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**Lawrence Berkeley Laboratory**

**Radiological Control  
Manual**

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## **PART 1 Lawrence Berkeley Laboratory (LBL) Radiological Control Manual**

### **110 Introduction**

This Lawrence Berkeley Laboratory Radiological Control Manual (LBL RCM) has been prepared by Lawrence Berkeley Laboratory to provide guidance for site-specific additions, supplements, and clarifications to the DOE Radiological Control Manual. The guidance provided in this manual is based on the requirements given in Title 10 Code of Federal Regulations Part 835, Radiation Protection for Occupational Workers, DOE Order 5480.11, Radiation Protection for Occupational Workers, and the DOE Radiological Control Manual. The information given in this manual is also intended to be consistent and compatible with the guidance provided in the Implementing Guides and Technical Guides issued by the DOE-HQ EH &ER organizations.

The LBL RCM and LBL Publication-3000, when taken in total, incorporate all of the DOE Radiological Control Manual (DOE RCM). Thus, the LBL RCM replaces the DOE RCM and will be revised as necessary to ensure that current requirements from Rules, Orders, and the DOE RCM are represented. The LBL RCM will form the implementation manual for the LBL Radiological Control Program.

The system of identification of Articles used in the DOE RCM is retained in the LBL RCM. Deviations from the DOE RCM are documented on EXCEPTION forms, copies of which can be found at the back of the document.

### **111 Radiological Control Policy**

A key element of the Radiation Protection Guidance to the Federal Agencies for Occupational Exposure approved by President Reagan on January 20, 1987, and a fundamental principle underlying this Manual is:

*"There should not be any occupational exposure of workers to ionizing radiation without the expectation of an overall benefit from the activity causing the exposure."*

The Department of Energy is firmly committed to having a Radiological Control Program of the highest quality. This applies to those DOE activities that manage radiation and radioactive materials and that may potentially result in radiation exposure to workers, the public, and the environment.

**DEPARTMENT OF ENERGY RADIOLOGICAL CONTROL POLICY****ALARA**

Personal radiation exposure shall be maintained As-Low-As-Reasonably-Achievable (ALARA).

Radiation exposure of the work force and public shall be controlled such that radiation exposures are well below regulatory limits and that there is no radiation exposure without commensurate benefit.

**OWNERSHIP**

Each person involved in radiological work is expected to demonstrate responsibility and accountability through an informed, disciplined, and cautious attitude toward radiation and radioactivity.

**EXCELLENCE**

Excellent performance is evident when radiation exposures are maintained well below regulatory limits, contamination is minimal, radioactivity is well controlled, and radiological spills or uncontrolled releases are prevented.

Continuing improvement is essential to excellence in radiological control.

**112 Manual Applicability and Control**

Throughout this document, DOE RCM is used to identify the DOE EH Radiological Control Manual. LBL RCM is used to identify the Lawrence Berkeley Laboratory Site Radiological Control Manual.

The DOE RCM establishes practices for the conduct of radiological control activities under the auspices of DOE. The DOE RCM states DOE's positions and views on the best courses of action currently available in the area of radiological controls. Accordingly, the provisions in the DOE RCM shall be viewed by LBL as an acceptable technique, method or solution for fulfilling their duties and responsibilities. The LBL RCM shall be used by DOE Office of Nuclear Safety in evaluating the performance of LBL. For Lawrence Berkeley Laboratory, the contractor is the University of California.

The DOE RCM is not a substitute for Regulations; it is intended to be consistent with all relevant statutory and regulatory requirements and shall be revised whenever necessary to ensure such consistency. Some of the DOE RCM provisions, however, challenge the user to go well beyond minimum requirements. Following the course of action delineated in the DOE RCM will result in achieving and surpassing related statutory or regulatory requirements.

1. The LBL RCM is a living document. LBL intends to review and update provisions on a periodic basis to incorporate lessons learned and suggestions for improvement. The Radiation Control Manager is responsible for this task. Recommendations to correct or improve the LBL RCM are encouraged and should be sent to the Radiation Control Manager.

Similarly, the Assistant Secretary for Environment, Safety and Health is responsible for reviewing and updating the DOE RCM. Recommendations to correct or improve the DOE RCM are encouraged and should be sent to the Radiological Control Program Advisor (Article 151) of the Program Secretarial Officer (PSO) responsible for the affected work activity through DOE-SF, Director for Energy Research (ER). Information copies should also be sent to the other members of the Radiological Control Coordinating Committee (Article 153). The Program Secretarial Officer will transmit such recommendations to the Office of Environment, Safety and Health for consideration. The recommended wording of the change, as well as the basis and justification for the change, should be included.

2. The Department of Energy intends to incorporate by reference the provisions in the DOE RCM into contracts or regulatory plans, as appropriate. These incorporated provisions shall be enforceable pursuant to the contract or underlying regulations. No exception to or interpretation of an incorporated provision shall be made except as provided pursuant to the contract. When incorporating a provision, DOE shall approve an implementation plan that includes a compliance schedule. It is expected that implementation of the LBL RCM will occur in a phased manner over a period of time consistent with the schedules and resources identified in the DOE-approved implementation plan.
3. In those cases where contractors or subcontractors are used to conduct DOE-funded radiological activities at non-DOE sites or facilities, and such organizations do not possess a U.S. Nuclear Regulatory Commission (NRC) or Agreement State license for the proposed activity, the application of this Manual is required. The lead Program Secretarial Official and the Office of Environment, Safety and Health shall be included in the review and concurrence process in these situations. In those cases at non-DOE sites or facilities where a specific activity is being conducted pursuant to an NRC or Agreement State license, the provisions of the DOE RCM are not binding to that activity.
4. The LBL RCM shall be kept current and should be entered into LBL's document control system.
5. The provisions of the DOE RCM do not apply to facilities and activities of the Naval Nuclear Propulsion Program, which are separately covered under Executive Order 12344 (42 U.S.C 7158, note) and patients undergoing medical treatment at a DOE or DOE-funded facility.

### 113 Compliance

1. The DOE RCM sets forth DOE's views on the proper course of action in the area of radiological control within the scope of DOE sponsored activities. If a user fully implements a provision, the user will have complied with, and most likely exceeded, any related statutory, regulatory, or contractual requirement. When incorporated into contracts, the provisions of the DOE RCM are binding requirements. The words "shall" and "should" have the meaning below when a provision is incorporated into a contract.
2. The word "shall" identifies those elements and requirements that have been considered and found by DOE to be mandatory unless prior approval of an alternative approach is obtained from DOE Headquarters. If a contractor wishes to implement an alternative approach, the contractor shall submit the suggested alternative approach to the lead Program Secretarial Official for review. Prior to final approval by the lead Program Secretarial Official, other effected Program Secretarial Officials and the Office of Environment, Safety and Health shall concur on the suggested alternative approach. The submittal shall contain the description of the alternative approach, the technical rationale and basis, the suggested wording and justification that the alternative will achieve equal or improved performance employing equal or better techniques, solutions or methods.
3. The word "should" means the contractor has the responsibility of either following the provision or demonstrating technical equivalency by an alternative solution. The use of "should" recognizes that there may be site- or facility-specific attributes that warrant special treatment and that literal compliance with the elements and requirements of the provision may not achieve the desired level of radiological control performance. In those cases where a contractor decides to follow an alternative technique, approach or method in lieu of the "should" provision, the following actions are required:
  - The alternative solution shall be documented, with supporting technical basis, analysis and justification to demonstrate technical equivalency.
  - Prior to implementation, the approval of the Radiological Control Manager and LBL's Senior Line Manager responsible for Operations shall be required. DOE approval is not required nor expected.
  - The documented justification, including the required approvals, shall be readily retrievable for review and audit by DOE.
  - At the conclusion of each calendar year LBL shall provide to the DOE Field Office Manager and the lead Program Secretarial Officer, a tabulation of all such equivalency determinations approved within the past 12 months. For ease of reference, these may be referred to as Article 113 determinations.

**114 Site-Specific Manual**

1. Since LBL is a single contractor multiple facility site, LBL has determined that a single site-specific radiological control manual is the most effective method of providing consistent guidance for implementation of the DOE RCM at the LBL site. This LBL RCM consists primarily of the DOE RCM as written with site-specific additions, supplements, and clarifications. These additions are included in the appropriate chapters and are in or directly referenced to the corresponding Article in the DOE RCM. It is intended that the LBL RCM address unique situations and provide more detailed and prescriptive direction. Any conflicts with or significant changes to the requirements of the DOE RCM have been identified and documented on "EXCEPTION" forms located in Appendix 1E of the LBL RCM.
2. This LBL RCM has been issued by the Associate Director of Operations and endorsed by LBL's Senior Site Executive and the Radiation Control Manager. The contractor Senior Site Executive is that person at a DOE contractor-operated facility or site who has final on-site corporate authority and is often called President, General Manager, Site Manager, or Director.
3. Management policies, requirements, expectations and objectives for the site Radiological Control Program should be clearly and unambiguously stated.
4. The Site-Specific Manual shall be kept current and entered into LBL's document control system.
5. Subcontractors shall comply with the LBL RCM.
6. Where DOE employees are conducting the transport of nuclear devices or components, a Program Specific Radiological Control Manual, based upon the provisions of the DOE RCM, shall be issued and approved by the DOE Field Office Manager. Controlled copies of such Manuals shall be provided to the lead Program Secretarial Officer.
7. The initial approval of the LBL RCM by the Senior Site Executive or designee includes approval of the original EXCEPTIONS to the DOE RCM in place at the time of the initial approval.
8. Future EXCEPTIONS to the DOE RCM or the LBL RCM shall receive signature approval of LBL's Senior Site Executive or his delegate.

### 115 Application of Requirements

1. LBL has organizations that generally meet the requirements presented in the DOE RCM. It is not the intent of the DOE RCM to unnecessarily create new or separate organizations if those functions can be incorporated into existing ones. For example, the Radiological Awareness Committee functions of Article 132.3 may be performed by the existing Division safety committee. It is expected, however, that the existing Committee's charters be revised to reflect the requirements and emphasis of the DOE RCM. Similarly, titles such as Radiological Control Manager and Radiological Control Technician that are used in the DOE RCM may locally be designated differently. A phased approach to transition to the use of the titles of positions in the DOE RCM should be adopted. Corresponding position descriptions and organizational charts should be revised to accurately reflect required radiological responsibilities.

The following table lists the titles and organizations given in the DOE RCM with the comparable title and organization for LBL.

<u>RCM</u>	<u>LBL</u>
Radiological Control Organization	Radiation Assessment Group
Radiological Control Manager	Radiation Assessment Group Leader / Radiological Control Manager
Radiological Control Technician	Health and Safety Technician
Radiological Awareness Reports System	To be incorporated in charter changes to existing safety committees
Radiological Awareness Committee	Divisional Safety Committees
ALARA Committee	ALARA Executive Committee and ALARA Working Committee

While the titles for the various organizations and positions are different, the corresponding position descriptions and organization charts reflect the radiological responsibilities.

2. The degree of program formality and extent of the associated administrative process are expected to be commensurate with the radioactive material contamination and dose equivalent potential of each LBL Facility. At low doses and low amounts of radioactivity some program elements may be satisfied by brief policy statements.

## 116 User Groups

1. Contractors are encouraged to establish informal working associations that promote dialogue among the Radiological Control Organizations from similar or comparable facilities. User Groups should include representation from various contractors. Assignment of members to the user groups should be on a rotating basis.

LBL will be participating in informal working associations that promote dialogue among the Radiological Control Organizations of similar facilities. LBL is a participant in an ER Multi-purpose Laboratory User Group. The establishment of these User Groups is a recent development; assignment of members and protocol has yet to be developed.

2. To assist contractors in identifying and adopting proven practices and implementing procedures in a timely manner within the DOE Complex, contractors, through the User Groups, are encouraged to develop Radiological Work Practices Handbooks that can be used by a given category or class of facilities associated with the User Group.

Suggested User Group categories:

- Reactors
- Uranium
- Environmental Restoration/Waste Management
- Plutonium
- Tritium
- Accelerators
- Large Research and Development Laboratory Operations
- Small Research and Development Laboratory Operations (annual collective effective dose equivalent of one person-rem or less)

The development of such Handbooks should be coordinated with the Office of Environment, Safety and Health. LBL has participated in the Accelerator Good Practice handbook.

## **PART 2 Leadership in Radiological Control**

Superior, consistent performance is achieved, when qualified personnel use approved procedures, and management actively monitors the workplace and assesses ongoing activities. Such activities include, but are not limited to, operations, remediation, laboratory work, research and development, and cleanup. Constant review and informed interest by senior management is required to achieve a superior Radiological Control Program. Management leads by example. What management does speaks louder than what management says. Management at all levels should emphasize the need for high standards for radiological control through direct communication, instruction, and inspection of the work space. The DOE Field Office Manager and LBL's Senior Site Executive responsible for the site should have a basic knowledge of radiation, its effects, and radiological control requirements. The DOE Field Office Manager and LBL's Senior Site Executive should also be familiar with the current radiological performance record. Key principles common in a successful, well-managed Radiological Control Program are provided in this Chapter.

### **121 Senior Management Commitment**

1. Senior managers are expected to establish high standards for the performance of radiological control. These standards and management expectations should be frequently communicated to the work force.
2. Senior managers should state in writing their firm commitment to a Radiological Control Program of the highest quality (see Appendix 1A). Management commitment and support are demonstrated by allocating sufficient resources including personnel and providing for training to ensure workers are qualified for their assigned duties.
3. Managers are expected to ensure that orientation, training, and indoctrination reinforce rules and guidelines for each worker to minimize radiation exposure and control radioactivity.
4. Managers are expected to hold workers and their supervisors accountable for radiological control performance. Relevant knowledge and performance should be assessed as a specific part of each person's performance evaluation. This assessment should not be limited to those who perform radioactive work, since many other workers have an impact on the Radiological Control Program.
5. Senior managers should solicit feedback from their radiological control professionals, line management, and workers on radiological control performance.
6. Senior managers are expected to adopt and promote a positive attitude toward radiological control that encourages initiatives to identify concerns at an early stage, to prevent problems from deteriorating, and to promote doing the right job correctly the first time.
7. Prevention of the spread of radioactivity is less costly than remediation. Management should be willing to accept change that will improve radiological control and should foster this mindset throughout the organization.

8. Senior managers shall require and approve radiological improvement goals. Goals should be measurable, realistic, auditable, and challenging. Established goals should not be changed without technical justification and senior management approval. Senior management shall review progress toward the goals at least quarterly.
9. A performance indicator program for measuring and trending the effectiveness of the Radiological Control Program against predetermined goals should be established and maintained.
10. The authority and responsibility to establish a comprehensive and effective radiological control training program is expected to be assigned to EH&S managers and their subordinates. Training should be provided by the EH&S Division by knowledgeable and trained instructors, but the responsibility for quality and effectiveness rests with the line management.
11. Senior managers should be alert to opportunities for minimizing the generation of radiological waste and discharges to the environment, controlling contamination at its source, and reducing radiation exposure to workers and the public.
12. Reporting a problem to a superior (LBL or DOE) does not absolve the manager from promptly fixing or mitigating a situation.

## **122 Worker Attitude**

Minimizing worker radiation exposure can be achieved only if all persons involved in radiological activities have an understanding of, and the proper respect for, radiation.

1. Each worker is expected to understand that proper radiological control is an integral part of their daily duties.
2. Improving the attitude of the work force should be supported by the training program. To achieve this, training personnel need to be knowledgeable about the work environment and those aspects of radiological control that are important to developing a better worker attitude and perspective.
3. The attitude that constant improvement is required in radiological work needs to be developed at all levels of management and in the work force. Cooperation between the work force and the Radiological Control Organization has to be developed and fostered. The workers should not look upon radiological controls as hurdles or restrictions to be bypassed.
4. Radiological Control Organization personnel should be helpful in showing workers how to follow the rules. This spirit of cooperation needs to be developed without subverting the control functions of the Radiological Control Technicians. A situation in which radiological controls are left solely to the Radiological Control Organization is unacceptable.

**123 Worker Responsibilities**

Trained personnel should recognize that their actions directly affect contamination control, personnel radiation exposure and the overall radiological environment associated with their work. The following radiological control rules are applicable to each person in the workplace. A poster that displays the worker responsibilities, (presented on the next page), should be produced and displayed at appropriate access points and work areas at LBL.

This required poster should appear in a sufficient number of places to permit individuals engaged in DOE authorized activities to observe them on the way to or from any particular DOE authorized activity location to which the document applies, should be conspicuous, and should be replaced if defaced or altered.

**OBSERVE THESE RULES  
TO MINIMIZE YOUR RADIATION EXPOSURE AND CONTROL RADIOACTIVITY**

**OBEY**

- Posted, written and oral radiological control instructions and procedures, including instructions on Radiological Work Permits.
- "Evacuate" and "stop work" orders from Radiation Assessment personnel promptly.

**DO NOT**

- Loiter in radiation areas.
- Smoke, eat, drink, or chew in Contamination Areas, High Contamination Areas, Airborne Radioactivity Areas, and Radioactive Material Management Areas.

**BE SURE TO**

- Wear personnel monitoring devices where required by Radiological Work Permits, signs, procedures, or by radiological control personnel.
- Report immediately the loss, damage, or unexpected exposure of personnel monitoring devices or off-scale readings of self-reading dosimeters to the Radiation Assessment Group.
- Keep track of your radiation exposure status and avoid exceeding radiological Administrative Control Levels.
- Wear Personal Protective Equipment and clothing properly whenever required by Radiological Work Permits or postings.
- Minimize the spread of potential radioactive spills and promptly notify the appropriate personnel of all spills.
- Avoid contact of skin, clothing, and equipment with contaminated surfaces.
- Place contaminated tools, equipment, and solid waste items on disposable surfaces, such as plastic sheets, when not in use.
- Notify Radiation Assessment personnel (x5251) of alarming or faulty radiological control equipment.
- Notify Radiation Assessment, Dosimetry personnel (x7497) of off-site occupational radiation exposures so that worker dosimetry records can be updated.

**PRIOR TO ENTERING AREA**

- Assure that you are mentally alert and in physically sound condition.
- Limit the amount of material taken into contaminated areas to minimize radioactive waste and future decontamination.

**UPON LEAVING AREA**

- Properly remove Personnel Protective Equipment and clothing to minimize the spread of contamination.
- Frisk or be frisked for contamination (excluding Tritium) when leaving posted Contamination, High Contamination, or Airborne Radioactivity Areas, and associated Radiological Buffer Areas and notify Radiation Assessment personnel (x5251) when contamination is found.
- Self-monitor, as a minimum, hands and shoes after working with radioactive material, where automatic counters are provided and when directed by line management or the Radiation Assessment Group.

## 124 Radiation and Risk Communications

Due to the continuing concerns of many people related to low radiation exposure and health impacts, managers should be trained to deal with the perception of personnel concerning radiation risks. Managers and first-line supervisors should be sensitive to the fact that workers have to understand the fundamentals of radiation, its risks, and their role in minimizing exposure. It is not sufficient to rely solely on regulatory limits for establishing or defining acceptable work practices and work environments.

1. Appropriate personnel should receive training which is helpful in their dealing with workers who have anxiety about radiation. This training should include:
  - a. Guidance on handling such personnel interactions
  - b. Emphasis on being factual
  - c. Fundamentals of communicating risks.
  
2. Some personnel, such as those who may have internal deposition of radionuclides from prior years, are concerned about future exposures. Such instances warrant special attention on the part of the manager. Counseling with such personnel should be the preferred way to consider relevant factors. In some cases Special Control Levels (Article 216) should be applied.

## 125 Conduct of Radiological Operations

1. This Manual is consistent with the guidance in DOE 5480.19, "Conduct of Operations Requirements for DOE Facilities." The concepts of all chapters of DOE 5480.19 apply to the conduct of radiological control.
2. Managers at all levels are expected to be involved in the planning, scheduling and conduct of radiological work. Assurance of adequate radiological safety should not be compromised to achieve production, remediation, or research objectives.
3. Supervisors should be technically knowledgeable and inquisitive and should ask questions of the work force concerning radiological work details to assure and demonstrate worker understanding and comprehension.
4. Line managers should periodically monitor work areas to observe personnel at work and to identify radiological deficiencies and concerns. Frequent inspections and walk-throughs, including off-hours and weekends (where appropriate), are essential to reinforce management expectations to the work force.
5. Managers, supervisors, and workers are expected to be involved in the development of accurate, clear, written procedures for performing radiological work. If during the use of procedures a written requirement cannot be responsibly followed, the work should be stopped and guidance obtained.

6. Supervisors and managers should encourage the work force to identify radiological control deficiencies and concerns. Prompt action should be taken to address and eliminate identified issues and prevent recurrence. Retraining, indoctrination, and procedure review are useful in addressing these issues.
7. Managers and supervisors should establish working conditions that encourage improved radiological control. This includes temperature, humidity and lighting as well as the more difficult considerations of accessibility. Work conditions should be considered in planning work.
8. Cleanliness and good housekeeping are essential. A good Radiological Control Program cannot exist in a sloppy, dirty workplace. Cleaning up after operations should be automatic for each person. It is not reasonable to expect radiological control to be separated from the work environment; they go together.
9. Subcontractors and subcontracted employees should be treated the same as facility staff in the area of radiological matters, should have comparable training, and shall meet the same requirements and expectations.
10. Conditions that could cause or promote the spread of contamination, such as a leaking roof or piping, should be identified and corrected on a priority basis.

### **126 Improving Worker Awareness of Radiological Conditions**

In performing assigned duties within radiological areas, workers should be familiar with the area radiological conditions and be aware of the possibility that conditions may change due to unforeseen reasons. Although the conduct of radiological surveys is viewed as a traditional role of Radiological Control Technicians, experience has shown that properly trained and qualified workers are capable of performing supplemental radiological monitoring in the course of work. This process results in exposure savings and improved contamination control.

Specific examples of monitoring that may be effectively performed by workers and result in ALARA exposure reductions include self-monitoring of dose rates during High Radiation Area entries and the monitoring of tools and equipment for contamination as a qualitative check during work in Contamination Areas. The performance of legal record surveys such as release surveys remains the responsibility of qualified Health and Safety Technicians.

### **127 Critiques**

It is the Department's desire and expectation, based on concern for the safety and well-being of workers and the general public, that radiological work practices be continually scrutinized and questioned so that opportunities for improvement can be identified, assessed, and incorporated into the DOE RCM and the LBL RCM.

A formal process should be established to obtain pertinent facts following an unusual radiological situation or at the satisfactory conclusion of a new or unusual operation involving radiological controls. This process complements the Occurrence Reporting System of DOE 5000.3A. The process should be used to quickly establish facts in chronological order so that the underlying reasons or causes for the success or failure are well understood. Work force participation should be encouraged. Critiques are a management tool and should not be used to "fix blame" or restrict exchange of information.

## **128 Facility Modifications and Radiological Design Considerations**

1. Radiological control performance is affected by human performance and engineered design features. The LBL RCM primarily addresses the way people operate and use existing facilities and sites. Many existing designs do not incorporate current radiological control requirements. Designs for new facilities and major modifications to existing facilities should be based on the following additional radiological control design criteria:
  - a. Individual worker dose should be ALARA and less than 500 mrem per year.
  - b. Discharges of radioactive liquid to the environment are covered by the provisions of DOE 5400.5 and should not degrade the ground water.
  - c. Control of contamination should be achieved by containment of radioactive material through engineering controls where applicable.
  - d. Efficiency of maintenance, decontamination, and operations should be maximized.
  - e. Components should be selected to minimize the buildup of radioactivity.
  - f. Support facilities should be provided for donning and removal of protective clothing and for personnel monitoring, where appropriate.
  - g. Neutron quality factor of 20 should be used for design purposes.
2. Facilities currently under construction should be evaluated and the above criteria applied where practicable.
3. Existing facility designs that have office space and lunchrooms or eating areas within Radiation Areas, High and Very High Radiation Areas, Contamination and High Contamination Areas, Airborne Radioactivity Areas, Radioactive Material Areas, and Radiological Buffer Areas require priority attention. Generally:
  - a. Locating lunch rooms or eating areas, restrooms, drinking fountains, showers, and similar facilities and devices is strongly discouraged within these areas.
  - b. Locating office spaces within these areas is strongly discouraged; to the extent that such space is essential to support radiological work, steps should be taken to preclude unnecessary occupancy. Office spaces that exist within RMMA should be free of radioactive material.

## **PART 3 Improving Radiological Performance**

### **131 Radiological Performance/ALARA Goals**

Goals are intended as a measure of and a motivation for improvement, not an end in themselves. These performance indicators are not to be viewed narrowly as numerical goals. These indicators should be used as tools to assist management in focusing their priorities and attention. The following are examples of goals that may be appropriate:

1. Person-Rem of Collective Exposure: This goal should be based upon planned activities and historical performance and should include internal and external (Photon and Neutron).
2. Number of Skin and Personal Clothing Contamination Occurrences: Personnel contaminations may indicate a potential breakdown of controls intended to prevent the spread of contamination.
3. Number of Intakes of Radioactivity: Personnel intakes of radioactivity should be minimized and management should focus attention on any failure of the controls that results in intakes.
4. Square Feet of Contaminated Area (within buildings): Operating with a smaller contaminated area results in less radioactive waste, fewer personnel contaminations and improved productivity. The reduction of existing contaminated areas needs to be balanced by the recognition that this generates radioactive waste. Goals for both should be correlated.
5. Cubic Feet of Radioactive Waste: Minimizing the generation of radioactive waste reduces the environmental impact of DOE operations, helps reduce personnel exposure, and reduces costs associated with handling, packaging, and disposal.
6. Curies of Liquid and Airborne Radioactivity Released: Minimizing effluents reduces the environmental impact of DOE operations and reduces the costs associated with remediation.

### **132 Management of Radiological Performance/ALARA Goals**

1. The LBL Senior Site Executive or designee shall establish, approve, and maintain a radiological performance goals program. Annual LBL radiological performance goals are stated in Appendix 1C and are reviewed on an Annual Basis. LBL radiological performance goals are the LBL site ALARA goals.
2. The performance goals should be measurable, achievable, auditable, challenging, and meaningful in promoting improvement.
3. Performance/ALARA goals need to be developed primarily by those responsible for performing the work. LBL will include active participation of the work force through Division and Facility Safety Committees.

4. Radiological performance/ALARA goals should be reviewed at least annually and revised as appropriate. Normally, more stringent goals should be set annually to reflect the improved radiological performance at the facility. Occasionally, a goal may be made less stringent to accommodate changes in work load or mission.

