed Treatment Unit in Building 2, 25, 70A, 70F, 76, or 77?

Required:	EHS0650	HAZ WASTE OPS & ER TRAINING/24 HR.
	EHS0654	HAZ WASTE OPS&ER TRAINING/8HR REFRESH *

L11 __Y __N Is the employee/guest a Radiation Control Technician in the EH&S Division?

Required:	EHS0480	RCT PHASE FUNDAMENTALS
	EHS0485	RCT APPLIED TRAINING
	EHS0487	RCT ASSIGMENT-SPECIFIC TRAINING

L12 __Y __N Is the employee/guest the designated responsible person for a Waste Accumulation Area (WAA)?

Required:	EHS0610	WASTE ACCUMULATION AREAS

L13 __Y __N Does the employee/guest weld, grind, sand, or work on painted surfaces where paint particles could become airborne?

Required:	EHS0330	LEAD HAZARDS AWARENESS

L14 __Y __N Does the employee/guest melt lead in operations other than electronic soldering?

Required:	EHS0330	LEAD HAZARDS AWARENESS

L15 __Y __N Does the employee/guest handle extensive amounts of lead bricks (more than 20 bricks per work shift)?

Required:	EHS0330	LEAD HAZARDS AWARENESS

______WASTE MANAGEMENT______

M01 __Y __N Is the employee/guest a member of the Waste Management Group (WM) in the EH&S division? (If no, skip to next section.)

M02 __Y __N Is the employee/guest a member of the Hazardous Waste Handling Facility (HWHF) Operations Group?

Required:	EHS0116	FIRST AID-4HR-3YR CERTIFICATION
	EHS0123	CPR-3HR-2YR CERTIFICATION
	EHS0530	FIRE EXTINGUISHER SAFETY
	EHS0652	HAZ WASTE OPS&ER TRAINING/40 HOUR
	EHS0654	HAZ WASTE OPS&ER TRAINING/8HR REFRESH *
	ENV0630	HWHF CONTINGENCY PLAN TRAINING
	ENV0645	RCRA PART B TRAINING
	ENV0646	RCRA, PART B ANNUAL RE-TRAINING *
	ENV0821	HAZARDOUS MATERIALS SAMPLING TRAINING
	ENV6392	SITE-SPECIFIC HAZARD COMMUNICATION

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WASTE MANAGEMENT Continued

M03 __Y __N Is the employee/guest a member of the Operations Group who handles radioactive waste at HWHF?

Required:	ENV1820	CHARACTERIZATION
	ENV1825	PROCESSING LLW,MW,TRU WASTE AT HWHF
	ENV1827	ON SITE TRANSFER OF RAD AND MW TO HWHF
	ENV1828	OFFSITE TRANSFER OF RAD AND MW TO HWHF
	ENV1829	TRACKING OF LLW, MW, AND TRU WASTE
	ENV1833	DISCHARGE OF LL,DECAYED AQUEOUS WASTE
	ENV1840	QA AND COMPACTION OF SOLID LLW
	ENV1845	PACKAGING OF LL ADSORBED TRITIUM
	ENV1850	CONSOL. OF MW IGNITABLE LIQUIDS IN UNITH
	ENV1868	RELEASE OF HAZARDOUS WASTE FROM RMA
	ENV1883	EMPTY CONTAINER DISPOSAL

M04 __Y __N Is the employee/guest a member of the Certification Team?

Required:	EHS0654	HAZ WASTE OPS&ER TRAINING/8HR REFRESH *
	ENV0630	HWHF CONTINGENCY PLAN TRAINING
	ENV0645	RCRA PART B TRAINING
	ENV0646	RCRA, PART B ANNUAL RE-TRAINING *
	ENV1820	CHARACTERIZATION
	ENV1829	TRACKING OF LLW, MW, AND TRU WASTE
	ENV1845	PACKAGING OF LL ADSORBED TRITIUM
	ENV6392	SITE-SPECIFIC HAZARD COMMUNICATION
One Required:	EHS0650	HAZ WASTE OPS & ER TRAINING/24 HR.
	EHS0652	HAZ WASTE OPS&ER TRAINING/40 HOUR

M05 __Y __N Is the employee/guest a member of the Compliance Team?

Required:	EHS0654	HAZ WASTE OPS&ER TRAINING/8HR REFRESH *
	ENV0630	HWHF CONTINGENCY PLAN TRAINING
	ENV0645	RCRA PART B TRAINING
	ENV0646	RCRA, PART B ANNUAL RE-TRAINING *
	ENV1820	CHARACTERIZATION
	ENV1829	TRACKING OF LLW, MW, AND TRU WASTE
	ENV6392	SITE-SPECIFIC HAZARD COMMUNICATION
One Required:	EHS0650	HAZ WASTE OPS & ER TRAINING/24 HR.
	EHS0652	HAZ WASTE OPS&ER TRAINING/40 HOUR

* Indicates refresher courses.