### 133 Radiological Performance Reports

1. The Radiological Control Manager should provide a periodic summary report to LBL's Senior Site Executive for sites which exceed an annual collective dose of one person-rem. This report will be quarterly. This report should include at least the radiological performance goals established in accordance with Article 131. Examples of indicators that provide a more detailed analysis of performance are identified in Table 1-1. Indicators should be contained in the report for the quarter as well as tracking and trending for the prior twelve-month period. Instructions for preparation of the Quality Radiological Performance Indicator report are given in Appendix 1D.
2. The Personnel Dosimetry Office should provide radiation exposure information, such as supplemental dosimeter readings, to supervisors and managers on a frequent enough basis to permit priority management of exposure control. The frequency should be consistent with the nature of the workload and the radiation exposure potential. The Hazardous Waste Operations Manager should provide waste generation information in a similar manner.
3. To promote worker awareness of their radiation exposure status, selected indicators related to their work group should be posted in the workplace.
4. Reports on Radiological Performance Indicators shall be provided to DOE-SF annually on the Performance Indicator Report Form shown in Figure 1.1 of Appendix D. The report should include status of progress on the Radiological Performance Goals given in Article 131 and the Radiological Performance Indicators given in Table 1-1. Radiological Performance Indicators which do not apply to a contractor should be marked "Not Applicable."
5. The following criteria should be used in reporting the status of the Radiological performance Goals and Indicators:
  - facial contamination is considered detectable contamination on the face on or inside the sealing area of a full-face respirator.
  - positive bioassay as a Performance Indicator is considered to be a confirmed intake resulting in a dose equal to or greater than the Investigation Level as defined in the Internal Dosimetry Program Implementation Guide.
  - airborne event is an event that leads to a detection of airborne radioactive material other than natural radioactivity in an area not controlled and posted as an Airborne Radioactivity Area.

*Table 1-1 LBL Radiological Performance Indicators*

<b>Exposure control</b>	
a.	Collective dose
b.	Average worker dose
c.	Maximum dose to a worker
d.	Number of unplanned exposures resulting in doses greater than the Administrative Control Level
e.	Number of dose assessments for lost or damaged dosimeters
f.	Maximum neutron dose to a worker
<b>Personnel contamination</b>	
a.	Number of skin and personal clothing contaminations
b.	Number of contaminated wounds
c.	Number of facial contaminations
<b>Control of internal exposure</b>	
a.	Number of positive bioassays
b.	Number of airborne events
c.	Number of alarms on airborne monitors (actual and false)
d.	Number of Airborne Radioactivity Areas
<b>Control of contaminated areas in operational areas</b>	
a.	Number of Contamination and High Contamination Areas
b.	Area of Contamination Areas in Square Feet
c.	Number of spills
<b>Minimization of radioactive waste</b>	
a.	Volume and activity of radioactive waste in cubic feet and Curies, respectively
b.	Number of cubic feet not subject to volume reduction by incineration, compaction, or other means
<b>Control of radioactive discharges</b>	
a.	Activity of liquid radioactivity discharges in Curies
b.	Activity of airborne radioactivity discharges in Curies

### 134 Assessments

Assessment, as used in the DOE RCM and the LBL RCM, refers to the process of providing independent feedback to senior line managers to indicate the adequacy of the Radiological Control Program.

1. Inspections, audits, reviews, investigations and self-assessments are part of the numerous checks and balances needed in a good Radiological Control Program. Internal audits of the Radiological Control Program shall be conducted such that over a 3-year period, all functional elements are assessed for program performance, applicability, content and implementation. These should be performed by the Radiological Control Organization, the Office of Assessment and Assurance, and other organizations.
2. Managers, supervisors and workers should look upon assessments as helpful. It is desirable to approach assessments with nothing to hide and with the Radiological Control Program as an open book. Results of assessments should be incorporated into the ongoing process of improving radiological control.
3. Managers should encourage the positive view that identifying even minor deficiencies represents an opportunity for further improvement. The number of deficiencies do not in themselves measure the overall quality of the Radiological Control Program. A prioritization system to implement actions for resolving the deficiencies should be implemented.
4. In developing corrective action plans for assessment activities, managers should address basic underlying reasons for the identified deficiencies or concerns, not just the specific symptoms identified by the reviewer.
5. Feedback on findings from assessments, root-cause analyses, status of corrective actions, and adherence to action plan schedules should be frequently provided to management.

### 135 Workplace Awareness

1. Management initiatives to facilitate the expression of concerns on the part of the work force, to address such concerns and to solve them are strongly encouraged to ensure the proper respect for and understanding of radiation.
2. A Radiological Awareness Reports system should be established as part of Division's Safety Committees and supported by management. To enhance work force awareness, the program should encourage continuous evaluation and improvements, track resolution of concerns, provide feedback to employees, and post results and trends. This system may be integrated with similar reporting systems for other than radiological concerns.

### 136 Internal Exposures

Control and prevention of internal exposure from long-lived radionuclides in the workplace present special challenges to a Radiological Control Program and warrant particular attention. Even though internal exposure is measured in the same units as external exposure and carries the same risk per unit effective dose equivalent, the perception exists that it is of greater significance since the exposure is the result of radioisotopes retained within the body.

Administration of internal dose assessment is costly in dollars and worker time. Control and analysis of samples is also more complicated than the elements of external dosimetry.

In order to minimize internal exposures, managers should take deliberate actions to control contamination at the source and reduce Airborne Radioactivity, Contamination and High Contamination Areas. Work should be planned so the routine use of respiratory protection devices is not required. Internal exposures should be reduced to the minimum practicable level and the following should be considered:

- Workers may be exposed to unanticipated levels of elevated airborne radioactivity. For instance, during the period necessary to collect representative airborne radioactivity samples and for technicians or automated instruments to determine the airborne concentration of radionuclides it may occur that there is a contribution to the worker intake of radioactivity.
- If controls fail, internal depositions of radionuclides can occur in a short period of time.
- The continued exposure of workers to airborne radioactivity over extended periods of time can create worker concerns.
- Doses from some internal radionuclides are difficult to measure. Although some radionuclides, such as cesium and tritium, can be readily measured at levels that produce only a few mrem, some long-lived radionuclides, like plutonium, require years for accurate measurements of hundreds of mrem.
- Medical intervention, such as the administration of blocking and chelating agents, to mitigate internal deposition adds risks by introducing additional chemicals into the body.
- Sampling of body excretions and whole-body or organ counting techniques encourage worker perceptions of internal exposure significance.

### 137 Neutron Exposures

Neutron exposures have the following characteristics which require attention:

- The specific biological effects of neutrons are not as well understood as the effects of gammas.
- The human body may not repair damage from neutrons as well as it repairs damage from an equivalent dose of gamma radiation.
- Neutron dose equivalent is more difficult to assess than gamma dose equivalent.

As a result, those sites and facilities with neutron radiation should focus particular attention on minimizing collective neutron dose through setting aggressive goals (Article 131).

### 138 ALARA Committee

The As-Low-As-Reasonably-Achievable (ALARA) process of reducing radiation exposures is a fundamental requirement of every radiological control program. There is considerable leeway in determining how far is reasonable. Reducing exposure is desirable because of the direct relation to the health and safety of workers and the public. Reducing radiation exposure improves the quality of the workplace and in the long run saves resources.

An ALARA Executive Committee should be established. The membership should include managers and workers from the line organizations, the technical support organization and the Radiological Control Organization. The Director of Operations, Research, or Maintenance should serve as the Chair.

A working ALARA Committee consisting of line managers, safety representatives, and the Radiation Control Manager should be established. The working committee's function should be to screen and make recommendations to the ALARA Executive Committee. The ALARA Executive Committee should make recommendations to management to improve progress toward minimizing radiation exposure and radiological releases. The Committee should evaluate items such as construction and design of facilities and systems, planned major modifications or work activities, as well as experimental test plans for exposure, waste and release minimization. The Committee should also receive, as a minimum, the results of all reviews and audits, both internal and external, and should review the overall conduct of the Radiological Control Program.

## **PART 4 LBL Radiological Control Organization**

### **141 Radiological Control Organization**

1. A Radiological Control Organization shall be established to provide relevant support to line managers and workers. To effectively function, the Radiological Control Organization should be independent of the line organizational element responsible for production, operation, or research activities and should have an equivalent reporting level. A single, dedicated Radiological Control Organization for the site should be sufficient. The senior line manager responsible for operations at a LBL facility should have assigned radiological control personnel dedicated to the operation. Consistency of radiological control is critical. It is the intent of this Manual to specify organizational structure for Radiological Control and to use personnel in the most effective manner in workplace situations.
2. Radiological control personnel shall monitor adherence to the LBL RCM and be available to the facility line managers for radiological support to the work force. To effectively function in this capacity, they should receive their day-to-day priorities from the Radiation Control Organization Managers. To ensure independence in making correct radiological decisions, the Radiological Control Organization should be accountable to the Radiological Control Manager.
3. The Radiological Control Manager heads the Radiological Control Organization and is responsible for and should establish a high quality Radiological Control Program.
4. The Radiological Control Manager shall have access to the Senior Site Executive through the Associate Laboratory Director of Operations for radiological control matters. The organizational chart (Appendix 1B) shows the LBL reporting structure.

### **142 Radiological Control Manager Qualifications**

1. The Radiological Control Manager should be an experienced professional in radiological control and be familiar with the design features and operations of the site that affect the potential for exposures of persons to radiation.
2. The Radiological Control Manager should have the technical competence and experience to establish radiological control programs and the supervisory capability to direct the implementation and maintenance of radiological control programs.
3. The Radiological Control Manager should have a minimum of a bachelor's degree or the equivalent in science or engineering, including some formal training in radiological control. Advanced academic degrees can count as experience where course work related to radiological control is involved. At least three years of professional experience should be in applied radiological control work. Certification by the American Board of Health Physics provides equivalency to the above.

4. In situations where the most effective manager for this position does not satisfy the above qualifications, special arrangements should be made.
5. Management should provide persons assigned to or being considered for the Radiological Control Manager a structured program leading to certification by the American Board of Health Physics.

#### **143 Radiological Control Organization Functions and Staffing**

1. The senior staff of the Radiological Control Organization should include health physicists and other professionals with four-year degrees in science or engineering. A continuing training program shall be established. Pursuit of certification by the American Board of Health Physics for senior and professional staff members is encouraged.
2. Radiological support personnel provide health physics and radiological engineering, dosimetry, bioassay, independent oversight, instrumentation, and calibration functions. These personnel should have technical qualifications pertinent to their assigned duties.

#### **144 Relationship Between Radiological Control Technicians and Workers**

Radiological Control Technicians and their supervisors perform the functions of assisting and guiding workers in the radiological aspects of the job.

1. Radiological workers should be sufficiently qualified to recognize the symptoms of deteriorating radiological conditions and seek advice from Radiological Control Technicians and their supervisors.
2. Radiological Control Technicians and their supervisors shall have the responsibility and authority to stop work or mitigate the effect of an activity if they suspect that the initiation or continued performance of a job, evolution, or test will result in the violation of radiological control standards or result in imminent danger or unacceptable risk. Any worker through their supervisor also has stop work authority in accordance with Article 345.
3. The actions or presence of radiological control personnel does not absolve the workers of their responsibility for properly conducting radiological aspects of the job. Radiological control personnel are not present to compensate for poor management of the work force and should not be required to do so. A poorly trained work force should participate in an accelerated training initiative.

#### **145 Marginal Radiological Control Performance**

1. When radiological control performance is less than adequate, consideration should be given to strengthening line management and the Radiological Control Organization to provide adequate radiological control.

2. **In cases where the work force does not have the required level of sensitivity for radiological work practices, additional management attention is needed to assure the proper outcome. Line management should be held accountable for implementation of the Radiological Control Program. Initial actions should include:**
  - a. **More direct line supervision in the work space**
  - b. **Curtailment of work schedules**
  - c. **Deferral of work**
  - d. **Addition of extra radiological control personnel**
  - e. **Conduct of additional training.**
  
3. **When the workers and supervisors achieve the proper level of radiological performance, the number of radiological control personnel should be reevaluated.**

## **PART 5 DOE Management**

### **151 Program Office**

1. Program Secretarial Officers are responsible for the establishment and maintenance of radiological control programs for activities under their cognizance, and are accountable for the quality and performance of radiological work conducted at their assigned sites.
2. Each Program Secretarial Officer shall designate a person who can be the Program Office focal point on radiological control matters with the DOE Field Office Managers, counterparts within DOE and LBL organizations. This person is referred to in this Manual as the Radiological Control Program Advisor.

### **152 Field Office**

1. Field Office Managers are responsible for the line management function of conducting day-to-day oversight of LBL activities, including monitoring the quality and performance of radiological work.
2. Field Office Managers shall designate a person to be responsible for providing radiological control program oversight, which includes appraisals, surveillance, and monitoring of performance, interacting routinely with the Radiological Control Program Advisors of the affected DOE Program Offices, assisting the DOE field line organization in the use of the RCM, and interacting on a periodic basis with counterparts at other sites.

### **153 Department Policy**

The Assistant Secretary for Environment, Safety and Health (EH) is responsible for promulgating and maintaining the overall DOE policy and standards with respect to radiological health and safety. EH is also responsible for periodically revising the DOE RCM to make corrections or improvements to the document. Subject matter experts within EH for areas such as radiological health effects, health physics, dosimetry, instrumentation, training, and radiological controls should be relied upon by other DOE elements for technical support in addressing problems or unique situations.

### **154 Department Independent Radiological Control Performance Oversight**

The Office of Nuclear Safety carries out its responsibility to provide independent radiological control performance oversight, on behalf of the Secretary of Energy, through various means, including:

1. Uses the DOE RCM as its basis document.

2. Assesses DOE Program and Field Office performance of their line management responsibilities for implementing and maintaining radiological controls as detailed in the Radiological Control Manual.
3. Assesses LBL performance against the requirements of the LBL RCM.

### **155 Radiological Control Coordinating Committee**

1. The DOE Headquarters Radiological Control Coordinating Committee shall, as a minimum, consist of the Radiological Control Program Advisors from the Offices of Nuclear Energy, Defense Programs, Environmental Restoration and Waste Management, and Energy Research, along with a representative from the Offices of Environment, Safety and Health and Nuclear Safety. A charter for this committee shall be approved and its performance monitored by the Senior Nuclear Managers Group.
2. The Radiological Control Coordinating Committee is expected to receive and review suggestions, concerns, and comments from its individual members, Field Offices and contractors. The Committee shall function in a collective manner to promote a consistent and uniform emphasis in the direction and implementation of the DOE RCM. Communications with the Radiological Control Coordinating Committee should follow standard administrative and reporting channels.
3. The Radiological Control Coordinating Committee should meet at least quarterly and more frequently during periods of transition. A Chairperson shall be designated by the Under Secretary and should be appointed for a minimum of one year.
4. Radiological Control Coordinating Committee meetings should include representatives from Field Offices and recognized industry experts from outside the Department. The interaction with non-DOE professionals enhances the awareness of state-of-the-art technology and practices.

### **156 DOE Employees in the Workplace**

DOE employees involved in or monitoring radiological work activities at a site or facility operated by a DOE contractor are subject to and shall adhere to the provisions of the DOE RCM and the LBL RCM.

**PART 6 Summary of Responsibilities****161 Department of Energy**

1. **Assistant Secretary for Environment, Safety and Health (EH):**
  - Review and update RCM provisions and incorporate lessons learned and proposed changes for improvement by Contractors and DOE Field Offices.
  - Promulgate and maintain the overall DOE policy and standards with regard to radiological health and safety. (153)
  - Revise the RCM to incorporate corrections or improvements. (153)
2. **Office of Nuclear Safety (NS):**
  - Provide independent oversight for radiological programs. (154)
  - Assess DOE Program and Field Office performance of their line management responsibility in radiation protection and implementation of the RCM. (154.2)
  - Assess LBL performance in radiological protection against the requirements of LBL RCM. (154.3)
3. **Program Secretarial Officer (PSO):**
  - Establish and maintain radiological control programs for activities under their cognizance. (151.1)
  - Assume accountability for quality and performance of radiological work performed at LBL. (151.1)
  - Designate a Radiological Control Program Advisor. (151.2)
4. **DOE Field Office Manager:**
  - Conduct oversight of LBL activities as line management. (152.1)
  - Designate a person to provide radiological control program oversight and act as contact and coordinator.

**162 Senior Site Executive**

1. At the end of each calendar year provide to the cognizant DOE field office and PSO a tabulation of all equivalency/Article 113 determinations made during the past twelve months. (113.2)
2. Issue and endorse a site-specific RM.
3. Maintain and keep a document control system. (114.3)
4. Establish, approve, and maintain a radiological performance goals program. (132.1)
5. Review radiological performance goals at least annually and revise as appropriate. (1232.4)
6. Have an established Radiological Control Organization. (141.1)
7. Ensure access by the Radiological Control Manager for radiological control matters. (141.4)
8. Ensure that the Radiological Control manager is qualified per Article 142 of the LBL RCM. (142)
9. Hold line management accountable for implementation of the RCM Program. (121, 145.2)

**163 Line Management**

1. Establish and communicate high standards for performance of EH&S. (121.1)
2. Document a commitment to excellence in radiological control. (121.2)
3. Assess EH&S knowledge and performance as a specific part of each person's performance evaluation. (121.4)
4. Require and approve radiological improvement goals. (121.8)
5. Review progress of radiological improvement goals at least quarterly. (121.8)
6. Review and track the LBL performance indicator program. (121.9)
7. Ensure that a comprehensive and effective radiological control training program is implemented. (121.10)
8. Control contamination at site origin. (121.11)
9. Minimize radiation exposures to workers and the public. (121.11)
10. Produce and display the "Worker Responsibilities" rules at appropriate access points and work areas. (123)

11. Periodically monitor work areas, observe work practices, and identify radiological deficiencies and concerns. (125.4)
12. Involve workers in the development of procedures for performing radiological work. (125.5)
13. Encourage the work force to identify radiological control deficiencies and concerns and provide corrective action. (125.6)
14. Ensure that subcontractors and subcontracted employees are treated the same as LBL staff, that they have comparable training, and that they meet the same requirements and expectations. (125.9)
15. Identify and correct, on a priority basis, conditions that could cause or promote the spread of contamination. (125.10)
16. Establish a formal process to obtain pertinent facts following an unusual radiological occurrence or at the satisfactory conclusion of a new or unusual operation involving radiological controls. (127)
17. Implement a self-assessment program and prioritize correct actions to resolve deficiencies. (134.3)
18. Address basic root causes in developing the corrective action plan (CAP) for assessment activities. (134.4)
19. Provide a mechanism to back, analyze corrective action, CAP and prove status of these actions to management. (134.5)
20. Establish a Radiological Awareness Reports System through Division Safety Committee.
21. Ensure that the EH&S Contamination Control Program is effective in reducing contamination and minimizing radiological areas. (136)
22. Plan work to avoid routine use of respiratory protective equipment. (136)
23. Reduce internal exposure to the minimum practical. (136)
24. Establish an ALARA Committee. (138)

#### **164 Radiological Control Manager**

1. Ensure compliance in the application of the design criteria of Article 128 to new facilities and to major modifications to existing facilities. (128.1)
2. Use performance indicators as a tool to focus management priorities and attention. (131)
3. Provide a periodic report to the Senior Site Executive on the status of the radiological performance goals. (133.1)

4. Ensure radiation exposure data and other pertinent information is provided to program supervisors and managers. (133.2)
5. Post in the appropriate location radiation exposure indicators related to specific work groups. (133.3)
6. Cause functional audits for Radiological protection of Programs and internal audits of the Radiation Assessment Group.
7. Ensure adherence to the LBL RCM. (141.2)
8. Be available to line managers for radiological support to the work force. (141.2)
9. Establish and be responsible for a high quality Radiological Control Program. (141.3)
10. Establish a continuing training program for the senior staff of the radiological control organization. (143.1)
11. Ensure that Health and Safety Technicians and their supervisors have the responsibility and authority to stop work. (144.2)

#### **165 ALARA Committee**

1. Make recommendations to management to improve progress toward minimizing radiation exposure and radiological releases. (138)
2. Evaluate construction and design of facilities and systems, planned major modifications or work activities, and waste and release minimization. (138)
3. Review the conduct of the Radiological Control Program. (138)

#### **166 Quality Assurance Organization**

1. Oversight of LBL Assessment Program. (134.1)
2. Develop LBL OAA Program. (134)

#### **167 Employees**

1. Be responsible for understanding that proper radiological control is an integral part of the daily duties. (122.1)
2. Observe the "Worker Responsibilities" posted rules. (123)
3. Stop work and obtain guidance if a written requirement in a procedure cannot be responsibly followed. (125.5)

**Appendix 1A**

**LAWRENCE BERKELEY LABORATORY**  
Associate Laboratory Director Office for Operations  
Bldg. 50A Room 5104 Ext. 6120

**MEMORANDUM**

April 9, 1993

**TO:** Distribution, PUB-3113 (Radiological Control Manual)

**FROM:** Klaus Berkner, Associate Laboratory Director for Operations

**SUBJECT:** LBL Radiological Control Manual

The Department of Energy (DOE) has developed an expanded set of requirements for radiation protection. These requirements apply to all DOE contractors and their personnel. They are described in the attached LBL Radiological Control Manual (Pub. 3113). The manual supplements and elaborates on DOE Orders 5480.11, 5480.25 and 5400.5 and Draft 10 Code of Federal Regulations Part 835. It gives specific guidance on how LBL workers are to protect themselves, the workplace, and the environment from potential radiation hazards. Specific topics addressed are: protection limits, contamination control, training, record requirements and control and posting of radiological areas.

The Radiological Control Manual (PUB 3113) will be a Technical Resource Document in a new PUB 3000, currently scheduled for distribution in the summer of 1993. In the interim, the LBL Radiological Control Manual will be issued separately as a controlled document.

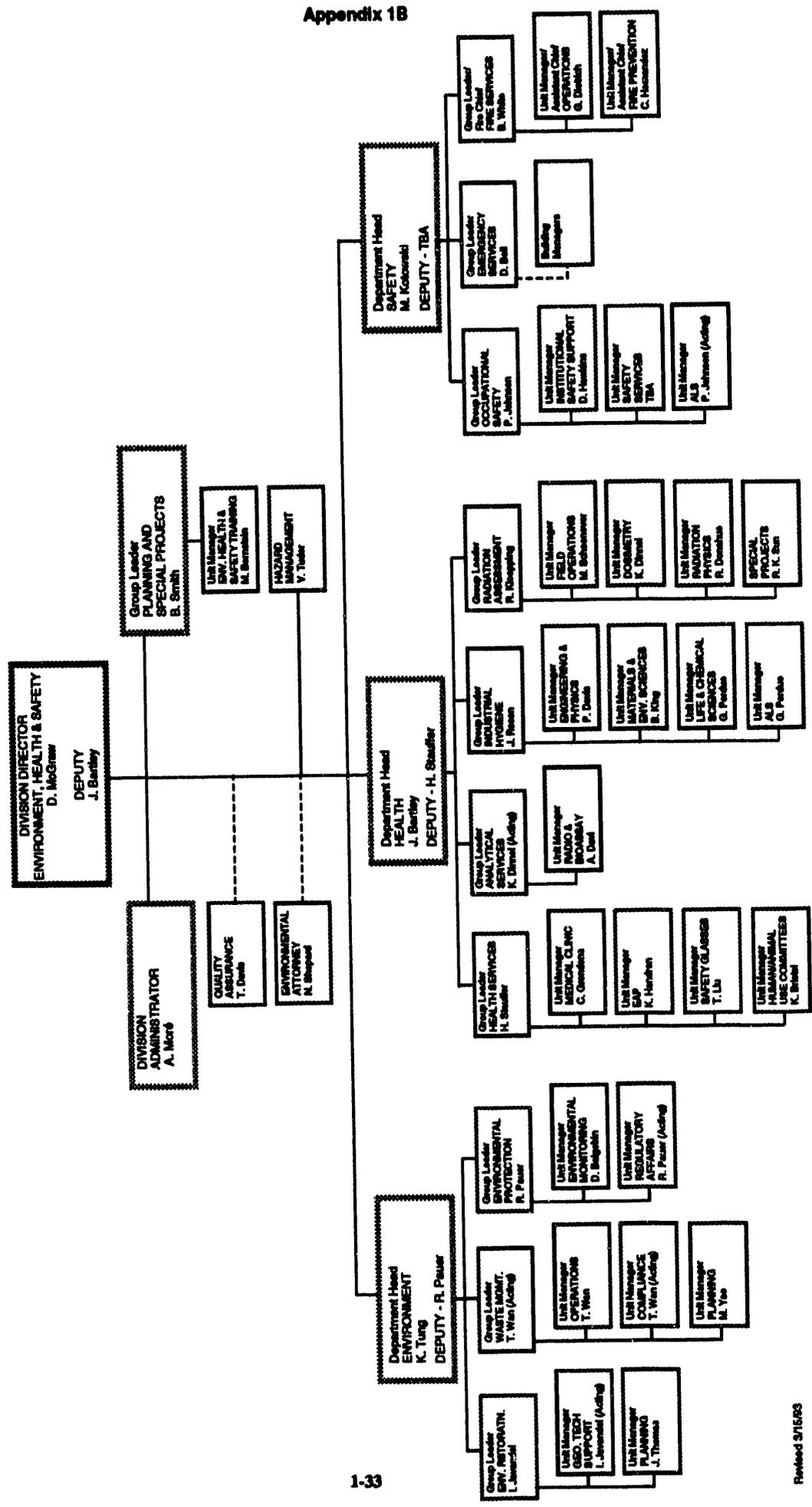
LBL Senior management is firmly committed to a radiological control program of the highest quality. Senior managers are expected to establish high standards for radiological control in the workplace. The EH&S Radiation Protection Group is available to assist management in carrying out this responsibility. If assistance is required, call Roger Kloepping at 7608 or Mike Schoonover at 6424.