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__________WASTE MANAGEMENT_____Continued______

M06 __Y __N Is the employee/guest responsible for certification of waste for shipment to TSDFs?

Required:	ENV0653	HANFORD WASTE DESIGNATION TRAINING
	ENV1831	HANFORD'S DOCUMENTATION RELEASE PROCED.

M07 __Y __N Is the employee/guest a member of the Waste Minimization Generator Assistance Team?

Required:	EHS0654	HAZ WASTE OPS&ER TRAINING/8HR REFRESH *
	ENV0653	HANFORD WASTE DESIGNATION TRAINING
One Required:	EHS0650	HAZ WASTE OPS & ER TRAINING/24 HR.
	EHS0652	HAZ WASTE OPS&ER TRAINING/40 HOUR

M08 __Y __N Does the employee/guest supervise personnel or serve in the Waste Mangement Team Leader position?

Required:	EHS0653	HAZ WASTE OPS AND ER TRAIN. FOR SUPERVIS

M09 __Y __N Is the employee/guest responsible for training HWHF personnel?

Required:	ENV0651	TRAIN THE TRAINER

M10 __Y __N Is the employee/guest responsible for procurement of material at HWHF?

Required:	ENV1822	CONTAINER PROCURMENT, RECEIPT,& CONTROL

M11 __Y __N Is the employee/guest a member of the WM group responsible for the HWHF inspection and/or WAA inspection?

Required:	ENV1815	INSPECTIONS

__________88" CYCLOTRON ACTIVITIES__________

N01 __Y __N Does the employee/guest work at the 88" Cyclotron? (If no, skip to required signature area.)

N02 __Y __N Is the employee/guest a Cyclotron Operator?

Required:	NSD1002	VAULT RADIATION SURVEY PROCEDURE TR
	NSD1003	EXPERIMENTAL AREA SURVEY PROCEDURE TR
	NSD1004	VAULT SEARCH & SECURE PROCEDURE TRAINING
	NSD1005	PIT SEARCH & SECURE PROCEDURE TRAINING
	NSD1006	TRENCH SEARCH & SECURE PROCEDURE TR
	NSD1007	CAVES SEARCH & SECURE PROCEDURE TR
	NSD1016	VAULT ROOF SEARCH & SECURE PROCEDURE TR
	NSD1017	BLDG.88 LOTO PROCEDURE TRAINING

* Indicates refresher courses.

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____________________88" CYCLOTRON ACTIVITIES______Continued______

	Required:	NSD1018	OXYGEN DEFICIENCY HAZARD SURVEY PROC TR
		NSD1019	SLAMMER VALVE OPERATING PROCEDURE TR
		NSD1020	OPERATORS AIDS POSTING PROCEDURE TR
		NSD1021	SHIFT CHANGE-OVER PROCEDURE
N03 __Y __N	Does the employee/guest perform electronic maintenance (EM), electronic installation (EI), or electrician duties at the Cyclotron?		
	Required:	NSD1001	SAFETY CHAIN CHECK PROCEDURE TRAINING
		NSD1017	BLDG.88 LOTO PROCEDURE TRAINING
N04 __Y __N	Does the employee/guest operate a crane at the Cyclotron?		
	Required:	NSD1023	DEFLECTOR BLOCK MOVING PROCEDURE TR
N05 __Y __N	Does the employee/guest perform Mechanical Technician duties at the Cyclotron?		
	Required:	NSD1022	CYCLOTRON RF RESONATOR TANK ENTRY PROC
N06 __Y __N	Does the employee/guest run experiments using the Cyclotron beam?		
	Required:	NSD1007	CAVES SEARCH & SECURE PROCEDURE TR
		NSD3002	88" CYCLOTRON SHIFT EXPERIMENTER TR
N07 __Y __N	Does the employee/guest use the isobutane flammable gas system?		
	Required:	NSD2165	FLAMMABLE GAS AND PROCEDURE TRAINING
N08 __Y __N	Does the employee/guest use the 88" Machine Shop on an occasional basis?		
	Required:	NSD3003	EXPERIMENTER MACHINE SHOP SAFETY TRAIN.

* Indicates refresher courses.

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Signatures:

Employee	Supervisor	Date
Date	Matrix Supervisor	Date