Lawrence Berkeley Laboratory  
Environment, Health and Safety Division  
Organization Chart



Appendix 1B



Appendix 1C

**Radiological Performance Goals FY 93**

1.	Annual Collective Personnel Exposure	< 15 person rem
2.	Skin and personal clothing contamination occurrences	< 5 per annum
3.	Intakes of Radioactivity	< 250 mrem per annum †
4.	Square feet of Contaminated Areas	< 1000 square feet
5.	Cubic feet of Radioactive Waste (includes liquid waste solidified)	< 1000 cubic feet
6.	Environmental Releases	
	Liquid	Alpha* ** < 5X10 <sup>-9</sup> µci/ml Beta* < 5X10 <sup>-8</sup> µci/ml
	Aerosol	< 125 ci per annum

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† includes routine tritium operations, weekly bioassays  
 \* sanitary sewer  
 \*\* limit of sensitivity

## Appendix 1D

### Instructions for Preparation of Quarterly Radiological Performance Indicator Report

#### Exposure Control

- a. **Collective Dose**
  1. Collective deep dose equivalent received by all workers monitored for external exposure in a given period. (Workers assigned a multi-purpose dosimeter).
  2. Collective committed effective dose equivalent assessed on an annual basis during the calendar year (fourth quarter only).
  3. Sum of items 1 and 2.
- b. **Average Worker Dose**
  1. Average deep dose equivalent received by all workers monitored for external exposure on a quarterly frequency or more frequent basis for whom a measurable dose was recorded.
  2. Number of monitored workers (external).
  3. Number of monitored workers (internal).
- c. **Maximum Dose to a Worker**
  1. Deep dose equivalent.
  2. Effective dose equivalent.
- d. Number of unplanned exposures resulting in doses greater than the Administrative Control Level.
- e. Number of Assessments for lost or damaged dosimeters.
- f. Maximum neutron dose to a worker.

#### Personnel Contamination

- a. **Number of Skin and Personal Clothing Contaminations**
  1. Skin contamination events reported in accordance with DOE 5000.3A.
  2. Clothing contamination events reported in accordance with DOE 5000.3A.
  3. Number of skin and clothing contamination events for which a record dose was assigned.

- b. **Number of Contaminated Wounds**
- c. **Number of Facial Contaminations**
  - 1. **Skins contaminations recorded in item a.1 (above) involving contamination of the face within the area that would be covered by a full-face respirator.**

**Control of Internal Exposure**

- a. **Number of Positive Bioassays**
  - 1. **Confirmed intake(s) resulting in a dose equal to or greater than the Investigation Level as defined in the Internal Dosimetry Program Implementation Guide.**
- b. **Number of Airborne Events**
  - 1. **Events in which airborne radioactive material, excluding naturally-occurring radon, is detected in an area that is not posted and controlled as an Airborne Radioactivity Area.**
- c. **Number of Alarms on Airborne Monitors:**
  - 1. **Actual alarms**
  - 2. **False alarms**

**Control of Contaminated Areas in Operational Areas**

- a. **Number of Contamination and High Contamination Areas**
  - 1. **Areas normally intended for occupancy that are posted as Contamination Areas. (NOTE: Do not include the interior volumes of process spaces such as ducts, tanks, canyons, etc., unless routine access is established.)**
  - 2. **Areas normally intended for occupancy that are posted as High Contamination Areas.**
- b. **Area of Contamination Areas in Square Feet**
  - 1. **Area of Contamination Areas identified in a.1 (above).**
- c. **Number of Spills**
  - 1. **Events involving the spread of radioactive contamination reported in accordance with DOE Order 5000.3A.**

**Minimization of Radioactive Waste**

- a. Volume and activity of radioactive waste in cubic feet and Curies, respectively.
  - 1. Volume
  - 2. Activity
- b. Number of cubic feet not subject to volume reduction by incineration, compaction or other means.
  - 1. That portion of the radioactive waste volume in a.1 above disposed without volume reduction efforts.

**Control of Radioactive Effluents**

- a. Liquid Effluents
  - 1. Volume (L)
  - 2. Activity (Ci)
- b. Gaseous effluents
  - 1. Activity (Ci)

**Appendix 1D (continued)**

**LBL RCM RA Performance Indicator Report**

**Figure 1.1**

**Exposure Control**

- a. **Collective Dose**
  - 1. **Collective Deep Dose Equivalent**  
 Period \_\_\_\_\_ Dose \_\_\_\_\_
  - 2. **Collective Committed Dose Equivalent**  
 Annual \_\_\_\_\_ Dose \_\_\_\_\_
  - 3. **Annual Summation**  
 Year \_\_\_\_\_ Dose \_\_\_\_\_
- b. **Average Workers Dose**  
 Period \_\_\_\_\_ Dose \_\_\_\_\_
- c. **Maximum Dose to a Worker**  
 α Period \_\_\_\_\_ Dose \_\_\_\_\_  
 n Period \_\_\_\_\_ Dose \_\_\_\_\_
- d. **Unplanned exposures**  
 > 100 mrem Period \_\_\_\_\_ # \_\_\_\_\_  
 > 500 mrem Period \_\_\_\_\_ # \_\_\_\_\_
- e. **Assessments for lost or damaged badges**  
 Period \_\_\_\_\_ # \_\_\_\_\_

**Internal Exposure Control**

- a. **Positive Bioassay**  
 Period \_\_\_\_\_ # \_\_\_\_\_
- b. **Number of Airborne Events > 10% DAC**  
 Period \_\_\_\_\_ # \_\_\_\_\_
- c. **Number of Alarms on airborne monitors**  
 Period \_\_\_\_\_ # \_\_\_\_\_
- d. **Number of Airbone Activity Areas** # \_\_\_\_\_

**Personnel Contamination**

- a. Number of Skin and Personal Clothing Contaminations  
Skin Period \_\_\_\_\_ # \_\_\_\_\_  
Clothing Period \_\_\_\_\_ # \_\_\_\_\_
- b. Contaminated Wounds  
Period \_\_\_\_\_ # \_\_\_\_\_
- c. Facial Contamination (breathing zone)  
Period \_\_\_\_\_ # \_\_\_\_\_

**Control of Contamination, Operations**

- a. Contamination Areas # \_\_\_\_\_
- b. High Contamination Areas # \_\_\_\_\_
- c. Area of Contamination Area \_\_\_\_\_ ft<sup>2</sup>
- d. Spills > 5000.3A reporting levels  
# \_\_\_\_\_ Facilities

**Radioactive Waste Minimization**

- a. Volume \_\_\_\_\_ ft<sup>3</sup> Activity \_\_\_\_\_ ci
- b. Volume not subject to volume reduction \_\_\_\_\_ ft<sup>3</sup>

**Control of Radioactive Effluents**

- a. Liquid  
Period \_\_\_\_\_ Volume \_\_\_\_\_ Activity \_\_\_\_\_ ci
- b. Gaseous  
Period \_\_\_\_\_ Activity \_\_\_\_\_

Appendix 1E

**Article 113 Determinations/Expectations**

None at this time.

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## **PART 1 Administrative Control Levels and Dose Limits**

The DOE's objective is to maintain personnel radiation exposure well below regulatory dose limits. To accomplish this objective, challenging numerical Administrative Control Levels are established at levels below the regulatory limits to administratively control and help reduce individual and collective radiation dose. These control levels are multi-tiered with increasing levels of authority required to approve higher Administrative Control Levels.

With issuance of this Manual, the committed effective dose equivalent shall be used to assign internal dose received by personnel at DOE facilities. The committed effective dose equivalent is the resulting dose committed to the whole body from internally deposited radionuclides over a fifty year period after intake.

### **211 Administrative Control Levels**

1. A DOE Administrative Control Level of 2,000 mrem per year per person is established for all DOE activities. Approval by the Program Secretarial Official (PSO) or designee shall be required prior to allowing a person to exceed 2,000 mrem.
2. Annual LBL Administrative Control Levels have been established and are presented in Table 2-1. The selection of the specific value shall be more restrictive than the DOE Administrative Control Level. Based upon historical and projected radiation exposures, work load, and mission, the LBL RCM Administrative Levels shall be reevaluated annually. The choice of a low level for one year shall not preclude choosing either a higher or lower level in a subsequent year.
3. Approval authorities to exceed the multi-tiered Administrative Control Levels are given in Table 2-1. Approvals shall be documented.
4. No person shall be allowed to go above the site Administrative Control Level without the prior approval of the Associate Laboratory Director of Operations and the Radiological Control Manager.

### **212 Lifetime Control Level**

1. To administratively control a worker's lifetime occupational radiation exposure, a Lifetime Control Level of N rem shall be established where N is the age of the person in years. Formal approval by management identified in Table 2-1 shall be required to exceed the Lifetime Control Level. Special Control Levels (Article 216) shall be established for personnel who have doses exceeding N rem.
2. The internal contribution to lifetime dose should continue to be reassessed as further bioassay results and improved methods for assessing internal dose become available.

**213 Radiological Worker Dose Limits**

1. Dose limits are provided in Table 2-2 and shall not be exceeded. These regulatory limits are consistent with the "Radiation Protection Guidance to Federal Agencies for Occupational Exposure" signed by the President.
2. Radiological workers from other DOE or DOE contractor facilities may receive occupational exposure as a radiological worker if they:
  - a. Provide record of current Radiological Worker I or II standardized core training.
  - b. Receive site-specific Radiological Worker I or II training at the facilities where they will be working.
  - c. Provide their radiation dose records for previous years and written estimates for the current year.
3. Proposed use of the 10-rem Planned Special Exposure as specified in DOE 5480.11 shall be applied only in extraordinary situations and when the following requirements have been met:
  - a. The proposed activity has been reviewed by the Radiological Control Manager and submitted by the senior site executive to the lead PSO for approval.
  - b. The proposed activity has been jointly approved by the PSO and the Assistant Secretary for Environment, Safety and Health.
4. Emergency exposure limits are not Planned Special Exposure limits. Guidelines for emergency exposures are provided in Appendix 2A.

*Table 2-1 Administrative Control Levels*

Maximum Dose Equivalent (Annual), mrem (msv)				Approval to Exceed This Level
Whole Body	Skin and Extremity	Lens of Eye	Any Organ	
2,000				DOE—PSO
100* (1)	1000* (10)	500* (5)	1000* (10)	Level 1, Line Manager, Radiological Control Manager
500 (5)	5,000 (50)	500 (5)	5,000 (50)	Level 2, ALD Operations, Line Manager, Radiological Control Manager
Age X 1,000 = Lifetime Cumulative Dose Equivalent				Level 2, ALD Operations, Line Manager, Radiological Control Manager

\* May be authorized as part of LBL, RWP/Use Authorization Permit System (Chapter 3)

*Table 2-2 Summary of Dose Limits*

Exposures shall be well below the limits in this table and maintained as low as reasonably achievable. The Administrative Control Levels for limiting exposure are described in Article 211.

TYPE OF EXPOSURE	ANNUAL LIMIT
Radiological Worker: Whole Body (internal + external)	5 rem
Radiological Worker: Lens of Eye	15 rem
Radiological Worker: Extremity (hands and arms below the elbow; feet 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/Fetus	0.5 rem in nine 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 in accordance with Articles 632 or 633, or have not met the special considerations of Article 657.

Notes:

1. Internal dose to the whole body shall be calculated as committed effective dose equivalent. The committed effective dose equivalent is the resulting dose committed to the whole body from internally deposited radionuclides over a 50-year period after intake. See Appendix 2B for the weighting factors to be used in converting organ dose equivalent to effective dose equivalent for the whole body dose.
2. Background, therapeutic, and diagnostic medical exposures shall not be included in either personnel radiation dose records or assessment of dose against the limits in this Table.
3. See Appendix 2C for guidance on non-uniform exposure of the skin.

**214 Visitor Dose Limit**

Visitors to the LBL Site shall be limited to an annual radiation dose equivalent of 100 mrem from the sum of internal and external radiation sources unless they either qualify as radiological workers in accordance with Article 632 or 633, or meet the special considerations of Article 657.

### 215 Embryo/Fetus Dose Limits

After a female radiological worker voluntarily notifies her LBL supervisor in writing that she is pregnant, for the purposes of fetal/embryo dose protection, she is considered a declared pregnant worker.

1. LBL shall provide the option of a mutually agreeable assignment of work tasks, without loss of pay or promotional opportunity, such that further occupational radiation exposure is unlikely.
2. For a declared pregnant worker who chooses to continue working as a radiological worker:
  - a. The dose limit for the embryo/fetus from conception to birth (entire gestation period) is 500 mrem.
  - b. Efforts should be made to avoid exceeding 50 mrem per month to the pregnant worker.
3. If the dose to the embryo/fetus is determined to have already exceeded 500 mrem when a worker notifies her employer of her pregnancy, the worker shall not be assigned to tasks where additional occupational radiation exposure is likely during the remainder of the gestation period.
4. For declared pregnant workers all dose information and Occupational Assignments shall be entered into the worker's medical records.

### 216 Special Control Levels

Certain situations require lower individualized exposure control levels. In addition to considering recommendations from senior radiological control and medical officials, the LBL senior site executive or designee may obtain advice from professionals in other disciplines such as human resources and legal in establishing Special Control Levels. The LBL senior site executive or designee may wish to establish these Special Control Levels using a radiological health advisory group, e.g. ALARA Executive Committee.

1. A Special Control Level for annual occupational exposure shall be established for each person with a lifetime occupational dose exceeding N rem, where N is the age of the person in years. The Special Control Level shall not exceed 1 rem and shall allow the person's lifetime occupational dose to approach N rem as additional occupational exposure is received.
2. LBL Management should be attentive to special circumstances of employees, such as those undergoing radiation therapy, and establish Special Control Levels as appropriate.

3. **An employee who receives radiation exposure due to a medical exposure shall report the exposure to his or her management and to the Radiological Control Organization. Medical exposures may include radiation therapy or administration of radioactive material under the control of a physician. If necessary, the Radiological Control Organization shall ensure that the individual receives a temporary dosimeter. The Radiological Control Organization should also make recommendations on work restrictions while the individual's condition affects the radiation dose.**
4. **Employees shall not wear assigned personnel dosimeters during medical (radiation therapy or diagnostic procedures) and dental radiation exposures. Employees shall inform the Radiological Control organization if such exposure accidentally occurs.**
5. **Employees should not wear personnel dosimeters off the LBL site.**

## **PART 2 Contamination Control and Control Levels**

Control of radioactive contamination is achieved by using engineering controls and worker performance to contain contamination at the source, reducing existing areas of contamination, and promptly decontaminating areas that become contaminated.

### **221 Personnel Contamination Control**

1. Personnel exiting Contamination Areas, High Contamination Areas, Airborne Radioactivity Areas, or Radiological Buffer Areas established for contamination control shall perform a personal survey or be surveyed by a Health and Safety Technician. This does not apply to personnel exiting areas containing only radionuclides, such as tritium, that cannot be detected using hand-held or automatic survey equipment.
2. Monitoring for contamination should be performed using survey equipment that under laboratory conditions can detect total contamination of at least the values specified in Table 2-3. Use of automatic monitoring units that meet the above requirements is encouraged.
3. Personnel found with detectable contamination on their skin or personal clothing, other than noble gases or natural background radioactivity, should be promptly decontaminated as described in Article 541.
4. Individuals shall verify that the hand-held survey instrument or automatic personnel monitor is operable before each use for personnel contamination survey.
5. Training for personal contamination monitoring is given in LBL RAD I Worker Training.

### **222 Contamination Control Levels**

1. A surface shall be considered contaminated if either the removable or total radioactivity is detected above the levels in Table 2-3. If an area cannot be decontaminated promptly, then it shall be posted as specified in Article 235. This does not include containers of radioactive material unless contamination is removable from the external surfaces.
2. Surfaces exceeding the values of Table 2-3 for total contamination may be covered with a fixative coating to prevent the spread of contamination. However, management should not substitute painting of surface contamination in lieu of cost-effective decontamination efforts.
3. In addition to the posting criteria in Article 235, the conditions for establishing and maintaining Fixed Contamination Areas include:
  - a. Radiological surveys shall be performed to detect contamination that may become removable over time.
  - b. A formal inventory shall be maintained of Fixed Contamination Areas.
  - c. Markings shall be kept legible.
  - d. Removable contamination should be reduced to below detectable levels before a fixative coating is applied.

- e. Painted-over contaminated surfaces should be covered by a yellow undercoat and at least two coats of a different finish color.
  - f. Marking should include the standard radiation symbol, be clearly visible from all directions and contrast with the colors of the surface coatings.
  - g. Additional coating should be applied when the bottom color appears.
  - h. A plan for identifying and adding to the inventory of existing areas of fixed contamination not included in the initial inventory should be developed.
4. A Fixed Contamination Area may be located outside Controlled Areas unless unrestricted access is likely to result in a dose to any person greater than 100 mrem in a year.
  5. A Fixed Contamination Area is exempt from the general posting requirements of Article 231 and entry and exit requirements of Chapter 3.
  6. For contaminated soil that is not releasable in accordance with DOE 5400.5, a Soil Contamination Area shall be established that:
    - a. is posted as specified in Article 235. Posting should include instructions or special warnings to workers such as "Consult With Radiological Control Organization Before Digging" or "Subsurface Contamination Exists."
    - b. meets the requirements of Article 231.1 through 231.8.
  7. Soil Contamination Areas may be located outside a Radiological Buffer Area.

### **223 Airborne Radioactivity Control Levels**

1. Personnel should not be exposed unnecessarily to airborne radioactivity. Use of engineering and administrative controls to reduce the potential for internal exposure should be evaluated before allowing personnel, with or without respiratory protection, to enter areas with airborne radioactivity. LBL currently has no airborne radioactivity areas.
2. Occupied areas with airborne concentrations of radioactivity that are greater than or potentially greater than 10 percent of a Derived Air Concentration shall be posted as specified in Article 235. For most radionuclides, air containing 10 percent of a Derived Air Concentration results in a committed effective dose equivalent of approximately 10 mrem if inhaled continuously for one work week. Values of Derived Air Concentrations are provided in DOE 5480.11.

*Table 2-3 Summary of Contamination Values*

<b>NUCLIDE</b> (See Note 1)	<b>REMOVABLE</b> (dpm/100 cm <sup>2</sup> ) (See Notes 2 & 3)	<b>TOTAL (FIXED +</b> <b>REMOVABLE)</b> (dpm/100 cm <sup>2</sup> )
U-natural, U-235, U-238 and associated decay products	1,000 alpha	5,000 alpha
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-129, I-125	20	500
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above. Includes mixed fission products containing Sr-90.	1,000 beta-gamma	5,000 beta-gamma
Tritium organic compounds, surfaces contaminated by HT, HTO, and metal tritide aerosols	10,000	10,000

Notes:

1. The values in this Table apply to radioactive contamination deposited on, but not incorporated into the interior of the contaminated item. Where contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for the alpha- and beta-gamma-emitting nuclides apply independently.
2. The amount of removable radioactive material per 100 cm<sup>2</sup> of surface area should be determined by swiping the area with dry filter or soft absorbent paper while applying moderate pressure and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. For objects with a surface area less than 100 cm<sup>2</sup>, the entire surface should be swiped, and the activity per unit area should be based on the actual surface area. Except for transuranics, Ra-228, Ac-227, Th-228, Th-230, Pa-231, and alpha emitters, it is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual contamination levels are below the values for removable contamination.
3. The levels may be averaged over one square meter provided the maximum activity in any area of 100 cm<sup>2</sup> is less than three times the values in Table 2-3.

**PART 3 Posting****231 Posting Requirements**

1. Radiological posting shall be used to alert personnel to the presence of radiation and radioactive materials and to aid them in minimizing exposures and preventing the spread of contamination. Boundaries used for radiological control purposes are depicted in Figure 2-1.
2. Signs shall contain the standard radiation symbol colored magenta or black on a yellow background. Lettering shall be either magenta or black. Magenta is the preferred color over black. Standardized signs, as described in the standardized core training, should be used where practicable.
3. Radiological postings should be displayed only to signify actual or potential radiological conditions. Signs used for training should be clearly marked, such as "For Training Purposes Only."
4. Posted areas should be as small as practicable for efficiency.
5. Postings should be maintained in a legible condition and updated based upon the results of the most recent surveys.
6. If more than one radiological condition (such as contamination and high radiation) exists in the same area, each condition should be identified.
7. In areas of ongoing work activities, the dose rate and contamination level or range of each should be included on or in conjunction with each posting as applicable.
8. Entrance points to areas of ongoing work activities controlled for radiological purposes should state basic entry requirements, such as dosimetry, Radiological Work Permit (RWP), and respirator required.
9. Rope, tape, chain, and similar barriers used to designate the boundaries of posted areas should be yellow and magenta in color.
10. Physical barriers should be placed so that they are clearly visible from all directions and at various elevations. They shall not be easily walked over or under, except at identified access points. These barriers shall be set up such that they do not impede the intended use of emergency exits or evacuation routes.
11. Posting of doors should be such that the postings remain visible when doors are open or closed.
12. A radiological posting that signifies the presence of an intermittent radiological condition should include a statement specifying when the radiation is present, such as "CAUTION: RADIATION AREA WHEN RED LIGHT IS ON."

### **232 Posting Controlled Areas**

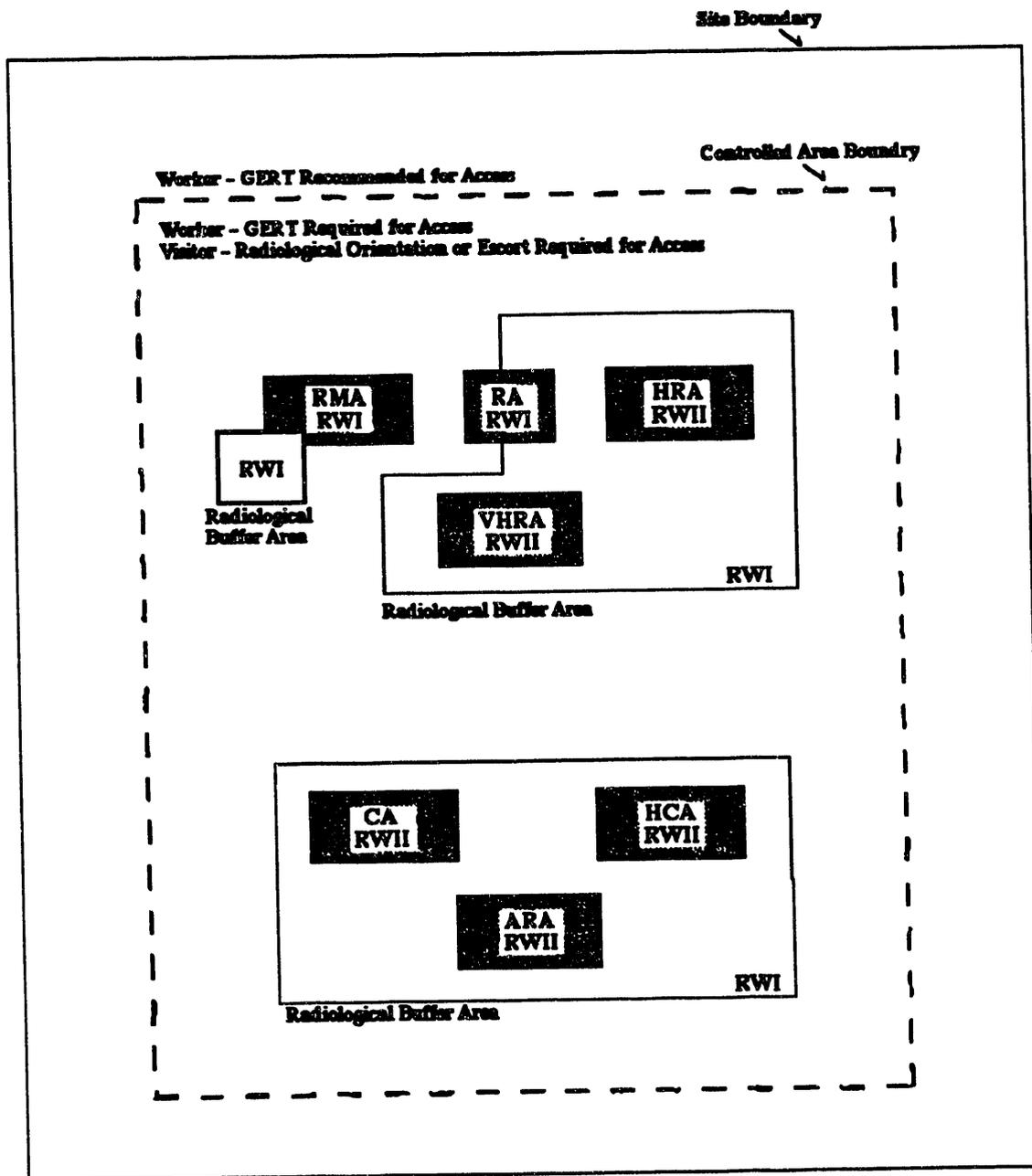
1. Areas within the site boundary should be clearly posted to alert personnel to the presence of radiation and radioactive materials above natural background levels. These areas shall be designated Controlled Areas. Persons who enter only the Controlled Area without entering Radiation, Contamination, Airborne Radioactivity, or Radiological Buffer Areas are not expected to receive more than 100 mrem in a year.
2. The contractor may select the type of sign used to avoid conflict with local security requirements. This selection should be approved by the Associate Laboratory Director for Operations, the Radiological Control Manager, and DOE-SF. The signs used for posting should be consistent throughout the LBL Site to ensure applicability of the training material and maximum employee recognition. The "Controlled Area for Radiological Protection" shall be blue lettering on white.

### **233 Posting Radiological Buffer Areas**

A Radiological Buffer Area shall be established within the Controlled Area to provide a second boundary to minimize the spread of contamination. The Radiological Buffer Area is intended for use where ongoing work activities may create airborne radioactivity or the spread of contamination. It is not expected that Radiological Buffer Areas be established around inactive or secured Contamination Areas. The need for Radiological Buffer Areas in conjunction with Radioactive Material Management Areas should be evaluated.

1. The size of the Radiological Buffer Area should be commensurate with the potential for the spread of contamination outside Contamination, High Contamination and Airborne Radioactivity Areas. At a minimum, the Radiological Buffer Area should include the area adjacent to any exit from and entrance to Contamination, High Contamination, and Airborne Radioactivity Areas.
2. A Radiological Buffer Area is not required for High Contamination Areas that are completely within Contamination Areas.
3. A Radiological Buffer Area should surround or be contiguous with Radiation, High Radiation and Very High Radiation Areas. The boundary for the Radiological Buffer Area and these radiation areas may be one in the same.
4. Posting of Radiological Buffer Areas shall be in accordance with Article 231 and shall contain the wording "CAUTION: RADIOLOGICAL BUFFER AREA." Radiological Buffer Areas that have the same boundaries as radiation areas do not have to be posted as radiological buffer areas.

Figure 2-1  
Establishing Control Areas



**234 Posting Radiation Areas**

1. Areas shall be posted to alert personnel to the presence of external radiation in accordance with Table 2-4 and Article 231.
2. Dose rate measurements used to determine criteria for Radiation Areas should be made at a distance of 30 centimeters from the radiation source or from any surface through which the radiation penetrates. For Very High Radiation Areas, the measurement should be made at 100 cm.
3. Contact readings should be used to determine the presence of Hot Spots.
4. Posting of Hot Spots is not required in High Radiation Areas with general area dose rates greater than 1 rem/hr or in Very High Radiation Areas.
5. The type of personnel dosimeter used by the facility should be included on the sign if the personnel dosimeter is not a Thermoluminescent Dosimeter (TLD).
6. The requirement for an RWP should be included either on or in conjunction with the posting.
7. Dose received in an hour may be used as the criterion for posting (Column 2 of Table 2-4). In this table, the unit "rad" is associated with dose rates that pose an immediate danger.

*Table 2-4 Criteria for Posting Radiation Areas*

AREA	DOSE RATE CRITERIA	POSTING
Radiation Area	$0.005 < H \leq 0.1$ rem/h	"CAUTION, RADIATION AREA" "TLD Required for Entry"
High Radiation Area	$0.1 < H \leq 500$ rad/hr	"DANGER, HIGH RADIATION AREA" "TLD, Supplemental Dosimeter and RWP Required for Entry"*
Very High Radiation Area	$D > 500$ rad/hr	"DANGER, VERY HIGH RADIATION AREA" "SPECIAL CONTROLS REQUIRED FOR ENTRY"*
Hot Spot	5 times general area dose rate and $> 0.1$ rem/hr	"CAUTION, HOT SPOT"

\* Access requirements may be deleted or modified if personnel access is specifically prohibited.

**235 Posting Contamination, High Contamination, and Airborne Radioactivity Areas**

1. Areas shall be posted to alert personnel to contamination in accordance with Table 2-5 and Article 231.
2. The requirement for an RWP should be included either on or in conjunction with each posting as applicable.
3. Derived Air Concentration (DAC) values for use with Table 2-5 are found in DOE 5480.11.
4. With the exception of outdoor locations, all contamination and high contamination areas should be circumscribed by a rope, chain, fence, wall, or other physical barrier to prevent inadvertent entry. Posting of areas defined by chain or radiation rope shall be visible from any reasonable approach. Signs should be no further than 30 m apart.

*Table 2-5 Criteria for Posting Contamination, High Contamination and Airborne Radioactivity Areas*

AREA	CRITERIA	POSTING
Contamination	Levels (dpm/100 cm <sup>2</sup> ) > 1 time but ≤ 100 times Table 2-3 values	"CAUTION, CONTAMINATION AREA"
High Contamination	Levels (dpm/100 cm <sup>2</sup> ) > 100 times Table 2-3 values	"DANGER, HIGH CONTAMINATION AREA" "RWP Required for Entry"
Fixed Contamination	No removable contamination and total contamination levels > Table 2-3 Column 3 values	"CAUTION, FIXED CONTAMINATION"
Soil Contamination	Contaminated soil not releasable in accordance with DOE 5400.5	"CAUTION, SOIL CONTAMINATION AREA"
Airborne Radioactivity	Concentrations (uCi/cc) > 10% of any DAC value	"CAUTION, AIRBORNE RADIOACTIVITY AREA" "RWP Required for Entry"

**236 Posting Radioactive Material Management Areas**

1. Areas where radioactive materials are used, handled or stored should be posted "CAUTION, RADIOACTIVE MATERIAL MANAGEMENT AREA (RMMA)." The posting shall meet the requirements in Article 231. Posting of areas in which instrument check or low-level counting instrument calibration sources are located is not required.
2. Radioactive Material Management Areas should be located within Controlled Areas.
3. Posting for Radioactive Material Management Areas is not required when the radioactive material is inside a Contamination or Airborne Radioactivity Area.
4. The definition of radioactive material and the requirements for labeling radioactive material are contained in Chapter 4.

**237 Posting Underground Radioactive Material Management Areas**

1. Underground Radioactive Material Management Areas shall be established to indicate the presence of underground items that contain radioactive materials such as pipelines, radioactive cribs, covered ponds, covered ditches, catch tanks, inactive burial grounds, and sites of known, covered, unplanned releases (spills).
2. Underground Radioactive Material Management Area shall be posted "UNDERGROUND RADIOACTIVE MATERIAL." The posting shall meet the applicable requirements of Article 231.
3. Underground Radioactive Material Management Areas can be located inside or outside Controlled Areas and are exempt from the entry and exit requirements of Chapter 3.

**PART 4 Summary of Responsibilities****241 Department of Energy****Program Secretarial Officer (PSO)**

- Provide prior approval for any individual exceeding 2000 mrem in one year. (211.1)
- Approve each use of the 10-rem Planned Special Exposure. (213.3b)

**Assistant Secretary for Environment, Safety and Health. (EH)**

- Approve each use of the 10-rem Planned Special Exposure. (213.3b)

**242 Senior Site Executive and Associate Laboratory Director for Operations**

- Establish an annual facility Administrative Control Level and reevaluate annually. (211.4)
- Provide prior approval for any individual exceeding the facility Administrative Control Level. (211.4)
- Submit each proposed use of the 10-rem Planned Special Exposure to the lead PSO for approval. (213.3a)
- Establish Special Control Levels for use in special circumstances. (216)
- Approve the type of sign used to post Controlled Areas. (232.2)

**243 Line Management**

- Establish a Lifetime Control Level of N rem to control a worker's lifetime occupational radiation exposure. (212.1)
- Establish Special Control Levels for personnel who have exceeded N rem lifetime dose. (212.1)

**244 Radiological Control Manager**

- Review each proposed use of the 10-rem Planned Special Exposure. (213.3a)
- Approve the application of fixative coatings for contamination control. (222.2)
- Provide prior approval for any individual exceeding the facility Administrative Control Level. (211.4)

**245 Employees**

- **Notify the Radiological Control Organization of medical exposures to radiation, radioactive material, or accidental exposure of dosimeters to medical radiation sources. (216.3,4)**
- **Conduct a personal survey when exiting Contamination Areas, High Contamination Areas, Airborne Radioactivity Areas, or Radiological Buffer Areas. (221.1)**
- **Verify operability of hand-held survey instrument or automatic personnel contamination monitor prior to use. (221.5)**

Appendix 2A

**Guidelines for Control of Emergency Exposures**

In extremely rare cases, emergency exposure to radiation may be necessary to rescue personnel or to protect major property. The dose limits for personnel performing these operations are listed below.

<b>DOSE LIMIT (Whole Body)</b>	<b>ACTIVITY PERFORMED</b>	<b>CONDITIONS</b>
5 rem	All	
10 rem	Protecting major property	Where lower dose limit not practicable
25 rem	Lifesaving or protection of large populations	Where lower dose limit not practicable
>25 rem	Lifesaving or protection of large populations	Only on a voluntary basis to personnel fully aware of the risks involved

Notes:

1. The dose limit to the lens of the eye should be three times the listed values.
2. The dose limit to the skin of the whole body and the extremities is ten times the listed values.

## Appendix 2B

## Weighting Factors for Organs and Tissues

ORGANS OR TISSUES	WEIGHTING FACTOR
Gonads	0.25
Breasts	0.15
Red bone marrow	0.12
Lungs	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder	0.30

## Notes:

1. Weighting factors as defined in ICRP Publication 26 and NCRP Report 91 are used to convert organ or tissue dose equivalent to effective dose equivalent for the whole body. The effective dose equivalent is obtained by multiplying the organ dose by the weighting factor. For example, a 5 rem dose to the thyroid would be multiplied by the weighting factor 0.03 to yield 0.15 rem.
2. "Remainder" means the five other organs or tissues with the highest dose (e.g. liver, kidney, pancreas, stomach, small intestine and upper large intestine). The weighting factor of 0.3 results from 0.06 for each of the five remainder organs.

Appendix 2C

**Non-Uniform Exposure of the Skin**

Non-uniform exposures of the skin from x-rays, beta radiation and radioactive materials on the skin, including hot particles shall be assessed and recorded as specified in the table below:

<b>AREA OF SKIN IRRADIATED</b>	<b>METHOD OF AVERAGING, ADDING TO OTHER DOSES RECEIVED, AND RECORDING NON-UNIFORM SKIN DOSE</b>
<p><math>\geq 100 \text{ cm}^2</math></p>	<p>Averaged over the <math>100 \text{ cm}^2</math> of skin receiving the maximum dose</p> <p>Added to any uniform dose equivalent also received by the skin</p> <p>Recorded as the annual extremity or skin (shallow) dose equivalent (H)</p>
<p><math>&lt; 100 \text{ cm}^2</math></p>	<p>Averaged over the <math>1 \text{ cm}^2</math> of skin receiving the maximum dose (D), reduced by the fraction (f) which is the irradiated area in <math>\text{cm}^2</math> divided by <math>100 \text{ cm}^2</math> (i.e. <math>H=fD</math>)</p> <p>Added to any uniform dose equivalent also received by the skin</p> <p>Recorded as the annual extremity or skin (shallow) dose equivalent</p>
<p><math>&lt; 10 \text{ cm}^2</math></p>	<p>Averaged over the <math>1 \text{ cm}^2</math> of skin receiving the maximum dose</p> <p>Not added to any other dose equivalent, extremity, or shallow dose equivalent (skin) recorded for the annual dose equivalent</p> <p>Recorded in a person's radiation dose record as a special entry</p>



## CHAPTER 3

### CONDUCT OF RADIOLOGICAL WORK

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## **PART 1 Planning Radiological Work**

### **311 Requirements**

Technical requirements for the conduct of work, including construction, modifications, operations, maintenance, and decommissioning, shall incorporate radiological criteria to ensure safety and maintain radiation exposures ALARA. To accomplish this, the design and planning processes should incorporate radiological considerations in the early planning stages. The checklist in Appendix 3A is helpful in reducing occupational radiation exposure.

### **312 Planning for Maintenance, Operations, and Modifications**

1. Maintenance and modification plans and procedures shall be reviewed to identify and incorporate radiological requirements, such as engineering controls and dose and contamination reduction considerations. Performance of this review is the responsibility of line management, with support and concurrence from the Radiological Control Organization.
2. For routine tasks, such as surveillance, tours and minor nonradiological maintenance, performance of the above review and documentation of identified radiological requirements may be conducted as part of the Radiological Work Permit process (see Article 321).
3. The LBL Site trigger levels requiring formal radiological review of nonroutine or complex work activities are:
  - a. Estimated individual or collective dose greater than 1000 person-mrem,
  - b. Predicted airborne radioactivity concentrations in excess of one times the DAC or an integrated exposure of 400 DAC-hours,
  - c. Work area removable contamination greater than 100 times the values in Table 2-2,
  - d. Entry into areas where dose rates exceed 1 rem in a given hour,
  - e. Potential radioactive releases to the environment that exceed 1 mrem.
4. Tasks with the potential to exceed the above trigger levels shall undergo a formal, documented radiological or ALARA review. At a minimum, this review should consider:
  - a. Inclusion of Radiological Control Hold Points in the technical work documents,
  - b. Elimination or reduction of radioactivity through line flushing and decontamination,
  - c. Use of work processes and special tooling to reduce time in the work area,
  - d. Use of engineered controls to minimize the spread of contamination and generation of airborne radioactivity,
  - e. Specification of special radiological training or monitoring requirements,
  - f. Use of mock-ups for high exposure or complex tasks,
  - g. Engineering, design and use of temporary shielding to reduce radiation levels,
  - h. Walkdown or dry-run of the activity using applicable procedures,
  - i. Staging and preparation of necessary materials and special tools,
  - j. Maximization of prefabrication and shop work,

- k. Potential accident situations or unusual occurrences and a review of abnormal and emergency procedures and plans,
  - l. Identification of points where signatures and second party or independent verifications are required,
  - m. Establishment of success or completion criteria, with contingency plans to anticipate difficulties,
  - n. Development of a pre-job estimate of collective exposure to be incurred for the job
  - o. Provisions for waste minimization and disposal.
5. Radiological requirements identified as part of the above radiological review should be documented in the job plans, procedures, or work packages.
  6. Radiological tasks anticipated to exceed individual or collective dose criteria established in Article 312.3 should be reviewed and approved by the site ALARA Committee.
  7. Optimization techniques, including cost-benefit analysis, represent a fundamental part of radiological design analysis and work review. For review of minor activities with low associated doses, a cost-benefit evaluation is an intrinsic part of the engineering review process and a detailed evaluation is not necessary. For review and planning of major tasks involving higher collective dose expenditures, a detailed and documented evaluation shall be performed.

### **313 Infrequent or First-Time Activities**

At those facilities with routine, recurring process operations, special management attention should be directed to radiological activities that are infrequently conducted or represent first-time operations. Planning for such activities should include:

1. Formal radiological review in accordance with Article 312.4
2. Senior management review directed toward anticipation of concerns and emphasis and specification of protective measures
3. Review and approval by the site's ALARA Committee
4. Enhanced line and Radiological Control management oversight during the initiation and conduct of the work.

### **314 Temporary Shielding**

1. The installation, use, and removal of temporary shielding shall be controlled by procedure.
2. The effects of the additional weight of temporary shielding on systems and components shall be evaluated and established to be within the design basis prior to installation.
3. Installed temporary shielding should be periodically inspected and surveyed to verify effectiveness and integrity.

4. Radiation surveys should be performed during the alteration or removal of installed temporary shielding.
5. Installed temporary shielding shall be visibly marked or labeled with the following or equivalent wording: "Temporary Shielding - Do Not Remove Without Permission from Radiological Control."
6. Installed temporary shielding should be periodically evaluated to assess the need for its removal or replacement with permanent shielding, or removal of the radioactive source through decontamination or component replacement.
7. Shielding used as part of bench-top activities (e.g., vial shields, shadow shields used in hoods, etc.) are exempt from the recommendations of this article requirement unless specifically addressed in the RWP or technical work document.

### **315 Technical Work Documents**

1. Technical work documents, such as procedures, work packages, or job or research plans, should be used to control hands-on work with radioactive materials. Technical work documents are not required for incidental or routine work activities that involve a low potential of worker exposure or workplace contamination, such as the collection of trash or used protective clothing.
2. Technical work documents used to control radiological work activities should be reviewed and approved by the Radiological Control Organization.
3. Radiological Control Hold Points should be incorporated into technical work documents for steps that require action by the Radiological Control Organization to prevent radiation exposures in excess of Administrative Control Levels, high airborne radioactivity concentrations, or the release of radioactivity to the environment.

### **316 Minimization of Internal Exposure**

The minimization and control of internal exposure as discussed in Article 136 should be conducted in accordance with the following hierarchy of controls:

1. Engineering controls, including containment of radioactive material at the source wherever practicable, should be the primary method of minimizing airborne radioactivity and internal exposure to workers.
2. Administrative controls, including access restrictions and the use of specific work practices designed to minimize airborne contamination, should be used as the secondary method to minimize worker internal exposure.

3. When engineering and administrative controls have been applied and the potential for airborne radioactivity still exists, respiratory protection shall be used to limit internal exposures. Use of respiratory protection shall be considered under the following conditions:
  - a. Entry into posted Airborne Radioactivity Areas,
  - b. During breach of contaminated systems or components,
  - c. Work in areas or on equipment with removable contamination levels greater than 100 times the values in Table 2-2,
  - d. During work on contaminated or activated surfaces with the potential to generate airborne radioactivity.
4. The selection of respiratory protection equipment should include consideration of worker safety, comfort and efficiency. Positive pressure respiratory protection devices should be used wherever practicable to alleviate fatigue and increase comfort.
5. In specific situations the use of respiratory protection may be contraindicated due to physical limitations or the potential for significantly increased external exposure. In such situations, written authorization should be obtained from the line organization manager and the Radiological Control Manager prior to incurring internal exposure. Specific justification of the need to accept the exposure, including a description of measures taken to mitigate the airborne radioactivity, should be documented as part of the authorization process.
6. The following controls are applicable for activities authorized in accordance with the above:
  - a. Stay time controls to limit intake should be established for the entry,
  - b. Evaluation of workplace airborne radioactivity levels should be provided through the use of continuous air monitors or air-samplers with expedited assessment and analysis of results.

## **PART 2 Work Preparation**

### **321 Radiological Work Permits**

The RWP is an administrative mechanism used to establish radiological controls for intended work activities. The RWP informs workers of area radiological conditions and entry requirements and provides a mechanism to relate worker exposure to specific work activities. The RWP should include the following information:

1. Description of work
2. Authorized personnel and locations
3. Work area radiological conditions
4. Dosimetry requirements
5. Pre-job briefing requirements, as applicable
6. Training requirements for entry
7. Protective clothing and respiratory protection requirements
8. Radiological Control coverage requirements and stay time controls, as applicable
9. Limiting radiological conditions that may void the RWP
10. Special dose or contamination reduction considerations
11. Special personnel survey considerations
12. Technical work document number, or OSP reference, as applicable
13. Unique identifying number
14. Date of issue and expiration
15. Authorizing signatures.

### **322 Use of Radiological Work Permits**

1. RWPs shall be used to control the following activities:
  - a. Entry into High and Very High Radiation Areas,
  - b. Entry into High Contamination Areas,
  - c. Entry into Airborne Radioactivity Areas.

2. RWPs should be used to control the following activities:
  - a. Entry into Radiation Areas,
  - b. Entry into Contamination Areas,
  - c. Any work with radioactive materials.
3. Job-specific RWPs shall be used to control nonroutine operations or work in areas with changing radiological conditions. The job-specific RWP shall remain in effect only for the duration of the job.
4. General RWPs may be used to control routine or repetitive activities, such as tours and inspections or minor work activities, in areas with well-characterized and stable radiological conditions. General RWPs should not be approved for periods longer than 1 year.
5. Radiological surveys shall be routinely reviewed to evaluate adequacy of RWP requirements. RWPs shall be updated if radiological conditions change to the extent that protective requirements need modification.
6. RWPs should be posted at the access point to the applicable radiological work area.
7. Workers shall sign that they have read, understand, and will comply with the RWP prior to initial entry to the area and after any revisions to the RWP.
8. Worker pocket or electronic dosimeter readings should be recorded in a format that identifies and provides linkage to the applicable RWP.
9. An alternative formal mechanism, such as written procedures or experiment authorizations, may be used in lieu of an RWP as the administrative control over radiological work activities. If an alternative mechanism is used, it should meet the requirements of this Article and Articles 321 and 323.

### **323 Radiological Work Permit Preparation**

1. The responsibility for ensuring adequate planning and control of work activities resides with line management. The lead work group responsible for the planned activity or for the area should initiate the preparation of the RWP by preparing a Project Review Form, OSP or similar document that describes the project.
2. Procedures shall be reviewed and approved by the Radiological Control Organization, who will perform a hazards assessment and prepare the RWP.
3. The RWP shall be based on current radiological surveys and anticipated radiological conditions.
4. The RWP shall be approved by the supervisor responsible for the work or area, the Division Director and the Radiological Control Manager. Revisions or extensions to RWPs.

**324 Pre-Job Briefings**

1. At a minimum, pre-job briefings should be held prior to the conduct of work anticipated to exceed the trigger levels identified in Article 312.3.
2. At a minimum, the pre-job briefing should include:
  - a. Scope of work to be performed,
  - b. Radiological conditions of the workplace,
  - c. Procedural and RWP requirements,
  - d. Special radiological control requirements,
  - e. Radiologically limiting conditions, such as contamination or radiation levels that may void the RWP,
  - f. Radiological Control Hold Points,
  - g. Communications and coordination with other groups,
  - h. Provisions for housekeeping and final cleanup,
  - i. Consideration of potential accident situations or unusual occurrences and a review of abnormal and emergency procedures and plans,
  - j. Emergency response provisions.
3. Pre-job briefings should be conducted by the cognizant work supervisor.
4. Workers and supervisors directly participating in the job, cognizant Radiological Control personnel, and representatives from involved support organizations should attend the briefing.
5. A summary of topics discussed and attendance at the pre-job briefing should be documented. This documentation should be maintained with the technical work document.

**325 Personal Protective Equipment and Clothing**

1. Personnel shall wear protective clothing during the following activities:
  - a. Handling of contaminated materials with removable contamination in excess of Table 2-2 levels,
  - b. Work in Contamination, High Contamination, and Airborne Radioactivity Areas,
  - c. As directed by the Radiological Control Organization or as required by the RWP.
2. Protective clothing and shoes designated for radiological control shall be:
  - a. Marked in accordance with Article 461,
  - b. Used only for radiological control purposes.
3. Protective clothing dress-out areas should be established directly adjacent to the work area. Workers should proceed directly to the radiological work area after donning Personal Protective Equipment and clothing. Dress-out areas for Radioactive Materials Management Areas are normally not applicable at LBL. If required, dress-out area requirements will be stipulated in a RWP.

4. **Personal Protective Equipment and clothing shall be selected as prescribed by the controlling RWP. General guidelines for protective clothing selection and use are provided in Appendix 3C and in Table 3-1.**
5. **The use of lab coats as radiological protective clothing is appropriate for limited applications such as those discussed in Appendix 3C where the potential for personal contamination is limited to the hands, arms, and upper front portion of the body. Lab coats should not be used as protective clothing for performing physical work activities in High Contamination or Airborne Radioactivity Areas. The decision to use laboratory coats as protective clothing in Contamination Areas should be based on the activities to be performed (e.g., walk-through inspections, tours).**
6. **Instructions for donning and removing protective clothing shall be posted at the dress-out and step-off pad areas as required in section 325.1.**
7. **The use of Personal Protective Equipment or clothing (including respiratory protection) beyond that authorized by the Radiological Control Organization detracts from work performance and is contrary to ALARA principles and waste minimization practices. Such use should not be authorized.**
8. **Company-issued clothing, such as work coveralls and shoes, should be considered the same as personal clothing. Company-issued clothing should not be used for radiological control purposes.**

**PART 3 Entry and Exit Requirements****331 Controlled Areas**

Successful completion of Visitor Orientation or General Employee Radiological Training is required for unescorted entry into Controlled Areas.

**332 Radiological Buffer Areas**

1. Minimum requirements for unescorted entry into Radiological Buffer Areas shall include:
  - a. Radiological Worker I training,
  - b. Personnel dosimetry, as appropriate.
2. Personnel who exit a Radiological Buffer Area containing Contamination Areas, High Contamination Areas, or Airborne Radioactivity Areas shall perform or obtain a survey as specified in Article 338.

**333 Radioactive Material Management Areas**

1. Radiological Worker I training shall be required for unescorted entry into Radioactive Material Management Areas containing either:
  - a. Sealed radioactive sources, or
  - b. Radioactive material labeled and packaged in accordance with Articles 412 and 413.
2. Entry into Radioactive Material Management Areas where whole body dose rates exceed 5 mr/hr or removable contamination levels exceed Table 2-2 values shall be in accordance with the requirements of Articles 334.1 and 335.1, respectively.

**334 Radiation, High Radiation, Restricted High Radiation, and Very High Radiation Areas**

1. Minimum requirements for unescorted entry into Radiation Areas shall include the following:
  - a. Radiological Worker I training,
  - b. Worker's signature on the RWP as applicable,
  - c. Personnel dosimetry.
2. Physical controls to prevent inadvertent or unauthorized access to High, Restricted High, and Very High Radiation Areas shall be maintained in accordance with Appendix 3B.

3. Minimum requirements for unescorted entry into High Radiation Areas shall include:
  - a. Radiological Worker II training (or Radiological Worker I training with specialized High Radiation area training in accordance with Article 632.5),
  - b. Worker's signature on the RWP
  - c. Personnel and supplemental dosimeters,
  - d. Survey meter or dose rate indicating device available at the work area.
4. Minimum requirements for unescorted entry into High Radiation Areas where dose rates exist such that a worker could exceed a whole body dose of one rem in one hour shall include those items listed in Article 334.3 and:
  - a. A determination of the worker's current exposure, based on primary and supplemental dosimeter readings,
  - b. Pre-job briefing, as applicable,
  - c. Review and determination by the Radiological Control Organization regarding the required level of Radiological Control Technician coverage.
5. Workers shall be prevented from entry to Very High Radiation Areas when the radiation source is exposed and very high radiation fields are present. In addition to the controls required in Articles 334.2 and 334.3, a survey shall be made prior to the first entry to the area after the source has been secured or shielded to verify the very high radiation field has been terminated.
6. Facility operations personnel should be notified prior to personnel entry to areas where operational or system changes made by operations personnel could result in significantly increased area dose rates.
7. The number, issue, and use of keys shall be strictly controlled where locked entryways are used to control access to High, Restricted High, and Very High Radiation Areas.
8. The Radiological Control Organization should maintain an inventory of High and Very High Radiation Areas.
9. A detailed, rigorous test of the physical access controls to Restricted High and Very High Radiation Areas (interlock system as described in the Health Physics Manual of Good Practice for Accelerators, SLAC-327) should be conducted every 6 months.
10. Weekly verification of the physical access controls to High and Very High Radiation Areas should be made to verify controls are adequate to prevent unauthorized entry. Such checks should be conducted during maintenance or shut down periods only.

### **335 Contamination, High Contamination, and Airborne Radioactivity Areas**

1. Minimum requirements for unescorted entry into Contamination Areas shall include:
  - a. Radiological Worker II training,
  - b. Worker's signature on the RWP, as applicable

- c. Protective clothing,
  - d. Personnel dosimetry, as appropriate.
2. Minimum requirements for unescorted entry into High Contamination or Airborne Radioactivity Areas shall include:
  - a. Radiological Worker II training,
  - b. Worker's signature on the RWP,
  - c. Protective clothing and respiratory protection, as specified by the RWP,
  - d. Pre-job briefing for High Contamination or Airborne Radioactivity Areas, as applicable,
  - e. Personnel dosimetry, as appropriate.
3. Personnel exiting Contamination, High Contamination, or Airborne Radioactivity Areas shall:
  - a. Remove protective clothing as specified in Appendix 3C,
  - b. Perform whole body surveying to detect personnel contamination in accordance with Article 338,
  - c. Tools or equipment being removed from the area shall be monitored for release in accordance with Article 421 or for retention in the contaminated tool crib in accordance with Article 442.5.
4. Exit points from Contamination, High Contamination, or Airborne Radioactivity Areas shall include:
  - a. Step-off pad located outside the exit point, contiguous with the area boundary,
  - b. Step-off pads maintained free of radioactive contamination,
  - c. Labeled containers inside the area boundary for the collection of protective clothing and equipment,
  - d. Contamination monitoring equipment located as close to the step-off pad as background radiation levels permit.
5. Multiple step-off pads should be used at the exits from High Contamination Areas. Use of multiple step-off pads is described in Appendix 3C.
6. Protective clothing and monitoring requirements specific to benchtop work, laboratory fume hoods, sample stations, and gloveboxes are identified in Article 347.

### **336 Visitor Entry Requirements**

1. Site procedures shall identify area entry requirements and access restrictions for visitors.
2. Visitors with a demonstrated need to enter the following areas may be allowed access if such access is controlled with a combination of training and the use of escorts trained for the specific area:

- a. Radiological Buffer Areas,
  - b. Radiation and High Radiation Areas,
  - c. Contamination Areas,
  - d. Radioactive Material Management Areas.
3. Visitors shall be prevented from entering Very High Radiation Areas in accordance with Article 334.5 and should be prohibited access to High Contamination and Airborne Radioactivity Areas.
  4. Training requirements for visitors are identified in Articles 622 and 657.

### **337 Controlling the Spread of Contamination**

The following measures should be used to prevent the spread of contamination across the boundary of Contamination Areas, High Contamination Areas, and Airborne Radioactivity Areas.

1. Use solid barriers to enclose areas wherever practicable.
2. Mark and secure items such as hoses and cords that cross the boundary.
3. Control and direct airflow from areas of lesser to greater removable contamination potential.
4. Use engineering controls and containment devices such as glovebags, gloveboxes, and tents.

### **338 Monitoring for Personnel Contamination**

1. Personnel shall perform a whole body frisk under the following conditions:
  - a. Immediately upon exiting Contamination Areas, High Contamination Areas, and Airborne Radioactivity Areas,
  - b. As directed by the RWP or the Radiological Control Organization.
2. In addition to the above, personnel exiting a Radiological Buffer Area containing Contamination, High Contamination, or Airborne Radioactivity Areas should, at a minimum, perform a hand and foot survey. This survey is optional if the Radiological Buffer Area exit is immediately adjacent to the location where the exiting worker has already performed a whole body survey.
3. Where surveys cannot be performed at the exit from Contamination Areas, High Contamination Areas, or Airborne Radioactivity Areas due to high background radiation levels, personnel shall:
  - a. Remove all protective equipment and clothing at the exit,
  - b. Proceed directly to the nearest designated monitoring station,
  - c. Conduct a whole body survey.

4. Personnel surveys shall be performed after removal of protective clothing and prior to washing or showering.
5. Personnel surveys shall be performed using instruments that meet the minimum detection requirements of Article 221.2. Guidelines for personnel surveying are provided in Appendix 3D.
6. Automated personnel contamination monitors should be used where practical.
7. Personal items, such as notebooks, papers, and flashlights, shall be subject to the same survey requirements as the person carrying them.
8. Instructions for personnel surveying should be posted adjacent to personnel surveying instruments or monitors.
9. The personnel surveying requirements contained in this Article are not applicable at those facilities that contain only radionuclides, such as tritium, that cannot be detected by currently available hand-held or automated surveying instrumentation. At such facilities, additional emphasis should be placed on worker bioassay programs and routine contamination and air sampling programs.

**PART 4 Radiological Work Controls****341 Requirements**

1. Radiological work activities shall be conducted as specified by the controlling Technical Work Document and Radiological Work Permit.
2. Prerequisite conditions, such as tag-outs and system isolation, should be verified in accordance with the technical work documents before work is initiated.

**342 Work Conduct and Practices**

1. Contamination levels caused by ongoing work shall be monitored and maintained ALARA. Work should be curtailed and decontamination performed at pre-established levels, taking into account worker exposure.
2. Tools and equipment should be inspected to verify operability before being brought into Contamination, High Contamination, or Airborne Radioactivity Areas.
3. The use of radiologically clean tools or equipment in Contamination, High Contamination, or Airborne Radioactivity Areas should be minimized by the implementation of a contaminated tool crib in accordance with Article 442.5. When such use is necessary, as in the case of portable radiological survey instruments, tools, or equipment with complex or inaccessible areas should be wrapped or sleeved to minimize contamination.
4. Engineering controls, such as containment devices, portable or auxiliary ventilation and temporary shielding, should be installed in accordance with the technical work documents and inspected prior to use.
5. Hoses and cables entering the work area should be secured to prevent the spread of contamination or safety hazards.
6. The identity of components and systems should be verified prior to work.
7. Work activities and shift changes should be scheduled to prevent idle time in radiation areas.
8. Where practicable, parts and components should be removed to areas with low dose rates to perform work.
9. Upon identification of radiological concerns, such as inappropriate work controls or procedural deficiencies, workers should immediately report the concern to line supervision or the Radiological Control Organization.
10. Requirements for area cleanup should be included in the technical work documents. Work activities should not be considered complete until support material and equipment have been removed and the area has been returned to at least prework status.

11. To minimize intakes of radioactive material by personnel, smoking, eating, chewing, or drinking, except as specified below, shall not be permitted in Contamination, High Contamination, or Airborne Radioactivity Areas. When a potential exists for personnel heat stress, drinking may be permitted within a Contamination Area under the following conditions and controls:
  - a. The potential for heat stress cannot be reduced by the use of administrative or engineering controls,
  - b. All drinking is from approved containers or sources,
  - c. At a minimum, worker's hands and faces are monitored for contamination prior to drinking,
  - d. Participating workers are monitored as part of the bioassay program,
  - e. The applicable requirements and controls are described in approved procedures.

### **343 Logs and Communications**

1. Radiological Control personnel should maintain logs to document radiological occurrences, status of work activities, and other relevant information.
2. During continuous or extended daily operations, oncoming Radiological Control personnel should review logs and receive a turnover briefing from the personnel they are relieving.
3. Communication systems required by the RWP or technical work document should be checked for operability before being brought into the work area and periodically during work.
4. Workers should keep Radiological Control personnel informed of the status of work activities that affect radiological conditions.

### **344 Review of Work in Progress**

1. As part of their normal work review, work supervisors should periodically review ongoing jobs to ensure prescribed radiological controls are being implemented.
2. Radiological Control personnel should conduct frequent tours of the workplace to review the adequacy of radiological work practices, posting, and area controls.
3. During the performance of jobs for which a pre-job dose estimate was made, the Radiological Control Organization, in cooperation with line management, should periodically monitor collective dose accumulation and compare it with the pre-job dose estimate. Differences should be reviewed to identify causes and assess the need for corrective actions.

**345 Stop Radiological Work Authority**

1. Radiological Control Technicians and their supervisors, line supervision, and any worker through their supervisor has the authority and responsibility to stop radiological work activities for any of the following reasons:
  - a. Inadequate radiological controls,
  - b. Radiological controls not being implemented,
  - c. Radiological Control Hold Point not being satisfied.
2. Stop radiological work authority shall be exercised in a justifiable and responsible manner.
3. Once radiological work has been stopped, it shall not be resumed until proper radiological control has been reestablished.
4. Resumption of radiological work requires the approval of the line manager responsible for the work and the Radiological Control Manager.

**346 Response to Abnormal Situations**

1. Standard responses to abnormal radiological conditions shall be adopted and incorporated into RWPs, technical work documents, area and building emergency plans, or radiological worker training programs as appropriate. See PUB-3000 and/or building emergency plans for the appropriate LBL response.
2. Response to a Continuous Air Monitor alarm shall include the following actions:
  - a. Stop work activities,
  - b. Immediately exit the area,
  - c. Notify Radiological Control personnel.
3. Response to increasing or unanticipated radiation levels, as identified by a supplemental dosimeter or Area Radiation Monitor Alarm, shall include the following actions:
  - a. Stop work activities,
  - b. Alert others,
  - c. All personnel immediately exit the area,
  - d. Notify Radiological Control personnel.
4. Response to a personnel contamination monitor alarm shall include the following actions:
  - a. Remain in the immediate area,
  - b. Notify Radiological Control personnel,
  - c. Take actions that may be available to minimize cross-contamination, such as putting a glove on a contaminated hand,
  - d. Take follow-up actions in accordance with Article 541.

5. Response to a spill of radioactive material shall include the following actions:

- a. Stop or secure the operation causing the spill,
- b. Warn others in the area,
- c. Isolate the spill area if possible,
- d. Minimize individual exposure and contamination,
- e. Secure unfiltered ventilation,
- f. Notify Radiological Control personnel.

For spills involving highly toxic chemicals, workers shall immediately exit the area without attempting to stop or secure the spill. They shall then promptly notify the Industrial Hygiene or Hazardous Material team and Radiological Control personnel.

### 347 Controls for Benchtop Work, Laboratory Fume Hoods, Sample Stations, and Gloveboxes

The following requirements are applicable to radiological work in localized benchtop areas, laboratory fume hoods, sample stations, and glovebox operations located in areas that are otherwise contamination free.

1. A RWP shall be issued to control radiological work in localized benchtop areas, laboratory fume hoods, sample sinks, and gloveboxes.
2. The following controls apply to localized benchtop and laboratory fume hood operations:
  - a. Protective clothing shall, at a minimum, include lab coats and gloves. Gloves should be secured at the wrist as necessary.
  - b. Shoecovers should be considered based on the potential for floor contamination.
  - c. Workers shall periodically monitor their hands and area before and during work.
  - d. Upon completion of work or prior to leaving the area, workers shall monitor those areas of their body that are potentially contaminated. At a minimum, this includes hands, arms, and front portions of the body. Workers should perform a whole body survey.
3. The following controls apply to sample station operations:
  - a. Protective clothing shall, at a minimum, include labcoats and gloves. Gloves should be secured at the wrist as necessary.
  - b. Shoecovers should be considered based on the potential for floor contamination.
  - c. If there is a potential for splashing or airborne radioactivity, such as when taking pressurized samples, additional controls such as rubber aprons, face shields, full PCs, or respiratory protection should be instituted.
  - d. Workers should periodically monitor their hands and the area before and during work.
  - e. Upon completion of work or prior to leaving the area, workers shall monitor the area and those areas of their body that are potentially contaminated. At a minimum, this includes hands, arms, and front portions of the body. Workers should perform a whole body survey.

4. The following controls apply to glovebox operations:
  - a. Gloveboxes should be inspected for integrity, operability, and monitored prior to use.
  - b. Gloveboxes should be marked with or survey measurements should be posted to identify whole body and extremity dose rates.
  - c. Protective clothing shall, at a minimum, include labcoats and gloves. Gloves should be secured at the wrist as necessary.
  - d. Shoecovers should be considered based on the potential for floor contamination.
  - e. Workers should periodically monitor their hands and area before and during work.
  - f. Upon completion of work or prior to leaving the area, workers shall monitor the area and those areas of their body that are potentially contaminated. At a minimum, this includes hands, arms, and feet. Workers should perform a whole body survey.

#### **348 Controls for Hot Particles**

Hot particles are small, discrete, highly radioactive particles capable of causing extremely high doses to a localized area in a short period of time. Hot particle contamination may be present or be generated when contaminated systems are opened or when operations such as machining, cutting, or grinding are performed on highly radioactive materials.

1. Hot particles are small (typically less than 1 mm in diameter), generally insoluble particles which, when located on the surface of the skin, are capable of producing a shallow dose equivalent greater than 100 mrem in one hour.
2. Measures for controlling hot particles, as identified in items 3 through 7 of this Article, should be implemented under the following conditions:
  - a. Upon identification of hot particles.
  - b. During new or nonroutine operations with a high potential for hot particles, based on previous history.
  - c. Upon direction of the Radiological Control Organization.
3. Areas or operations with the potential for hot particle contamination should be surveyed in accordance with Article 554.7.
4. Contamination Area posting should be annotated to specifically identify the presence of hot particles.
5. Access to hot particle areas should be controlled by a job-specific RWP. The following controls should be considered for inclusion on the RWP:
  - a. Periodic personnel monitoring during the work activity at a frequency based on the potential magnitude of skin exposure.
  - b. Additional Personal Protective Equipment and clothing

- c. Direct Radiological Control coverage during work or assistance during protective clothing removal
  - d. Use of sticky pads or multiple step-off pads.
6. Personal Protective Equipment and clothing used in Contamination Areas with hot particles should be segregated from other radiological protective equipment and clothing during laundering and surveyed prior to reuse.
7. Response to hot particle skin contamination of personnel should include:
- a. Immediate removal and retention of the hot particle for subsequent analysis
  - b. Analysis of the particle
  - c. Assessment of worker dose
  - d. Evaluation of work control adequacy.

## **PART 5 Evaluation of Performance**

During the conduct of radiological work and the handling of radioactive materials, abnormal events may occur that could indicate a weakness or area of programmatic breakdown of radiological controls. Prompt, consistent gathering of facts related to such events is required to satisfy reporting and investigation requirements and to formulate corrective actions to prevent recurrence. In addition, successful performance or completion of unique activities shall be evaluated to identify and incorporate appropriate lessons learned.

Analysis of the facts should reveal areas where improvements can be made or identify methods to prevent the recurrence of undesired results.

### **351 Conduct of Critiques**

Critiques are meetings of the personnel knowledgeable about an event (either a success or an abnormal event) to document a chronological listing of the facts. The purpose of the critique is not to assign blame, but to establish and record the facts.

1. Critiques should be conducted for successes and abnormal events
2. Critique leaders should be trained in the required elements of the critique process and the appropriate methods of conducting and controlling the critique.
3. Critique meetings should be conducted as soon as practicable after the event or situation is stabilized, or after a successful evolution is completed. Critiques of abnormal events should preferably be conducted before involved personnel leave for the day.
4. At a minimum, the general critique process should include the following elements:
  - a. Formal meetings, chaired by a critique leader
  - b. Attendance by all who can contribute
  - c. Personal statement forms completed by selected personnel before the meeting
  - d. Attendance records
  - e. Minutes, recorded and signed by the critique leader and all contributors
  - f. Personal statements, signed and attached to the meeting minutes
  - g. A listing of the facts in chronological order
  - h. Supporting materials, including documents, records, photographs, parts, and logs, maintained by the critique leader.
5. Evaluation of complex evolutions or events may require multiple critiques.

### **352 Post-Job Reviews**

Post-job reviews shall be performed for jobs or tasks that exceed the trigger levels established in article 312.3.

**353 Lessons Learned**

Lessons learned are available from post-job reviews and reports of past radiological events on site and at other facilities. The Radiological Control Organization, in conjunction with line management, should evaluate lessons learned, provide prompt distribution, and incorporate the lessons into the LBL Site Radiological Control Program, the radiological training program, and related operations.

## **PART 6 Special Applications**

This Part provides supplemental information to augment the basic requirements of the Manual. Articles 361 through 365 provide information to be used in developing the LBL Site Radiological Control Manual. Written guidance and requirements contained within DOE documents, consensus standards, or Federal regulations that delineate specifics for each application are referenced.

Articles 361 and 362 of this Part are not applicable to LBL. This Part is not intended to apply to facilities that use the subject radionuclides in limited or tracer amounts, such as analytical laboratories.

### **363 Tritium Operations**

The following characteristics of tritium require consideration in the implementation of the Radiological Control Program at tritium facilities:

1. Tritium emits low energy beta particles which cannot be monitored using external dosimeters, consequently requiring the use of bioassay measurements to evaluate worker dose.
2. Worker exposure to tritium as water vapor causes a much greater dose than exposure to elemental tritium gas.
3. Normal personnel surveying techniques are ineffective for tritium. Consequently, a high reliance is placed on worker bioassay and routine contamination and air monitoring programs.
4. Due to its high permeability, tritium is difficult to contain. Special attention shall be directed to the selection of Personal Protective Equipment and clothing.

For the above reasons, guidance contained in the document, "Health Physics Manual of Good Practices at Tritium Facilities," MLM-3719, should be considered when developing procedures for tritium operations at the LBL Site. This manual provides specific guidance related to internal dosimetry, contamination and good practices air monitoring, tritium containment practices and techniques and Personal Protective Equipment and clothing selection. The guidance for conducting work at LBL in the National Tritium Labeling Facility is contained in the NTLF OSP.

### **364 Accelerator Operations**

Special considerations associated with accelerator facilities include the presence of extremely high dose rates, high energy and heavy particles, the generation of activation products and detection and monitoring difficulties associated with pulsed or high energy radiation. For these reasons:

1. In addition to the provisions of this Manual, guidance contained in the document, "Health Physics Manual of Good Practices for Accelerator Facilities," SLAC-327, should be considered for accelerator operations at the LBL Site. This manual of good practices

provides specific guidance related to radiological monitoring, dosimetry, shielding design, use of interlocks, and procedures and administrative controls.

2. Consideration should be given to the information provided in ANSI N43.1, "Radiological Safety in the Design and Operation of Particle Accelerators," when developing plans and procedures for accelerator operations at the LBL Site.
3. Safety devices and interlocks shall be operational prior to and during operation of a beam. Operational status shall be verified by testing.

### 365 Radiation-Generating Devices

Special considerations associated with the use of radiation generating devices (RGD) include the presence of extremely high dose rates and the potential for uncontrolled exposures. Operation of these devices require stringent physical and administrative controls to prevent overexposure to operating and support personnel and those in adjacent work areas. In addition to requirements for RGD operations contained in this document, requirements for RGDs used for industrial and are based primarily on ANSI standards mandated by DOE 5480.4 and Pub-3000.

1. ANSI N543 entitled "General Safety Standard for Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources, Energies up to 10 MeV," and LBL PUB-3000 shall be used for operations involving the irradiation of materials.
2. ANSI N43 entitled, "Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment," shall be used for operations involving analytical diffraction and fluorescence.
3. The site organization responsible for RGD design and operation shall include:
  - a. A Qualified Expert who provides guidance and approval on the safe operation of RGD installations. The Qualified Expert shall be appointed by line management and approved by the Radiological Control Organization. New or modified RGD installations shall not be routinely operated until the Qualified Expert reviews and approves the design or modification, and pre-operational inspection and survey results.
  - b. The X-ray System Supervisor or facility supervisor provides control of RGDs and RGD installations. The supervisor should be appointed by line management and approved by the Radiological Control Organization.

The Supervisor should:

- Maintain control of all keys, combinations, or codes necessary for operation of the RGD installation,
- Maintain current as-built schematics, including diagrams of the interlocks,
- Maintain a list of RGD sealed sources, if applicable,

- Provide initial training to qualify staff as RGD operators and provides retraining every two years,
- Ensure that operating procedures are available and up-to-date at each RGD installation,
- Maintain a list of all qualified RGD operators,
- Train RGD operators every two years in site job-specific procedures,
- Ensure that inspections and radiological surveys are conducted prior to operation of new or modified RGD installations, and ensures that periodic inspections and surveys are conducted annually.

c. **Radiation Generating Device Operators**

Line Management certifies qualified RGD Operators. The X-ray Supervisor should approve qualified RGD Operators. RGD Operators shall be qualified as a minimum as Radiological Worker I and shall receive every two years job-specific (RGD installation) training. The level of training shall be commensurate with the RGD Operator's job assignment.

The RGD Operator should have a working knowledge of:

- methods used in the limiting exposures to as low as reasonably achievable,
- methods for defining radiation areas and for controlling access to these areas,
- access control devices, including interlocks,
- warning devices,
- fixed and portable monitoring devices,
- applicable personnel monitoring devices,
- operating, transporting, calibrating, and maintaining RGDs in the installation,
- methods for inspecting RGD installations,
- methods used for radiological surveys of the RGD installations and adjacent areas,
- maintains logs and records, and,
- minimum actions and persons to be contacted in the event of response to abnormal operations.

**d. Radiological Control Organization**

**The Radiological Control Manger will ensure that designated Radiological Control Organization staff provide overview for RGD installations.**

**The Radiological Control Organization staff assigned to RGD installations should:**

- **Conduct pre-operational, annual, and unscheduled inspections**
  - **Conduct pre-operational, annual, and unscheduled radiological surveys**
  - **Periodically review logs and records**
- 5. Devices for medical use shall be registered with the appropriate regulatory agency if applicable.**
- 6. On-site operations conducted by off-site contractors shall be approved by line management in coordination with the site Radiological Control Organization. These should include verification of contractor NRC or State licenses and that operational and emergency procedures are current.**
- 7. A physical radiation survey should be conducted during or immediately following activities that could alter the effectiveness of shielding used to protect personnel from RGDs.**

## **PART 7 Construction and Restoration Projects**

Construction and restoration projects, including decontamination and decommissioning (D&D), remedial action, or other actions involving materials which contain low levels of radioactivity may present special problems and require site-specific or program-specific control methods. Health and Safety Plans are normally developed to specify controls for all types of restoration programs including Formerly Utilized Sites Remedial Action Program (FUSRAP), Uranium Mill Tailings Remedial Action (UMTRA), and other restoration projects.

### **371 Requirements**

Radiological operations and work activities at construction and environmental restoration projects shall be conducted in accordance with this Manual. In light of the special nature of these activities, which typically involve low-levels of radioactivity and the use of heavy construction or earth-moving equipment, these projects require some radiological considerations different from other activities governed by this Manual.

For the following specific subject areas, the radiological requirements of this Manual, in consultation with the cognizant line managers, may be modified by the limited application of the provisions of Article 113.3. The Radiological Control Manager is authorized to change mandatory "shall" requirements to "should" to facilitate implementation of radiological controls in the following specific subject areas. The contractor has the responsibility to document the technical equivalency of alternative solutions.

1. Performance goals and indicators appropriate to remedial activities.
2. Personal Protective Equipment requirements and practices to accommodate other hazards on the site.
3. Use of respiratory protection as normal conduct of operation due to lack of engineering controls and temporary nature of the work.
4. Use of Contamination Reduction Corridors to accommodate movement of personnel and heavy equipment through a variety of decontamination stations.
5. Methods to obtain representative samples for release of equipment and material from the work areas.
6. Surveying of materials released from Soil Contamination Areas that exhibit significant contamination transfer properties.
7. Precedence of State and Federally mandated soil cleanup criteria over surface contamination criteria that otherwise apply.
8. Monitoring and survey frequency for inactive facilities or large areas that are infrequently occupied.

9. Outdoor storage of uncontained, bulk radioactive materials such as contaminated soil.
10. Postings of privately owned and adjacent property.
11. Evaluation of outdoor air monitoring methodologies that take into account dust loading, environmental factors, and supplemental breathing zone sampling.
12. Criteria for suspension of operations under inclement conditions, such as wind or rain.

### **372 Environmental Conditions**

Inclement weather or other environmental conditions may disrupt radiological controls. If that occurs, the following actions should be considered:

1. The use of covers, wind screens, and runoff collection basins to preclude the inadvertent spread of radioactive material.
2. Provisions for worksite personnel to assemble and be monitored prior to release or re-establishment of work.
3. Evaluation of work area to determine if a need exists for modified work controls or decontamination.

**373 Other Workplace Hazards**

Radiological controls should be implemented in a balanced way to ensure that protection from all workplace hazards can be implemented. Other hazards to consider include:

1. General construction hazards,
2. Confined spaces,
3. Flammable materials,
4. Reactive chemicals,
5. Heat stress,
6. Chemical exposures,
7. Energized electrical equipment,
8. Biological hazards,
9. Rotating equipment,
10. Noise and vibration,
11. Excavations.

**PART 8 Summary of Responsibilities****381 Senior Site Executive**

- Review infrequent or first-time operations. (313.2)

**382 Line Management**

- Plan for maintenance, operation, and modification activities. (312.1)
- Provide enhanced oversight of infrequent or first-time work. (313.4)
- Provide written approval for planned internal exposures. (316.5)
- Approve RWPs. (323.1)
- Provide adequate planning and control of work. (344.1)
- Conduct pre-job briefings. (324.3)
- Periodically monitor progress of work. (344.1)
- Periodically monitor collective dose for specific jobs. (344.3)
- Exercise stop-work authority. (345.1)
- Evaluate lessons learned from critiques. (353)
- Establish radiological control requirements for incidental X-ray devices. (365.3)

**383 Radiological Control Manager**

- Concur in planning for maintenance, operations, and modifications. (312.1)
- Provide enhanced oversight during infrequent or first-time work. (313.4)
- Review and approve technical work documents for radiological work activities. (315.2)
- Specify radiological hold points in technical work documents. (315.3)
- Provide written approval for planned internal exposures. (316.5)
- Review and approve RWPs. (323.2)
- Attend pre-job briefings. (324.4)
- Maintain and inventory High and Very High Radiation Area keys. (334.8)
- Maintain logs. (343.2)
- Conduct and receive turnover briefings. (343.2)
- Conduct frequent tours of work areas. (344.2)
- Periodically monitor collective dose for specific jobs. (344.3)
- Exercise stop-work authority. (345.1)
- Authorize resumption of work following a stop-work order. (345.4)
- Evaluate lessons-learned from critiques. (353)
- Establish radiological control requirements for incidental X-ray devices. (365.3)
- Modify radiological control requirements for unique construction or restoration project circumstances. (371)

**384 ALARA Committee**

- Approve radiological tasks anticipated to exceed individual or collective dose criteria. (312.3)
- Review infrequent or first-time operations. (313.3)

**385 Employees**

- Read and sign RWPs. (322.7)
- Attend pre-job briefings. (324.3)
- Perform monitoring for personal contamination. (332.2; 338)
- Keep radiological control personnel informed of changes in work. (343.4)
- Exercise stop-work authority. (345.1)

**386 Support Organizations**

- Attend pre-job briefings. (324.3)

## Appendix 3A

### Checklist for Reducing Occupational Radiation Exposure

#### Preliminary Planning and Scheduling

- Plan in advance
- Delete unnecessary work
- Determine expected radiation levels
- Estimate collective dose
- Sequence jobs
- Schedule work
- Select a trained and experienced work force
- Identify and coordinate resource requirements

#### Preparation of Technical Work Documents

- Include special radiological control requirements in technical work documents
- Perform ALARA pre-job review
- Plan access to and exit from the work area
- Provide for service lines (air, welding, ventilation)
- Provide communication (sometimes includes closed-circuit television)
- Remove or shield sources of radiation
- Plan for installation of temporary shielding
- Decontaminate
- Work in lowest radiation levels
- Perform as much work as practicable outside radiation areas
- State requirements for standard tools
- Consider special tools, including robots
- State staging requirements for materials, parts and tools
- Incorporate Radiological Control Hold Points
- Minimize discomfort of workers
- Revise estimates of collective dose
- Prepare RWPs if applicable

#### Temporary Shielding

- Design shielding to include stress considerations
- Control installation and removal by written procedure
- Inspect after installation
- Conduct periodic radiation surveys
- Prevent damage caused by heavy lead temporary shielding
- Balance radiation exposure received in installation against exposure saved by installation
- Shield travel routes

- Shield components with abnormally high radiation levels early in the maintenance period
- Shield position occupied by worker
- Perform directional surveys to improve design of shielding by locating source of radiation
- Use mock-ups to plan temporary shielding design and installation
- Consider use of water-filled shielding

#### Rehearsing and Briefing

- Rehearse
- Use mock-ups duplicating working conditions
- Use photographs and videotapes
- Supervisors conduct briefings of workers

#### Performing Work

- Comply with technical work documents and RWPs
- Post radiation levels
- Keep excess personnel out of radiation areas
- Minimize radiation exposure
- Supervisors and workers keep track of radiation exposure
- Workers assist in radiation and radioactivity measurements
- Delegate radiological control monitoring responsibilities
- Evaluate use of fewer workers
- Reevaluate reducing radiation exposures
- Compare actual collective dose against pre-job estimate
- Review work practices to see if changes will reduce dose
- Coordinate personnel at the job site to reduce nonproductive time

## Appendix 3B

### Physical Access Controls for High and Very High Radiation Areas

1. One or more of the following features should be used for each entrance or access point to a High Radiation Area and shall be used for each entrance or access point to a Restricted High Radiation Area where radiation levels exist such that a person could exceed a whole body dose of 1 rem (cSv) in any one hour:
  - a. A control device that prevents entry to the area when high radiation levels exist or upon entry causes the radiation level to be reduced below that level defining a High Radiation Area.
  - b. A device that functions automatically to prevent use or operation of the radiation source or field while personnel are in the area.
  - c. A control device that energizes a conspicuous visible or audible alarm signal so that the person entering the High Radiation Area and the supervisor of the activity are made aware of the entry.
  - d. Entryways that are locked, except during periods when access to the area is required, with positive control over each entry.
  - e. Continuous direct or electronic surveillance that is capable of preventing unauthorized entry.
2. In addition to the above requirements, additional measures shall be implemented to ensure personnel are not able to gain access to Very High Radiation Areas when dose rates are in excess of the posting requirements of Table 2-3.
3. Physical access controls over High and Very High Radiation Areas shall be established in such a way that does not prevent a person from leaving the area.

## Appendix 3C

### Contamination Control Practices

#### Selection of Protective Clothing

1. Workers should inspect protective clothing prior to use for tears, holes or split seams that would diminish protection. Any defective items should be replaced with intact protective clothing. If lab coats are the protective clothing the primary concern should be checking of gloves for defects and tears.
2. Protective clothing as prescribed by the Radiological Work Permit should be selected based on the contamination level in the work area, the anticipated work activity, worker health considerations, and regard for nonradiological hazards that may be present. Table 3-1 provides general guidelines for selection. As referenced in the table, a full set and double set of protective clothing (PC) typically includes:

#### Full Set of PCs

- a. Coveralls
- b. Cotton glove liners
- c. Gloves
- d. Shoe covers
- e. Rubber overshoes
- f. Hood

#### Double Set of PCs

- a. Two pairs of coveralls
- b. Cotton glove liners
- c. Two pairs of gloves
- d. Two pairs of shoe covers
- e. Rubber overshoes
- f. Hood

3. Cotton glove liners may be worn inside standard gloves for comfort, but should not be worn alone or considered as a layer of protection.
4. Shoecovers and gloves should be sufficiently durable for the intended use. Leather or canvas work gloves should be worn in lieu of or in addition to standard gloves for work activities requiring additional strength or abrasion resistance.
5. Use of hard hats in Contamination Areas should be controlled by the Radiological Work Permit. Hard hats designated for use in such areas should be distinctly colored or marked.
6. Shoe covers and gloves should be secured or taped at the coverall legs and sleeves when necessary to prevent worker contamination. Tape should be tabbed to permit easy removal.

7. Supplemental pocket or electronic dosimeters should be worn outside the protective clothing, in a manner accessible to the worker. Workers should protect such dosimeters from contamination by placing them in an outer coverall pocket or in plastic bags or pouches.
8. Outer personal clothing should not be worn under protective clothing for entry to High Surface Contamination Areas or during work conditions requiring a double set of protective clothing.

#### Removal of Protective Clothing

Potentially contaminated protective clothing should be removed without spreading contamination and in particular without contaminating the skin. Workers should be instructed not to touch the skin or place anything in the mouth during protective clothing removal. Instructions for protective clothing removal comparable to the sequence presented below should be posted adjacent to the step-off pad in accordance with Article 325.6.

#### Sequence for Removing a Full Set of Protective Clothing at the Step-Off Pad

Before stepping out of the Contamination Area or Airborne Radioactivity Area to the step-off pad, the worker should:

1. Remove exposed tape
2. Remove rubber overshoes
3. Remove gloves
4. Remove hood from front to rear
5. Remove respiratory protection, as applicable
6. Remove coveralls, inside out, touching inside only
7. Take down barrier closure, as applicable
8. Remove tape or fastener from inner shoe cover
9. Remove each shoe cover, placing shoe onto clean step-off pad
10. Remove cloth glove liners
11. Replace barrier closure, as applicable
12. Commence whole body surveying
13. Monitor badge and dosimeter.

The sequence for the removal of primary and supplemental dosimetry is dependent upon where the dosimetry was worn and the potential for contamination.

#### Sequence for Removing a Double Set of Protective Clothing using Two Step-Off Pads

Before stepping to the inner step-off pad, the worker should:

1. Remove exposed tape
2. Remove rubber overshoes
3. Remove outer gloves

4. Remove hood from front to rear
5. Remove respiratory protection, as applicable
6. Remove outer coverall, inside out, touching inside only
7. Remove tape from inner coverall and sleeves
8. Remove each outer shoe cover, stepping on inner step-off pad as each is removed.

Before stepping to the outer step-off pad, the worker should:

9. Remove inner rubber gloves
10. Remove inner coveralls, inside out, touching inside only
11. Take down barrier closure, as applicable
12. Remove tape or fastener from inner shoe cover
13. Remove each inner shoe cover, placing shoe on clean outer step-off pad
14. Remove cotton glove liners
15. Replace barrier closure, as applicable
16. Commence whole body survey
17. Monitor badge and dosimeter.

The sequence for the removal of primary and supplemental dosimetry is dependent upon where the dosimetry was worn and the potential for contamination.

Multiple Step-Off Pads are not applicable to LBL Operations.

*Table 3-1 Guidelines for Selecting Protective Clothing (PC)*

WORK ACTIVITY	REMOVABLE CONTAMINATION LEVELS		
	LOW (1 to 10 times Table 2-2 values)	MODERATE (10 to 100 times Table 2-2 values)	HIGH (> 100 times Table 2-2 values)
Routine	Full set of PCs	Full set of PCs	Full set of PCs, double gloves, double
Heavy work	Full set of PCs, work gloves	Double set of PCs, work gloves	Double set of PCs, work gloves
Work with pressurized or large volume liquids, closed system breach	Full set of non-permeable PCs	Double set of PCs (outer set non-permeable), rubber boots	Double set of PCs and non-permeable outer clothing, rubber boots

Note: For hands-off tours or inspections in areas with removable contamination at levels 1 to 10 times the values in Table 2-2, labcoats, shoecovers, and gloves may be used instead of full PCs. To work in RMMA's with radioactive material at levels approved in the General RWP lab coats and gloves are considered the normal protective clothing.

## Appendix 3D

### Guidelines for Personnel Monitoring with Hand-Held Survey Instruments\*

#### General Requirements

1. Verify that the instrument is in service, set to the proper scale and the audio output can be heard during surveying. Check battery, source response, and calibration.
2. Hold probe less than 1/2 inch from surface being surveyed for beta and gamma contamination, approximately 1/4 inch for alpha contamination.
3. Move probe slowly over surface, approximately 2 inches per second.
4. If the count rate increases during surveying, pause for 5 to 10 seconds over the area to provide adequate time for instrument response.
5. If the count rate increases to a value greater than a pre-established contamination limit or the instrument alarms, remain in the area and notify Radiological Control personnel.
6. The whole body survey should take at least two to three minutes.

#### Performance of Monitoring:

1. Survey the hands before picking up the probe.
2. Perform the survey in the following order:
  - a. Head (pause at mouth and nose for approximately 5 seconds)
  - b. Neck and shoulders
  - c. Arms (pause at each elbow)
  - d. Chest and abdomen
  - e. Back, hips, and seat of pants
  - f. Legs (pause at each knee)
  - g. Shoe tops
  - h. Shoe bottoms (pause at sole and heel)
  - i. Personnel and supplemental dosimeters.
3. Return the probe to its holder and leave the area. The probe should be placed on the side or face up to allow the next person to monitor their hands before handling the probe.

\*Comparable instructions to those presented here should be posted adjacent to monitoring instruments in accordance with Article 338.8.

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## **PART 1 Radioactive Material Identification, Storage and Control**

For the purposes of this Manual, radioactive material is any material, equipment, or system component determined to be contaminated. Items located in known or suspected Contamination, High Contamination, or Airborne Radioactivity Areas and having the potential to become contaminated are considered radioactive material. Radioactive material also includes activated material, sealed and unsealed sources, and materials that emit radiation. Controls for sealed sources are described in Article 431.

### **411 Requirements**

1. Materials in Contamination, High Contamination, or Airborne Radioactivity Areas shall be considered radioactive material until surveyed and released. These survey and release requirements do not apply to Airborne Radioactivity Areas where only gaseous, short-lived (half-life of 1 hour or less) activation products are present.
2. Except for sealed and unsealed sources, radioactive material located within Contamination, High Contamination, or Airborne Radioactivity Areas does not require specific labeling or packaging.
3. Radioactive material may be capable of generating a High Radiation Area. These areas shall have special controls in accordance with Article 334.
4. The Radiological Control Organization shall develop response and notification requirements associated with a loss of radioactive material, including searches, internal investigations, documentation and reporting. The Radiological Control Organization shall be notified in the event of a loss of radioactive material.

### **412 Radioactive Material Labeling**

1. Radioactive material outside Contamination, High Contamination, or Airborne Radioactivity Areas shall be labeled in accordance with Table 4-1.

*Table 4-1 Labeling Requirements for Radioactive Materials*

ITEM/MATERIAL	REQUIRED LABELING
Equipment, components, and other items that are radioactive, potentially radioactive, or have been exposed to radioactive contamination or activation sources	"CAUTION, RADIOACTIVE MATERIAL"
Sealed and unsealed radioactive sources or associated storage containers	"CAUTION, RADIOACTIVE MATERIAL" or standard radiation symbol
Equipment, components, and other items with actual or potential internal contamination	"CAUTION, INTERNAL CONTAMINATION" or "CAUTION, POTENTIAL INTERNAL CONTAMINATION"
Components, equipment, or other items with fixed contamination	"CAUTION, FIXED CONTAMINATION"

2. The following are not subject to labeling requirements:
  - a. Radioactive material surveyed and determined to have contamination levels lower than Table 2-3 values,
  - b. Radioactive material or containers packaged and labeled for off-site shipment in accordance with Department of Transportation Regulations,
  - c. Personal Protective Equipment and clothing,
  - d. Radiological control samples such as air, process and soil samples or swipes that are in the custody of Radiological Control personnel or personnel properly trained in the handling, packaging and transport of these samples,
  - e. Equipment or installed system components undergoing maintenance covered by a Radiological Work Permit,
  - f. Portable tools and equipment with fixed contamination permanently marked with yellow or magenta and maintained in a contaminated tool crib or storage and distribution area,
  - g. Installed system components located within an area, the entrance to which is posted in accordance with Table 2-4,
  - h. Nuclear weapon components,
  - i. Historical items, such as uranium hexafluoride cylinders and large items used in demonstration projects, located within a Radioactive Material Management Area; such items shall be properly labeled when they are removed from a Radioactive Material Management Area.
  
3. Labels shall have a yellow background with a magenta or black standard radiation symbol. Lettering shall be magenta or black. Magenta shall normally be used. The Radiological Control Manager may authorize the use of black for outdoor labels where excessive fading is a problem.
  
4. Labels should include contact radiation levels, removable surface contamination levels (specified as alpha or beta-gamma), dates surveyed, surveyor's name, and description of items.

5. Packaged radioactive material should have the label visible through the package or affixed to the outside.
6. Labels used in outdoor applications shall be securely attached and protected against harsh

#### **413 Radioactive Material Packaging**

1. Radioactive material that is outside Radioactive Material Management Areas, Contamination, High Contamination, or Airborne Radioactivity Areas and is confirmed or suspected of having removable radioactive contamination levels greater than Table 2-2 values shall be securely wrapped in plastic or placed in a container.
2. Radioactive material with sharp edges or projections should be taped or additionally protected to ensure package integrity.
3. Radioactive material with removable or potentially removable contamination levels in excess of 100 times Table 2-2 values should have additional packaging controls such as double-wrapping or the use of plastic bags inside containers.
4. LBL will use clearly labeled wrapping material for packaging radioactive material.
5. The amount of combustible material used in packaging should be minimized.

#### **414 Radioactive Material Storage**

1. Radioactive material should be stored in a designated Radioactive Material Management Area, Radioactive Material Storage Area, or for induced Radioactive Material in a Controlled Area.
2. Long-term (more than 60 days) storage of radioactive material should be in a specially designated Radioactive Material Management Area.
3. Decontamination or disposal of radioactive material is the preferred alternative to long-term storage.
4. Each type of Radioactive Material Management Area and Radioactive Material Storage Area should be approved by the Radiological Control Manager.
5. A custodian should be assigned responsibility for each Radioactive Material Management Area. A custodian may have responsibility for more than one storage area. A custodian at the LBL Site normally will be the Principle Investigator, program manager, or Radiological Control Organization.
6. The custodian should conduct walk-through tours of Radioactive Material Management Areas to check container integrity.

7. **The custodian or Radiological Control Organization shall conduct annual or more frequent reviews of their Radioactive Material Management, or Controlled Area, with emphasis on decontamination, movement of material to long-term storage locations, and disposal of unneeded material.**
8. **Radioactive material shall not be stored outdoors unless specifically authorized in writing by the Radiological Control Manager.**
9. **In cases where outdoor storage is necessary, the integrity of containers used shall be ensured to prevent degradation from weathering and subsequent release of radioactive material. The Field Operations Unit or custodian shall check container integrity monthly at outdoor Radioactive Material Storage Areas.**
10. **Radioactive material shall be stored in a manner that reduces combustible loading. The use of cardboard containers for storage is discouraged.**
11. **Flammable or combustible materials should not be stored adjacent to Radioactive Material Storage Areas.**
12. **Fire protection measures, such as smoke detectors, water sprinklers, and fire extinguishers, should be considered when establishing a Radioactive Material Management Area.**

**PART 2 Release and Transportation of Radioactive Material****421 Release to Controlled Areas**

1. Material in Contamination, High Contamination or Airborne Radioactivity Areas shall be surveyed for loose surface and fixed radioactive contamination prior to release. Materials released to Controlled Areas shall be demonstrated to have radioactive contamination levels less than Table 2-2 values. Material to be released to uncontrolled areas shall be surveyed in accordance with Article 422 and in accordance with LBL Procedure 708.
2. Material with radioactive contamination levels greater than Table 2-2 values shall be labeled and packaged prior to release to Controlled Areas.
3. Material not immediately released after survey should be controlled to prevent recontamination while awaiting release.
4. Records for release of potentially contaminated materials shall be in accordance with EH&S Procedure 708.

**422 Release to Uncontrolled Areas**

1. Materials in Controlled Areas or Radioactive Material Management Areas shall be surveyed for radioactive contamination prior to release to uncontrolled areas.
2. DOE 5400.5 describes criteria for releasing radioactive material to uncontrolled areas.
3. DOE 5400.5 describes criteria for releasing material that has been contaminated with radioactive material in depth or volume.
4. Material not immediately released after survey shall be controlled to prevent radioactive contamination while awaiting release.
5. Radiological labels shall be removed or defaced prior to release of material for unrestricted use.

**423 Transportation of Radioactive Material**

1. 49 CFR 170 through 180 describe requirements for inspecting and surveying packages, containers, and transport conveyances prior to off-site transport. The 49 CFR 173 contamination values shall be used as controlling limits for off-site shipments transported by non-DOE conveyances. These limits also apply to on-site transfers of shipments by non-DOE conveyances received from or destined to off-site locations.

2. Table 2-2 contamination values shall be used as controlling limits for on-site and off-site transportation when using a DOE conveyance. When a shipment is received from an off-site destination, a non-DOE conveyance, the 49 CFR contamination values shall be used when transfers are made by a DOE conveyance from the on-site receiving location to the ultimate on-site destination.
3. On-site transfers over non-public thoroughfares or between facilities on the same site shall be performed in accordance with written procedures utilizing pre-approved routes. The procedures shall include requirements to ensure appropriate monitoring and control of the radioactive material and should be approved by the Radiological Control Organization.
4. On-site transfers over public thoroughfares shall be performed in accordance with Department of Transportation, state, and local shipping requirements, and pre-approved agreements.
5. Off-site shipments of radioactive material, including subcontractors' handling of off-site shipments, shall be controlled and conducted in accordance with this Manual and applicable Federal, state, and local regulations.
6. Before shipment, and upon receipt of a radioactive shipment, a visual inspection of packages should be performed to ensure that packages are not damaged. The inspection should identify dents, flaking paint, debris, package orientation, and any indication of leakage.
7. Before shipment, and upon receipt of a radioactive shipment, a comparison of package count to the shipping manifest should be made to ensure accountability.
8. Transport conveyances should be visually inspected prior to loading to ensure the trailers are acceptable for the intended use.
9. Commercial transport conveyances used for primary radioactive transport should be radiologically surveyed upon entering the LBL Site. Commercial Transport conveyances used for waste or exclusive use, Type B shipment or used for primary radioactive transport should be surveyed prior to loading. This requirement does not apply to Commercial Shippers (e.g. Federal Express, UPS, etc.) routinely shipping Type A or exempt packages except in the case of suspected or known damaged shipment.
10. Transport of large volumes of radioactive material by non-DOE motor vehicles should be "exclusive use" to prevent commingling of DOE and other commercial shipments.
11. The site emergency plan should describe appropriate responses for potential on-site radioactive material transportation accidents.
12. Drivers of DOE and non-DOE motor vehicles should have a copy of their emergency response plan, or the emergency response information required by 49 CFR 172.600, during transport on-site or during off-site transportation.

**PART 3 Radioactive Source Controls****431 Radioactive Source Controls**

The following provisions apply to sealed and unsealed sources.

1. DOE N 5400.9 describes how sealed sources shall be controlled and maintained, and specifies requirements for receipt, inventory, storage, transfer, disposal, and integrity testing. Unsealed sources shall be controlled and maintained in a similar manner except for integrity testing.
2. The Radiological Control Organization shall maintain, or cause to be maintained, accountability records for sealed sources.
3. Source custodians shall be designated in writing by line management to maintain radioactive source controls.
4. Source custodians shall notify the Radiological Control Organization of changes in use, storage, transfer, disposal, or loss of a sealed source.
5. Sealed source integrity testing shall be done at least every 6 months or whenever damage might have occurred.
6. Labels used to identify sealed sources shall also identify the radionuclide, activity, date of assay, source model and serial number, and source custodian.
7. Procurement of radioactive sources shall be coordinated with the Radiological Control Organization.
8. Receipt surveys of radiological material shipments shall be performed by the Radiological Control Organization.
9. Radioactive sources, including radiography sources, shall not be brought on-site by external organizations without the prior written approval of the Radiological Control Organization.

**PART 4 Solid Radioactive Waste Management****441 Requirements**

1. DOE 5820.2A describes how solid radioactive waste is treated, packaged, stored, transported, and disposed.
2. Radiological operations generating radioactive waste should be designed and developed to permit segregation, monitoring, treatment, storage, and disposal.
3. Radioactive waste minimization goals and practices should be developed and implemented.

**442 Waste Minimization**

A radioactive waste minimization program shall be in effect to reduce the generation of radioactive waste and spread of contamination from Contamination, High Contamination, or Airborne Radioactivity Areas. The following practices should be instituted to support waste minimization:

1. Restrict material entering Radiological Buffer Areas to those needed for performance of work.
2. Restrict quantities of hazardous materials, such as paints, solvents, chemicals, cleaners and fuels, entering Radiological Buffer Areas and take measures to prevent inadvertent radioactive contamination of these materials.
3. Substitute recyclable or incinerable items in place of disposable ones and reuse equipment when practical.
4. Select consumable materials such as protective coverings and clothing that are compatible with waste-processing systems, volume reduction and waste form acceptance criteria.
5. Reserve an assortment of tools primarily for use in Contamination, High Contamination, or Airborne Radioactivity Areas. Tools should be maintained in a designated storage or distribution area or a contaminated tool crib. Controls should be established for tool issuance and use.
6. Survey potentially contaminated material from Radiological Buffer Areas to separate uncontaminated from contaminated materials.
7. Segregate known uncontaminated from potentially contaminated waste.
8. Segregate reusable items, such as protective clothing, respirators, and tools, at the step-off pad.
9. Minimize the number and size of Radioactive Material Management Areas.
10. Emphasize training in waste reduction philosophies, techniques, and improved methods.

**443 Mixed Waste**

Requirements specified in the Resource Conservation and Recovery Act and Toxic Substances Control Act apply to waste that contains both radioactive and hazardous materials.

1. DOE 5400.3 and 5820.2A describe controls for mixed waste.
2. DOE 5400.3 and 5820.2A, and Article 442, describe how mixed waste generation should be minimized.
3. Technical and administrative controls should be established to minimize the volume of mixed waste generated and the amount of radioactivity in such waste. Volume reduction methods include process optimization, materials substitution, and new technology development.
4. Materials suspected of being mixed waste should be identified and segregated as soon as practical in the generating process to avoid combining mixed waste with other waste forms.
5. The most stringent regulatory requirements for the types of waste present should be applied to waste classification and disposal.

## **PART 5 Control of Radioactive Liquids and Airborne Radioactivity**

### **451 Minimization and Control of Radioactive Liquid Wastes**

1. DOE 5820.2A provides criteria for minimizing the generation of radioactive liquid waste. Minimization should include evaluating operational requirements to reduce liquid usage and maximize recycling activities.
2. A water management program should be maintained to identify, trend and eliminate unnecessary sources of radioactive liquid waste. This program should include aggressive measures to identify and repair leaks.
3. Activities that produce radioactive liquid waste should be suspended unless sufficient processing, collection, and storage capacity is available to accommodate the waste.
4. DOE 5400.5 provides radioactive liquid waste discharge requirements.
5. Radioactive liquid waste discharges should be controlled on a batch basis to enhance monitoring capability and to reduce the potential for inadvertent release.
6. Radioactive liquid waste discharges should be analyzed prior to release, monitored during release, and the release terminated before exceeding predetermined limits.
7. Radioactive liquid waste that cannot be discharged shall be solidified and disposed of as solid radioactive waste.

### **452 Control of Radioactive Drains**

Radioactive drain systems are designed to transport radioactive liquids. Improper use may cause an environmental release.

1. Radioactive drain systems should not discharge to the environment nor be used for the disposal of nonradioactive liquids.
2. Existing radioactive drains should be evaluated to ensure the following:
  - a. Verification of the existing radioactive drain piping configuration,
  - b. Installation of flow-indicating devices in leak-off lines,
  - c. Use of plugs to prevent nonradioactive input,
  - d. Consideration of alternative work controls before systems are drained for maintenance,
  - e. Controls prohibiting unauthorized use of drains.

3. Modifications to the design or operation of existing radioactive drain systems should be controlled to include:
  - a. Design considerations that prevent nonradioactive drain connections into radioactive drains,
  - b. Procedural and design controls to prevent cross-connections of radioactive drains with nonradioactive systems,
  - c. Management review of subsequent changes to the design of radioactive drain systems or radioactive drain controls,
  - d. Management controls to restrict the introduction of hazardous wastes into radioactive drain systems.

#### **453 Control of Airborne Radioactivity**

1. Processes and activities with the potential for producing airborne radioactivity shall include engineering controls to limit releases.
2. The Radiological Control Organization shall be notified when engineering controls that prevent worker exposure to airborne radioactivity, such as barriers, gloveboxes, and glovebags, are compromised. An evaluation should be made of continuing operations with compromised engineering controls. The use of respiratory protection to continue is discouraged. Implementation of short-term engineering modifications that provide a commensurate level of worker protection is the preferred alternative.
3. Preventive maintenance and surveillance procedures shall be established to ensure equipment controls are maintained in an operable condition for containment of airborne radioactivity.

**PART 6 Support Activities****461 Personal Protective Equipment and Clothing**

1. Protective clothing designated for radiological control use shall be specifically identified by color, symbol, or appropriate labeling.
2. Protective clothing designated for radiological control use shall not be used for nonradiological work. Lab coats used as protective clothing for radiological control in RMMA's may be used for nonradiological work in the same RMMA or between adjacent RMMA's if approved in the RWP.
3. Personal Protective Equipment and clothing shall not be stored with personal street clothing.
4. Cleaned Personal Protective Equipment, such as face shields and respirators, that comes into contact with the wearer's face and company issued non-personal protective clothing shall be surveyed. This survey should be capable of detecting contamination levels equivalent to Table 2-2 total contamination values prior to reuse. The use of statistically representative sampling is acceptable.
5. Laundered protective clothing should be surveyed using statistically representative sampling and should meet the following criteria prior to reuse:
  - a. Beta-gamma radioactivity less than 10,000 dpm/100 cm<sup>2</sup>
  - b. Alpha radioactivity less than 1,000 dpm/100 cm<sup>2</sup> for transuranics and other alpha emitters in the same table 2.2 category, and less than 10K dpm/100 cm<sup>2</sup> for uranium.
6. Sites and facilities are encouraged to:
  - a. Apply the latest techniques and instrumentation to detect contamination on Personal Protective Equipment and clothing below Table 2-2 total contamination values,
  - b. Continue efforts to reduce contamination levels on reusable Personal Protective Equipment and clothing.

**462 Laundry**

1. Clothing and equipment should be laundered according to facility, color, type, and level of contamination.
2. Laundry activities should be performed using processes that minimize both potential worker exposure and the volume of waste generated.
3. Clothing and equipment should be screened before they are laundered to segregate those that are damaged, present special handling problems, or require disposal.

4. Waste streams that contain soaps, detergents, solvents, or other materials that could interfere with processing large-volume liquid waste streams should be segregated for separate processing.
5. Contracting for fully licensed laundry services is encouraged.
6. Cleaned Personal Protective Equipment and laundered protective clothing shall be inspected prior to use. Clothing should be free of tears, separated seams, deterioration and damage, or repaired in a manner that provides the original level of protection.

#### **463 Decontamination**

1. Radiological Work Permits or technical work documents shall include provisions to control contamination at the source to minimize the amount of decontamination needed.
2. Work preplanning shall include consideration of the handling, temporary storage, and decontamination of materials, tools and equipment.
3. Decontamination activities shall be controlled to prevent the spread of contamination.
4. Water and steam are the preferred decontamination agents. Other cleaning agents should be selected based upon their effectiveness, hazardous properties, amount of waste generated, and ease of disposal.
5. Decontamination methods should be used to reduce the number of contaminated areas.
6. Efforts should be made to reduce the level of contamination and the number and size of contaminated areas that cannot be eliminated.
7. Facility line management should be responsible for directing decontamination efforts.

#### **464 Vacuum Cleaners and Portable Air-Handling Equipment**

Improper use of vacuum cleaners and portable air-handling equipment may result in the generation of airborne radioactivity, loose surface contamination, or high dose rates.

1. Vacuum cleaners and portable air-handling equipment used in Contamination, High Contamination, Airborne Radioactivity, Radioactive Material Management, or Radiological Buffer Areas shall be equipped with High-Efficiency Particulate Air (HEPA) filters.
2. ANSI/UL 586 provides HEPA filter integrity testing criteria. Vacuum cleaner and portable air-handling equipment HEPA filters shall be integrity tested prior to initial use, when units have been opened, and annually.

3. Vacuum cleaners used for radiological work shall be:
  - a. Uniquely marked and labeled,
  - b. Controlled by an RWP,
  - c. Controlled to prevent unauthorized use,
  - d. Designed to ensure HEPA filter integrity under conditions of use,
  - e. Designed to prevent unauthorized or accidental access to the inner surfaces of the vacuum.
4. Radiation and contamination surveys shall be performed periodically for vacuum cleaners in use and labels on these units shall be updated. The frequency of radiation surveys should depend on the specific use of the vacuum cleaner.
5. Airborne radioactivity levels shall be monitored when a vacuum cleaner is used in a High Contamination Area.
6. A nuclear safety review shall be performed and documented prior to the use of a vacuum cleaner for fissile material.

**PART 7 Summary of Responsibilities****471 Senior Site Executive****472 Line Management**

- Designate radioactive material and sealed source custodians. (414.5; 431.3)
- Conduct periodic reviews of radioactive material storage areas. (414.6, 7)
- Maintain accountability records for sealed sources. (431.2)
- Coordinate procurement of radioactive sources with the Radiological Control Organization. (431.7)

**473 Radiological Control Manager**

- Develop response and notification procedures for at loss of radioactive material. (411.4)
- Approve the establishment of radioactive material storage areas. (414.4)
- Approve procedures for on-site transfers of radioactive material. (423.3)
- Perform receipt surveys of radioactive material shipments. (431.8)
- Provide prior written approval for radiography sources brought on site. (431.9)

**474 ALARA Committee****475 Workers**

- Notify the Radiological Control Organization in the event of the loss of radioactive material. (411.4)
- Possess an emergency response plan or emergency response information when operating a vehicle making radioactive material shipments. (423.12)
- Notify the Radiological Control Organization of changes in use, storage, transfer, disposal, or loss of a sealed source. (431.4)
- Notify the Radiological Control Organization in the event that engineering controls that prevent worker exposure to airborne radioactivity, such as barriers, gloveboxes, and glovebags, are compromised. (453.2)



## CHAPTER 5

### RADIOLOGICAL HEALTH SUPPORT OPERATIONS

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**PART 1 External Dosimetry****511 Requirements**

1. Personnel dosimetry shall be required for personnel who are expected to receive an annual external whole body dose greater than 100 mrem (1mSv) or an annual dose to the extremities, lens of the eye, or skin greater than 10 percent of the corresponding limits specified in Table 2.1. Neutron dosimetry shall be provided when a person is likely to exceed 100 mrem (1mSv) annually from neutrons.
2. Dosimeters shall be issued only to personnel formally instructed in their use and shall be worn only by those to whom the dosimeters were issued.
3. To minimize the number of personnel in the dosimetry program, the issuance of dosimeters is discouraged to other than personnel entering Controlled Areas, Radiation Areas, High Radiation Areas, or Radiological Buffer Areas where there is a potential for external exposure.
4. Personnel shall return dosimeters for processing as scheduled or upon request, and may be restricted by line management from continued radiological work until dosimeters are returned.
5. Personnel shall wear their primary dosimeters on the chest area or between the waist and the neck area, in the manner prescribed by dosimetry personnel.
6. It should be permissible to wear LBL personnel dosimeters off-site, although LBL personnel are encouraged to keep their personnel dosimeters on site.
7. Personnel shall notify line management and the Radiological Control Manager of pending off-site work involving exposures to radiation or radioactive material.
8. Personnel shall not wear dosimeters issued by their resident facilities while being monitored by a dosimeter at another site. Personnel shall not expose their dosimeters to security x-ray devices, excessive heat, or medical sources of radiation.
9. For work by LBL personnel at off-site facilities which will involve exposure to radiation or radioactive materials the Line Manager or Radiological Control Manager may specify the use of a special dosimeter during the work.
10. A person whose dosimeter is lost, damaged, or contaminated should place work in a safe condition, as appropriate, and immediately exit the area and report the occurrence to the Radiological Control Organization. Reentry of the person into Radiological Areas should not be made until a review has been conducted and management has approved reentry.

### **512 Technical Requirements for External Dosimetry**

1. DOE 5480.15 specifies the requirements for accreditation of personnel external dosimetry monitoring programs by the DOE Laboratory Accreditation Program (DOELAP). A LBL technical basis document shall describe the external dosimetry program. LBL personnel external dosimeters include but are not limited to:
  - a. thermoluminescent dosimeters (TLDs) for routine beta/gamma monitoring,
  - b. NTA Film for monitoring exposure to neutron radiation,
  - c. extremity dosimeters, and
  - d. special-purpose dosimeters.
2. The LBL technical basis document shall include performance requirements for dosimeters monitoring radiation outside the scope of DOELAP, such as dosimetry associated with high-energy accelerators and dosimeters used for measuring extremity exposure and other dosimeters used for special exposure situations.
3. LBL dosimetry program should participate in external dosimetry inter-comparison studies.
4. The technical basis document should describe the condition that warrants the use of multiple dosimeters and the methodology used in determining the dose of record when these are used. The use of multiple dosimeters shall be approved by the Radiological Control Manager and their use should be specified in the Radiological Work Permit. By definition a non-uniform radiation field exists when the dose to a portion of the whole body will not be properly measured by the whole body dosimeters and will exceed the dose to the primary dosimeter by more than 50 percent. No special measurement or correction shall be required if the anticipated whole body dose is less than 100 mrem (1mSv).
5. Personnel exposures to the skin, whole body, and extremities shall be reported separately for LBL Occupational Workers. Exposure to the lens of the eye shall be reported when monitored.
6. A dose assessment shall be performed for each instance of a lost, damaged, or contaminated personnel dosimeter. The dose assessment shall be performed by the radiological control organization dosimetry and health physics staff.

### **513 Pocket and Electronic Dosimeters**

Self-reading pocket and electronic dosimeters, hereafter called supplemental dosimeters, which are used to provide real-time indication of exposure to radiation and assist in maintaining personnel doses less than Administrative Control Levels.

1. Supplemental dosimeters shall be issued to personnel prior to entry into a Very High Radiation Area and for entry into a High Radiation Area, when a person could exceed 10 percent of an Administrative Control Level from external radiation in one work day. The requirement for use of these dosimeters should be included in the Radiological Work Permit (RWP). Pocket dosimeters should be selected with the lowest range applicable (typically 0-200 mR) for anticipated personnel exposures.

2. Supplemental dosimeters shall be worn simultaneously with the primary dosimeter and shall be located in accordance with Article 511.5 or as specified in the RWP for special exposure situations.
3. Supplemental dosimeters shall be read periodically while in use and should not be allowed to exceed 75 percent of full scale. The dose measured by the supplemental dosimeters should be recorded on the daily log when the work is complete.
4. Routine work permitted by a Radiological Work Permit shall be stopped when supplemental dosimeter readings indicate total exposure or rate of exposure substantially greater than planned. The Radiological Control Organization shall be consulted prior to continuation of work.
5. Only supplemental dosimeters which have been tested (e.g., energy dependence, stability, linearity) and approved by the LBL Instrument Calibration Section shall be used.
6. Use of electronic dosimeters should be considered for entry into High Radiation Areas or when planned doses greater than 100 mrem (1mSv) in one work day are expected. An electronic dosimeter provides an early warning of elevated doses through the use of alarm set points at specified dose or dose rates.
7. When the dose results from the supplemental dosimeters differ by more than 50 percent from the primary dosimeter result and the primary dosimeter result is greater than 100 mrem (1mSv), an investigation should be initiated to explain the difference.

#### 514 Area Monitoring Dosimeters

Establishment and maintenance of a comprehensive area dosimetry monitoring program may minimize the number of areas requiring the issuance of personnel dosimeters and demonstrate that doses outside Radiological Buffer Areas are negligible.

1. Area monitoring dosimeters shall be used to record and document radiation levels in routinely occupied areas adjacent to areas where radiation or operations with radiation exist. This monitoring requirement does not apply to radiation solely from low energy beta sources (e.g.  $^{14}\text{C}$  or  $^3\text{H}$ ).
2. Area monitoring dosimeters should be used in Controlled Areas to supplement existing monitoring programs and to provide data in the event of an emergency.
3. Area monitoring dosimeter results may be used to support dosimetry investigations where personnel express concerns about their work environments and exposure to ionizing radiation.

### **515 Nuclear Accident Dosimeters**

DOE 5480.11 specifies the requirements for a Nuclear Accident Dosimetry Program when sufficient quantities and kinds of fissile material exist to potentially constitute a critical mass as defined in DOE 5480.5 and where exposure of personnel to radiation from a nuclear accident is possible.

## **PART 2 Internal Dosimetry**

### **521 Requirements**

1. Personnel who enter Controlled Areas shall participate in the bioassay program when they are likely to receive intakes in a year resulting in a committed effective dose equivalent of 100 mrem (1mSv) or more.
2. Personnel shall participate in special bioassay monitoring when their routine bioassay results indicate an unplanned intake in the current year resulting in a committed effective dose equivalent of 100 mrem (1mSv) or more.
3. Personnel whose routine duties may involve exposure to surface or airborne contamination or to radionuclides readily absorbed through the skin, such as tritium, should participate in a bioassay program unless it is documented that it is improbable that intakes could exceed 100 mrem (1mSv) CEDE in a year.
4. Personnel shall submit bioassay samples, such as urine or fecal samples, and participate in in vivo monitoring, such as whole body or lung counting, at the frequency specified in the LBL Internal Dosimetry Program.
5. Line management, the Radiological Control Organization, and the affected workers shall be notified promptly of unplanned positive bioassay results and the results of dose assessments and subsequent refinements. Dose assessment results shall be provided in units of mrem (mSv) or rem (cSv).

### **522 Technical Requirements for Internal Dosimetry**

DOE plans to implement accreditation programs for bioassay measurements and internal dose assessment and to provide supplemental technical guidance on the implementation of internal dosimetry programs. Until these accreditation programs are available, this Manual provides the technical guidance to implement the LBL Internal Dosimetry Programs.

1. The LBL Internal Dosimetry Program shall meet or exceed DOE requirements and performance standards and recommendations from authoritative bodies. The LBL Internal Dosimetry Program shall be incorporated in a Technical Basis document. This document shall be reviewed and revised when significant changes are made in DOE requirements.
2. Baseline bioassay monitoring of personnel who are likely to receive intakes resulting in a committed effective dose equivalent greater than 100 mrem (1mSv) or who have previous exposures either on or off-site shall be conducted before they begin or resume work that may expose them to internal radiation exposure.

3. Routine bioassay monitoring methods and frequencies shall be established for personnel who are likely to receive intakes in a year resulting in a committed effective dose equivalent greater than 100 mrem (1mSv). The technical basis for the methods and frequency of bioassay monitoring should be documented in the LBL Internal Dosimetry Technical Basis Document.
4. Termination bioassay monitoring shall be required when a person who participated in the bioassay program terminates employment or concludes work involving the potential for internal exposure. The number of persons failing to achieve this monitoring should be reviewed periodically and should be used to determine whether further efforts to get cooperation are warranted.
5. Workers shall participate in a special bioassay program when any of the following occurs:
  - a. Facial contamination is detected that indicates a potential for intake of radioactive materials.
  - b. Air monitoring indicates the potential for intakes resulting in committed effective dose equivalent exceeding 100 mrem (1mSv).
  - c. Upon direction of the Radiological Control Organization when an intake is suspected.
6. Levels of intakes that warrant the consideration of medical intervention shall be established for site-specific radionuclides. The effectiveness of medical intervention, such as blocking or chelating agents, shall be documented using bioassay results.
7. A preliminary assessment of any intakes detected should be conducted prior to permitting an employee to return to radiological work.
8. The radionuclide standards used for bioassay measurements in the LBL Internal Dosimetry Program and the Whole Body Counting Program shall be traceable to the National Institute of Standards and Technology (NIST).
9. The LBL Internal Dosimetry Program and the Whole Body Counting Program should participate in DOE Inter-comparison Studies and should use the "DOE Phantom Library."

**523 Technical Requirements for Dose Assessment**

Interpretations of bioassay results and subsequent dose assessments should be documented and included in the person's radiological exposure history file, documentation should include the following to the extent known:

1. Characteristics of the radionuclide(s), such as chemical and physical form(s),
2. Bioassay results and the person's previous exposure history,
3. Exposure information, such as route of intake(s) and time(s) and duration(s) of exposure,
4. Biokinetic models used for dosimetry of radionuclides,
5. Models to estimate intake or deposition and to assess dose,
6. If medical intervention is used, it should be described.

### **PART 3 Respiratory Protection Program**

Respiratory protection equipment includes respirators with particulate or gas-filtering cartridges, supplied air respirators, self-contained breathing apparatus, and airline supplied-air suits and hoods.

#### **531 Requirements**

1. Use of respiratory protection shall be reduced to the minimum practicable by implementing engineering controls and work practices to contain radioactive materials at the source.
2. The LBL Respiratory Protection Program and associated training of personnel should be consistent with requirements in ANSI Z88.2 and 29 CFR 1910.134 as mandated in DOE 5480.4.
3. Respirators shall be issued only to personnel who are trained, fitted, and medically qualified to wear the specific type of respirator. Training and qualification testing shall be performed annually.
4. Positive controls shall be maintained for the issue, use and return of respirators to ensure that only qualified personnel wear suitable respirators.
5. DOE 5480.4 mandates that breathing air meet the specifications of ANSI/CGA G-7.1 Grade D breathing air as specified in 29 CFR 1910.134. Compressed air supplied to respirators shall be tested quarterly. Compressors shall be of the breathing air type and shall not allow oil or other chemicals and fumes to enter the breathing air supply. Special attention shall be focused on the location of compressor air supply intakes and on the prevention of cross-connections to other compressed gas systems.
6. Credit for the use of respiratory protection for routine work involving potential exposure to airborne radioactive materials should be controlled at the source through engineered systems, so that the need for respiratory protection can be reduced.

#### **532 Medical Assessment**

Each prospective respirator wearer shall have a medical assessment prior to being fit-tested. The medical assessment shall determine if an employee's medical condition precludes the use of respirators and should follow the guidance in ANSI Z88.6 on frequency and content of the examination. The ability of an employee to accommodate the additional stress placed on the body when working in a respirator is part of this assessment.

### 533 Use of Respiratory Protection

Personnel using respiratory protection shall:

1. Be issued respirators only upon verification of medical approval, training, and fit testing.
2. Perform fit checks of their respirators to ensure a proper seal before entering areas requiring respirator use.
3. Be clean shaven in the area of fit.
4. Use corrective lenses, if needed, that are approved for respirators.
5. Be instructed to leave the work area when experiencing respirator failure.
6. Be instructed to remove their respirators to avoid life-threatening situations when exiting an area after respirator failure.

### 534 Heat Stress

Heat stress may result from working in areas of high heat, humidity, and radiant heat; working in protective clothing; and using respirators, particularly where other protective equipment is required. Heat stress has occurred at ambient temperatures less than 70°F when multiple sets of protective clothing or plastic suits were in use or strenuous work was involved. Heat stress controls should be addressed in the planning stages for work in hot environments. Recommended work time limits and use of body cooling devices should be considered to reduce heat stress. Job supervisors should inform their personnel of heat stress precautions prior to work on job assignments in hot environments. If a person begins to feel symptoms of heat illness, the person should immediately notify the nearest co-worker, exit the area, remove Personal Protective equipment, notify the supervisor, and rest in a cool area. In such cases, medical assistance should be provided.

### 535 Half-Face Respirators

The LBL Policy requires approval of the use of half face respirators for work with any radioactive materials on a case by case basis is consistent with the current revision of 10 CFR Part 20, which states that half-face respirators are... not satisfactory for use where it might be possible (e.g., if an accident or emergency were to occur) for the ambient airborne concentrations to reach instantaneous values greater than 10 time the... [DAC values]."

1. Half-face respirators are not normally used at the LBL Site on a routine basis or as a precautionary measure for protecting workers from potential airborne radioactive materials. Half-face respirators are undesirable because their seal with the face is more likely to fail than with full-face respirators, particularly during heavy work. As a result, their permitted protection factor is low and difficult to predict.

2. **The use of half-face respirators in situations where intakes of radioactive material will be low, such as a few mrem, and where industrial and safety considerations warrant, such as during the operation of heavy equipment should be permitted only if there is no other practical solution. This special use shall be approved by management, the Radiological Control Organization, and after the LBL Internal Dosimetry staff are notified so that special bioassay analysis may be performed as appropriate.**

**PART 4 Handling Radiologically Contaminated Personnel****541 Skin Contamination**

1. Survey techniques shall be established to determine the extent of skin contamination.
2. When personnel detect skin contamination, they shall notify the Radiological Control Organization.
3. The extent of skin contamination should be determined prior to initiating decontamination procedures and shall be fully documented in the monitor log.
4. Skin decontamination methods should be consistent with approved techniques established for LBL. Skin abrasion should be avoided during the decontamination process. Intrusive decontamination methods, such as tissue removal, shall be performed only by LBL medical staff.
5. The LBL External and Internal Dosimetry Program LBL Medical documents should include levels of skin contamination that trigger the need for dose assessments. The LBL site trigger level is 100 mrem (1mSv).
6. Personnel with skin contamination that triggers the need for dose assessment should be informed of the initial external dose estimate for their skin as soon as practicable, preferably prior to the end of their work day.
7. Personnel with skin contamination for which dose assessment was not performed should be informed of the nature of the contamination and an upper estimate on the potential dose (such as less than 10 mrem) as soon as practicable, preferably prior to the end of their work day.
8. An assessment of skin exposure requires time to conduct a detailed evaluation. Assessments shall be conducted in accordance with Appendix 2B and, promptly after completion, the results should be explained to the persons affected.
9. Assessment of internal exposure, as necessary, resulting from skin contamination should be performed using special bioassay measurements. The results of this assessment shall be made available to the affected person(s) within the time frame identified by the LBL Internal Dosimetry Procedures by LBL.

**542 Contaminated Wounds**

1. Emergency medical care should be administered immediately for injuries involving radioactive materials in accordance with National Council on Radiation Protection and Measurements Report Number 65. Medical treatment of injuries takes precedence over radiological considerations.

2. Response to potentially contaminated wounds should be promptly coordinated between the Radiological Control Organization, LBL Medical, LBL Internal Dosimetry, and the treatment of contaminated injuries should include the following:
  - a. Treatment of contaminated wounds by medically qualified personnel,
  - b. Monitoring of wounds and associated bandages for contamination, including alpha emitters if applicable,
  - c. Identification of the radionuclides involved,
  - d. Medical determination of the need for therapeutic intervention such as blocking or chelating agents,
  - e. Initiation of appropriate bioassay monitoring,
  - f. Determination of need for work restrictions.
3. An injured person should be counseled promptly on the medical and radiological implications resulting from contaminated wounds that result in internal doses greater than 2 percent of the Table 2-1 limits. The counseling should be performed by senior radiological control organization and LBL medical professionals.
4. Coordination between the Radiological Control Organization and LBL Medical for doses that may require medical intervention.

### 543 Exposures to Airborne Radioactivity

Potential intakes of radioactive material are indicated when personnel without respiratory protection are exposed to airborne radioactive materials or when respiratory protection has been compromised. If intakes of radioactive material are indicated or suspected which could result in a committed effective dose equivalent greater than 100 mrem (1mSv), the following actions should be taken:

1. Identify personnel potentially exposed to airborne radioactive materials.
2. Obtain nasal smears for qualitative indication of intakes and characterization of the contamination, where appropriate.
3. Analyze air samples to determine airborne radioactive materials concentration and integrated exposure where appropriate. Note whether respiratory protection was used, the applicable protection factor, and whether respiratory protection was compromised.
4. Determine duration of potential exposure to airborne radioactive material.
5. Provide LBL Internal Dosimetry Staff with all the above information.
6. Perform special bioassay analyses as required for the radionuclides involved.
7. Assess the potential dose prior to permitting the worker to return to radiological work. This preliminary dose should be based on conservative assumptions and need not be formally documented.

8. **Coordination between the Radiological Control Organization, Internal Dosimetry, and LBL Medical for doses that may require medical intervention.**

**PART 5 Radiological Monitoring and Surveys****551 Requirements**

1. Radiological monitoring of radiation exposure levels, contamination and airborne radioactive material shall be conducted to characterize workplace conditions and to identify areas requiring postings.
2. Monitoring shall be performed only by trained and qualified personnel using properly calibrated, maintained, and response checked instruments.
3. Surveys for radiation, contamination, and airborne radioactive materials shall be performed as specified in Radiological Work Permits.
4. The Radiological Control Organization shall perform a study and document the adequacy of sampling and monitoring systems as part of any facility or operational changes affecting radiological control. In the absence of such changes, a documented study should be conducted annually.
5. Instruments used to perform radiation surveys shall be response-checked daily or prior to operation. When response checks are not within  $\pm 20$  percent of the expected value, the instrument should be taken out of service. When response checks are not feasible, such as with instruments used to measure neutrons or tritium, compensatory actions should be established to ensure continued proper instrument performance.
6. Assessment of radiological conditions should include a sufficient number of sampling points to characterize the radiation present and to verify boundaries.
7. Monitoring should be performed by trained radiation workers before, during, and at the completion of work that has the potential for causing changes in levels of radiation and/or dispersible radioactive material.
8. Survey frequencies should be established based on potential radiological conditions, probability of change in these conditions and area occupancy factors.
9. Monitoring results should be reviewed by the cognizant radiological control organization management. The review should ensure that all required surveys have been performed and that the documentation is accurate and complete.
10. Results of current surveys or survey maps should be conspicuously posted to inform personnel of the radiological conditions.
11. Monitoring results should be made available to management and used in support of pre- and post-job evaluations, ALARA planning, contamination control, and management of radiological control operations.

12. Monitoring data in each building or area should be compiled and reviewed at least quarterly. Trends should be noted and corrective actions assigned.

### **552 Radiation Exposure Surveys**

1. In addition to the requirements of Article 551, routine radiation surveys should be performed in accordance with the following minimum frequencies:
  - a. Weekly, in office space located in Radiological Buffer Areas where the potential exists for external radiation exposure,
  - b. Monthly, in routinely occupied Radiological Buffer Areas and Radiation Areas,
  - c. Upon initial entry, monthly during continuing operations, and when levels are expected to change or have changed in High Radiation Areas,
  - d. Monthly, for operating HEPA-filtered ventilation units where there is potential for generating radiation levels external to the ducting,
  - e. Weekly, for temporary Radiation Area boundaries to ensure that radiation areas do not extend beyond posted boundaries,
  - f. Monthly, or upon entry, if entries are less frequent than monthly for Radioactive Material Areas,
  - g. Quarterly, for potentially contaminated ducts, piping, and hoses in use outside radiological facilities, where there is potential for generating radiation levels external to the ducts, etc.,
  - h. Upon initial entry into Accelerator High or Very High Radiation Areas, when the machine is off or beam is prevented from these areas if there has been a reasonable potential for target or other material activation, and at least monthly.
2. The survey frequencies in 552.1 above shall be increased where data from trend analyses or operational changes suggest the radiological conditions are not stable or are not predictable.
3. Radiation surveys should include dose rate measurements of the general area, dose rates at a distance of 30 centimeters from a source or surface of interest (to evaluate potential whole body exposures), and contact for sources of radiation where there is a potential for hands-on work. (Note: Contact means the dose rate at the surface and not the dose rate noted when the detector is in contact with the surface.)
4. Surveys should be conducted whenever operations are being performed that might result in personnel being exposed to small intense beams of radiation, such as those generated by shielded x-ray devices or due to removal or alteration of shielding. Either the approved correction factors for LBL Instruments should be used or a special study should be performed to document alternate factors.

### **553 Area Radiation Monitors**

1. In addition to the requirements of Article 551, area radiation monitors (not to include area monitoring dosimeters discussed in Article 514) should be installed in frequently occupied locations with the potential for unexpected significant increases in dose rates and in remote

- locations where there is a need for local indication of dose rates prior to personnel entering remote locations.
2. Area radiation monitors should not be substituted for radiation exposure surveys in characterizing workplace conditions.
  3. Area Real Time radiation monitors may be used in place of radiation exposure surveys when approved by the Radiological Control Manager.
  4. The need and placement of area radiation monitors should be documented and assessed when changes to facilities, systems, or equipment occur.
  5. Area radiation monitors should be maintained and calibrated at least annually at the LBL Radiological Calibration Facility and operability and audibility under ambient working conditions and operability of visual alarms when so equipped.
  6. When installed instrumentation is removed from service for maintenance or calibration, a radiation monitoring program providing at least equal detection capability should be maintained, consistent with the potential for unexpected increases in radiation dose rates.
  7. Where an area radiation monitor is incorporated into a safety interlock system the circuitry shall be such that a failure of the monitor shall either prevent entry into the area or prevent operation of the radiation producing device.

#### **554 Contamination Surveys**

1. In addition to the requirements of Article 551, routine contamination surveys should be conducted as follows:
  - a. Prior to transfer of equipment and material from one Radiological Area to another,
  - b. Prior to transfer of equipment and material from highly contaminated areas within Radiological Buffer Areas unless precautions such as bagging or wrapping are taken prior to transfer,
  - c. Daily, at contamination area control points, change areas, or step-off pads when in use, or per shift in high use situations,
  - d. Weekly, in office space located in Radiological Buffer Areas for contamination control,
  - e. Daily, in lunch rooms or eating areas near Radiological Buffer Areas for contamination control,
  - f. Monthly, in routinely occupied Radiological Buffer Areas,
  - g. Monthly, or upon entry if entries are less frequent, in areas where radioactive materials are handled or stored,
  - h. Monthly, or upon entry if entries are less frequent, where contamination boundaries or postings are located,
  - i. During initial entry into a known or suspected contamination area, periodically during work, at completion of job, or as specified in a Radiological Work Permit,
  - j. After a leak or spill of radioactive materials.

2. The survey frequencies in 554.1 above shall be increased where data from trend analyses suggests the radiological conditions are not stable or are not predictable. Basic trigger levels should be established and incorporated into the RWP based, for example, on operational changes posing high risk of contamination or frequency of spills.
3. Survey requirements for the release of radioactive materials shall be conducted in accordance with Articles 421 and 422.
4. Contamination surveys should incorporate techniques to detect both removable and fixed contamination.
5. Items with inaccessible surfaces which were located in known or suspected contamination areas and had the potential to become contaminated at levels likely to exceed Table 2-2 values should be treated as potentially contaminated and subject to administrative controls unless the items are dismantled and monitored or special survey techniques are used to survey all surfaces. The Radiological Control Manager may exempt certain categories of equipment with inaccessible surfaces, such as radiological survey instruments and electronic test equipment, from the disassembly requirement provided that controls are established to prevent internal contamination.
6. The requirements specified in DOE 5400.5 for assessing representative samples of bulk material, such as sand, sweeping compounds, or plate steel, which are not suitable for normal loose and fixed contamination-level assessment techniques should be utilized.
7. Contamination surveys for removable contamination shall be reported in units of disintegrations per minute per 100 cm<sup>2</sup> (dpm/100 cm<sup>2</sup>). For surveys of small items covering less than 100 cm<sup>2</sup>, the results shall be reported in units of dpm per area surveyed.
8. Large area smearable surveys are encouraged and should be used to supplement standard survey techniques in areas generally assumed not to be contaminated, such as entrances to Radiological Buffer Areas. If an evaluation indicates that an area surveyed is contaminated, a thorough contamination swipe survey should be performed.
9. Areas identified as either contaminated with, or having the potential for being contaminated with, highly radioactive particles ("hot particles") should be surveyed weekly. These areas should be surveyed at least daily during periods of work that may result in the generation of hot particles. Special techniques to collect hot particles, such as tape and large area smear paper should be used.

### **555 Airborne Radioactivity Monitoring**

1. In addition to the requirements of Article 551, airborne radioactive material monitoring equipment should be used in situations where airborne radioactive materials levels can fluctuate and early detection of radioactive material could prevent or minimize inhalation of radioactivity by personnel. Selection of air monitoring equipment should be based on the specific job being monitored. Air monitoring equipment includes portable and fixed air sampling equipment and continuous air monitors.

2. Air sampling equipment shall be used in occupied areas where, under normal operating conditions, a person is likely to receive an annual intake of 2 percent or more of the specified Annual Limit of Intake (ALI) values (40 Derived Air Concentration (DAC) hours). An annual intake of 2 percent of a specified ALI generally represents a committed effective dose equivalent to a person of approximately 100 mrem (1mSv).
3. Continuous air monitoring equipment shall be installed in occupied areas where a person without respiratory protection is likely to be exposed to a concentration of radioactive material in air exceeding 1 DAC or where there is a need to alert potentially exposed workers to unexpected increases in the airborne radioactive material levels. A person exposed continuously to a concentration of radioactive material in air of 1 DAC for 1 work week would generally receive a committed effective dose equivalent of approximately 100 mrem (1mSv).
4. Air sampling equipment should be positioned to collect air samples to which are representative of concentrations to which persons are exposed. If this cannot be achieved, a program of personal breathing-zone air sampling should be considered. The LBL Internal Dosimetry Program staff should be contacted where conditions exist that exceed current state-of-the-art sampling capability to provide a reasonable estimate of potential worker exposure.
5. Air monitoring equipment shall be routinely calibrated and maintained at a frequency of at least once per year. Continuous air monitors should be capable of measuring 1 DAC when averaged over 8 hours (8 DAC-hours) under laboratory conditions.
6. Continuous air monitoring equipment required by Article 555.3 shall have alarm capability and sufficient sensitivity to alert personnel that immediate action is necessary in order to minimize or terminate inhalation exposures.
7. The proper operation of continuous air monitoring equipment should be verified weekly by performing an operational check. Operational checks should include positive air-flow indication, non-zero response to background activity, internal check sources, and 60 Hz electronic checks (when available.) Continuous air monitoring equipment should be verified monthly by checking for instrument response with a check source or with ambient levels of radon and thoron progeny. Continuous air monitoring equipment should be maintained and calibrated at least annually.
8. Preliminary assessments of air samples utilizing use of field survey instruments should be performed promptly upon removal. It should be noted that in situations where background levels of radon and thoron progeny exist, prompt field assessment of alpha air samples may not be possible.
9. Air sample results should be analyzed as quickly as practicable for evaluation of the need for respiratory protection, area evacuation (if necessary), worker intake, and worker relief from respirator use.

## **PART 6 Instrumentation and Calibration**

### **561 Standardization**

Radiation measurement instrumentation used at LBL for protecting workers and the environment should be standardized using commercially available radiological instrumentation where practical. All such instruments used at LBL shall be evaluated through the LBL Calibration Facility and evaluation program.

### **562 Inspection, Calibration, and Performance Tests**

1. Radiological instruments shall be used only to measure the radiation for which their calibrations are valid. Requirements contained in ANSI N323 for radiological instrumentation calibration as mandated in DOE 5480.4 and performance requirements in ANSI N42.17 a, b, & c shall be utilized in defining the requirements for instruments used at LBL. The calibration program shall be relatable to the National Institute of Standards and Technology (NIST) through the use of traceable sources or transfer instruments.
2. The calibration procedures defined in LBL EH&S 730 shall be used for each instrument type. These procedures include frequency of calibration, precalibration, primary calibration, periodic performance test, calibration record, and maintenance requirements.
3. Pocket and electronic dosimeters and area radiation monitors should be calibrated at least annually and in accordance with Article 562.1 and PUB 3000.
4. Radiation instrumentation response to interfering ionizing and non-ionizing radiation and environmental conditions should be determined. The effects of such interfering radiation has on an instrument should be considered prior to use and appropriate controls or correction factors should be adopted where errors in excess of  $\pm 20\%$  of the value could occur.
5. Functional tests should be used to assess designs for instrumentation used at LBL that include alarms or that involve a process control. All components involved in an alarm or trip function should be functional tested at least annually.
6. In unusual and limited situations it may be necessary to use an instrument in an application other than that envisioned by the manufacturer. Special calibrations should be performed at the LBL Radiological Calibration Facility for use of instrumentation outside manufacturer's specifications. The instrument should be adjusted, calibrated, and clearly labeled to identify the special conditions under which the instrument may be used. The specially calibrated instruments should not be used for other purposes.
7. Instruments shall bear a label or tag with the date of calibration and date calibration is due.

8. Instruments whose "as found" readings indicate that the instrument may have been used while out of calibration shall be reported to the Field Operations Unit. The Field Operations Unit should review surveys performed with the instrument while it was out of calibration.

### **563 Maintenance**

1. A LBL program for preventive and corrective maintenance of radiological instrumentation should be applicable to all radiation measuring instruments used to protect the worker or the environment.
2. Preventive and corrective maintenance should be performed using components and procedural recommendations at least as stringent as those specified by the manufacturer of the instrument and meet the requirements of the LBL program and manufacturer of the instrument.
3. Radiological instruments shall be calibrated prior to use following any preventive or corrective maintenance or any adjustment other than zero adjustment. A battery change is not normally considered maintenance.

### **564 Calibration Facilities**

1. The LBL Radiological Calibration Program should continue to perform inspections, calibrations, performance tests, use calibration equipment, and perform quality assurance in accordance with the recommendations of ANSI N323. The following actions are a part of this program.
  - a. All activities are located in a manner to minimize radiation exposure to operating personnel and to personnel in adjacent areas,
  - b. Sources of interference, such as backscatter and non-ionizing radiation, are minimized during the calibration of instrumentation and corrections for interferences are made as necessary,
  - c. The program will be maintained current with the referenced standards and recommendation of authoritative bodies,
  - d. Records of calibration, functional tests, and maintenance are generated in accordance with ANSI N323, ANSI N13.6, and DOE 1324.2A.
2. Any contracted special calibration services should be performed in accordance with the referenced standards and the procedures and calibration data should be documented in the LBL Calibration Facility Records.

**PART 7 Summary of Responsibilities****571 Department of Energy****572 Line Management**

- Require termination bioassay monitoring when personnel terminate employment or conclude work that required participation in a bioassay monitoring program. (522.4)

**573 Radiological Control Manager**

- Authorize use of special dosimeters offsite. (511.9).
- Perform and document reviews of the adequacy of sampling and monitoring systems. (551.2)

**574 Employees**

- Notify the Radiological Control Organization if assigned dosimeters are exposed to security x-ray devices, excessive heat, or medical sources of radiation. (511.8)
- Upon discovering the loss, damage, or contamination of a dosimeter, secure work, exit the area, and report the occurrence to the Radiological Control Organization. (511.9)
- Participate in bioassay monitoring programs as directed by the Radiological Control Organization. (521.4)
- Be clean-shaven in the respirator seal area prior to using respiratory protection devices. (533)
- Immediately notify the nearest co-worker, exit the area, remove Personal Protective equipment, notify supervisor, and rest in a cool area if heat illness is encountered. (534)
- Notify the Radiological Control Organization if skin or clothing contamination is detected. (541.2)



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## **PART 1 General Requirements**

### **611 Purpose**

This chapter establishes the requirements to ensure that personnel have the training to work safely in and around radiological areas and to maintain their individual radiation exposure and the radiation exposures of others As-Low-As-Reasonably-Achievable (ALARA). Training requirements in this chapter apply to personnel entering LBL.

### **612 Standardization**

Standardized core courses and training materials shall be used to achieve consistency, Department-wide. In establishing local training programs, the standardized core courses shall be presented and LBL site-specific information shall be added. For example, training for workers at accelerator facilities should expand course content for high energy radiation and activation products. Training at facilities working with transuranics should expand the course content for alpha contamination control. Training for workers involved in waste management activities should expand the course content on minimizing the production of mixed wastes. In all cases, the standardized core course materials should be fully implemented.

Standardized core course training material developed and maintained by DOE Headquarters (EH) consists of lesson plans, viewgraphs, student handbooks, qualification standards, question banks, and wallet-sized training certificates. The standardized core course training materials were based on ASTM E 1168 87, "Standard Guide for Radiological Protection Training for Nuclear Facility Workers", and were developed using the principles of performance-based training per DOE 5480.20. The standardized core course for the Health and Safety Technicians partially fulfills DOE training accreditation requirements of DOE 5480.18A.

1. Standardized core course training material shall be used for General Employee Radiological Training, Radiological Worker I and II training, and Health and Safety Technician training.
2. Wallet-sized training certificates that identify current training status should be provided.
3. Successful completion of the standardized courses for General Employee Radiological Training, Radiological Worker I and II, and Health and Safety Technician at one DOE site shall be recognized by other DOE sites. However, the LBL site-specific aspects of the radiological training shall be completed. LBL site-specific training for General Employee Radiological Training and Radiological Worker I and II training may be included with other site orientation training.
4. Training may be facility-specific if personnel access is limited to those facilities for which training has been completed.
5. The site Radiological Control Manager or a designee shall concur in site-generated radiological training material.

**613 Requirements**

1. Examinations for Radiological Worker I and II training and Radiological Control Technician qualification shall be used to demonstrate satisfactory completion of theoretical and classroom material. Examinations should be written, however, alternatives may be used to accommodate special needs. The examination process should require:
  - a. That a minimum passing score be established,
  - b. That true/false questions not be included,
  - c. Use of questions randomly selected from the question bank,
  - d. Acknowledgment by signature that the student participated in a post-examination review,
  - e. That competence in required skills be measured using performance-based examinations,
  - f. Remedial actions for failure to meet the minimum score,
  - g. That questions be selected to test what the student is expected to remember months after the training rather than to test short-term memory of theoretical material.
2. Training should address both normal and abnormal situations in radiological control.
3. General Employee Radiological Training shall be completed every 2 years. Changes to the program should be incorporated as they are identified and a decision made if retraining prior to the 2 year period is needed. In the alternate year when full retraining is not completed, the latest General Employee Radiological Training Handbook (Student Guide) should be distributed for self-study.
4. Radiological Worker I and II retraining shall be completed every 2 years. In the alternate year when retraining is not performed, refresher training shall be completed.
5. LBL site-specific training and refresher training shall include changes in requirements and updates of lessons learned from operations and maintenance experience and occurrence reporting, for the site and across the DOE complex.
6. Verification of the effectiveness of radiological control training should be accomplished by surveying a limited subset of former students in the workplace. This verification is in addition to performance evaluations routinely performed by training departments. This evaluation should include observation of practical applications, discussions of the course material, and may include written examinations. The survey should be performed by Radiological Control managers and supervisors, quality assurance personnel, or senior instructors after the former student has had the opportunity to perform work for several months. The results should be documented.
7. Requirements for respiratory protection training are included in Article 531.
8. Training programs developed for radiological control should meet the requirements for performance-based training and, when applicable, training accreditation.

9. Reading and comprehension skills in the English language are generally necessary for General Employee Radiological Training, Radiological Worker Training, and Health and Safety Technician Training. Visitor orientation and the use of trained escorts provide an alternate to training with the concurrence of the Radiological Control Manager. The Radiological Control Manager can approve alternate training methods for those lacking reading and comprehension skills in the English language.
10. Additional requirements for personnel training at nuclear facilities are stated in DOE 5480.18A and 5480.20.
11. Training records and course documentation shall meet the requirements of Article 725.

#### **614 Qualification Standards for Health and Safety Technicians**

1. Qualification Standards define the requirements for demonstrating completion of training. Signatures on the forms in Qualification Standards shall document satisfactory proficiency.
2. Qualification Standards from the standardized core course shall be used.
3. The Qualification Standards from the standardized core course shall be supplemented to include LBL site-specific elements.
4. Qualification Standards for the Health and Safety Technician position shall include on-the-job training to provide hands-on experience directly applicable to the job.
5. On-the-job trainees shall be under the control of qualified personnel. Before performing a job function without direct supervision, a trainee with partially completed qualifications shall have completed the qualifications for that task.

#### **615 Oral Examination Boards**

1. An Oral Examination Board shall determine the qualification of candidates for Health and Safety Technician and Supervisor positions.
2. The Radiological Control Manager shall designate the Board members and appoint a Chairperson.
3. The Board constituted to evaluate Health and Safety Technician qualification should be composed of at least three persons to include a Health and Safety Technician Supervisor, Radiological Control Staff, and line management operations department supervisors and staff personnel, as applicable. Health and Safety Technician Instructors may participate as nonvoting members.
4. The Board should assess the candidate's response to normal and emergency situations. Questions should be of the type that are not normally covered in a written examination.

5. **The Board constituted to evaluate Health and Safety Technician Supervisor qualifications should not include peers or subordinates as voting members.**

#### **616 Instructor Training and Qualifications**

1. **All instructors should be qualified in accordance with the contractor's site Instructor Qualification Program or possess equivalent qualifications.**
2. **Instructors should have the technical knowledge, experience, and instructional skills required to fulfill their assigned duties.**
3. **Instructors-in-training shall be monitored by a qualified instructor.**
4. **Subject matter experts without instructor qualification may provide training in their areas of expertise. However, these subject matter experts should be trained as instructors when this occurs routinely.**

## **PART 2 General Employee Radiological Training**

### **621 Site Personnel**

Personnel who may routinely enter a Controlled Area and encounter radiological barriers, signs or labels, or radioactive materials shall receive General Employee Radiological Training. This training shall be completed prior to potential occupational radiation exposure. All employees should receive General Employee Radiological Training. This training may be incorporated into existing General Employee Training Programs.

1. General Employee Radiological Training shall include the standardized core course training materials.
2. Standardized core General Employee Radiological Training shall be expanded to include LBL site-specific information, such as site-specific radiation types, alarm responses, and LBL policies.
3. Expected time to complete the standardized core and LBL General Employee Radiological Training is approximately one hour.
4. Additional training beyond General Employee Radiological Training is necessary for unescorted entry into Radiological Buffer Areas or areas posted for radiological control.
5. Information may be communicated by classroom lecture, videotape, or other applicable methods.

### **622 Radiological Orientation for Visitors**

1. Visitors who enter a Controlled Area shall receive a radiological safety orientation that should include the following topics:
  - a. Basic radiation protection concepts,
  - b. Risk of low-level occupational radiation exposure, including cancer and genetic effects,
  - c. Risk of prenatal radiation exposure,
  - d. Radiological protection policies and procedures,
  - e. Visitor and management responsibilities for radiation safety,
  - f. Adherence to radiological signs and labels,
  - g. Applicable emergency procedures,
  - h. Training for issuance of dosimeters, where applicable.
2. Information may be communicated by videotape or handout to personnel entering a site. An examination is not required unless required by DOE Order 5480.18A0.

3. **Records of the orientation shall be maintained. Visitor sign-in logs may be used as orientation records.**
4. **The orientation for continuously escorted individuals or groups should be commensurate with the areas to be visited. Records of orientation for such individuals or groups should be retained.**

## **PART 3 Radiological Worker Training**

### **631 Requirements**

1. Radiological Worker I training shall be completed prior to entering Radiological Buffer Areas, Radioactive Material Areas, and Radiation Areas without a qualified escort.
2. Radiological Worker II training is required for unescorted entry into areas as stated in Table 6-1. Additional training is required for special job functions with radiological consequences.
3. Workers may challenge Radiological Worker I or II standardized core knowledge requirements by passing a comprehensive examination. If unsuccessful in one attempt, the entire standardized core Radiological Worker I or II training shall be completed. Challenges do not apply to the LBL site-specific portions, where program changes and operational experience are updated.
4. Radiological Worker I training is not a prerequisite for Radiological Worker II training.
5. Radiological Worker I and Radiological Worker II training are self-contained courses. Radiological Worker II training includes all of the requirements of Radiological Worker I training and expands on the topic of hands-on work with radioactive materials. Radiological Worker II training prepares the worker to deal with radiological work where additional risks may be encountered.

### **632 Radiological Worker I**

1. Workers whose job assignments require access to Radiological Buffer Areas, Radioactive Material management Areas, and Radiation Areas shall complete DOE standardized core Radiological Worker I training and LBL site-specific Radiological Worker I training before being permitted to enter these areas without a qualified escort.
2. Radiological Worker I training shall use the DOE standardized core course training materials and, in addition, shall emphasize LBL site-specific information.
3. Radiological Worker I training should encompass, at a minimum, the following LBL site-specific practical factors:
  - a. Entering and exiting simulated Radiological Buffer Areas and Radiation Areas,
  - b. Performance of survey for personnel contamination, as applicable,
  - c. Verification of instrument response and source check,
  - d. Anticipated response to alarm situations.
4. Expected time to complete the standardized core course and LBL site-specific Radiological Worker I training is approximately 8 hours.

5. Unescorted worker access to High or Very High Radiation Areas is permitted upon successful completion of Radiological Worker I training and specialized High Radiation Area Training. Specialized High Radiation Area Training shall be approved by DOE Headquarters (EH). The completion of this specialized training does not fulfill Radworker II requirements and unescorted entry into Contamination, High Contamination, Soil Contamination, or Airborne Radioactivity Areas is not authorized.

### **633 Radiological Worker II**

Workers whose job assignments involve entry to High and Very High Radiation Areas, Contamination Areas, High Contamination Areas, and Airborne Radioactivity Areas shall complete Radiological Worker II training before being permitted to enter these areas without a qualified escort. Furthermore, workers who have potential contact with hot particles or use of gloveboxes with high contamination levels shall complete Radiological Worker II training.

1. Radiological Worker II training shall use the standardized core course training materials and, in addition, shall emphasize LBL site-specific information.
2. Radiological Worker II training shall encompass the following LBL site-specific practical factors, as applicable:
  - a. Proper wearing of protective clothing and equipment,
  - b. Entering a simulated Radiological Buffer Area, Contamination Area, and High Radiation Area to perform a task,
  - c. Anticipated response to simulated abnormal situations,
  - d. Anticipated response to simulated alarms or faulty radiological control equipment,
  - e. Removing protective clothing and equipment and subsequently exiting the simulated area,
  - f. Performance of surveys for area and personnel contamination,
  - g. Verification of instrument response and source check.
3. Expected time to complete the standardized core and LBL site-specific Radiological Worker II training is approximately 16 hours.

### **634 Specialized Radiological Worker Training**

Specialized Radiological Worker training shall be completed for nonroutine operations or work in areas with changing radiological conditions. This training is in addition to Radiological Worker II training and is required for personnel planning, preparing, and performing jobs that have the potential for high radiological consequences. Such jobs may involve special containment devices, the use of mockups and ALARA considerations.

*Table 6-1 Radiological Worker Entry Training Requirements*

AREAS	RADIOLOGICAL WORKER I	RADIOLOGICAL WORKER II
Entry into Radiological Buffer Areas	YES	YES
Entry into Radioactive Material Areas	YES	YES
Entry into Radiation Areas (<100 mrem/hr)	YES	YES
Entry into High or Very High Radiation Areas ( $\geq 100$ mrem/hr)*	NO**	YES
Entry into Contamination Areas and High Contamination Areas	NO	YES
Entry into Soil Contamination Areas (to perform work that disturbs soil)	NO	YES
Entry into Airborne Radioactivity Areas	NO	YES***

- \* Entry requirements further restricted by Article 334.
- \*\* Entry restricted unless the requirements of Article 632.5 are met.
- \*\*\* Requires respiratory protection qualification (Article 531)

**PART 4 Health and Safety Technician Qualification****641 Requirements**

Training and qualification of Health and Safety Technicians and their immediate supervisors shall address routine operations and also focus on recognizing and handling situations in both normal and changing radiological conditions. Newly qualified technicians and those still in training should be given the opportunity to work with qualified, experienced technicians to foster development.

**642 Health and Safety Technicians**

1. Health and Safety Technician qualification consists of the standardized core course training material, on-the-job training per the Qualification Standards, and passing both a final comprehensive written examination and final Oral Examination Board.
2. Health and Safety Technician training shall use the standardized core course training materials and in addition should emphasize LBL site-specific information.
3. Health and Safety Technician candidates who have prerequisite knowledge, such as college credit, operational experience, or related qualifications, may satisfy individual sections of the standardized core course training requirements by passing comprehensive challenge examinations.
4. Entry-level prerequisites shall be established to ensure that Health and Safety Technicians meet standards for physical condition and education. At a minimum, these standards should include the following:
  - a. High school education or equivalency,
  - b. Fundamentals of mathematics, physics, chemistry, and science,
  - c. Systems and fundamentals of process, operations, and maintenance,
  - d. Reading and comprehension level sufficient to follow procedures, write permits, prepare survey maps, write reports, and prepare shipping and transfer permits,
  - e. Ability to work in a support role, including communicating verbal instructions to others,
  - f. Physical requirements to handle Personal Protective Equipment, other equipment and assist others in work locations, commensurate with assignment.
5. Health and Safety Technicians are encouraged to pursue registration by the National Registry of Radiation Protection Technologists (NRRPT).
6. LBL shall give credit toward completion of standardized core training requirements for NRRPT registration.
7. LBL will give credit toward completion of standardized core training requirements for an accredited AA or BA/BS in radiological technology or science.

**643 Continuing Training**

1. Following successful completion of standardized core course requirements including practical training, the Health and Safety Technician shall pass both a comprehensive written examination and an Oral Examination Board for final qualification.
2. Following Oral Examination Board qualification, the Health and Safety Technician should begin a 2-year cycle of continuing training required for requalification. Every requalification requires completion of practical training, a comprehensive written examination, and a final Oral Examination Board.
3. Continuing training should provide continued improvement in the knowledge and skills of the Health and Safety Technician.
4. Continuing training should include LBL site-specific and DOE-wide changes in requirements and updates of lessons learned from operating experience and industry events.
5. Continuing training shall include written examinations, as applicable, demonstrations of proficiency controlled by qualification standards and written and oral examinations to prepare for the comprehensive biennial requalification.
6. Infrequently performed tasks, such as those for emergency response, may require annual training. Other tasks may require retraining prior to initiation of a task.
7. Personnel who maintain qualifications as a Health and Safety Technician satisfy the requirements of Radiological Worker II Training.

**644 Health and Safety Technician Supervisors**

1. Health and Safety Technician Supervisors shall have qualified as Health and Safety Technicians and should participate in the continuing radiological training programs.
2. Health and Safety Technician Supervisors should have supervisory and leadership capabilities to direct the work of technicians; effectively interact with crafts, line supervisors, professional staff and other managers; and be able to respond and direct others in emergency and abnormal situations.
3. Health and Safety Technician Supervisors shall be requalified every 2 years through comprehensive Oral Examination Boards in accordance with Article 615.
4. Oral Examination Boards should focus on the ability to analyze situations and supervise subordinates. The Health and Safety Technician Supervisor's depth of knowledge should exceed that expected of a Health and Safety Technician.

**645 Subcontracted Health and Safety Technicians**

1. Subcontracted Health and Safety Technicians should have the same knowledge and qualifications required of facility technicians performing the same duties. At a minimum, the training and qualification program should include the following:
  - a. Review of resumes to identify technicians with experience in jobs similar to those for which they will be employed,
  - b. Written examination and oral evaluation to verify appropriate knowledge level,
  - c. Identification of the duties technicians will be authorized to perform,
  - d. Training in facility procedures and equipment associated with the authorized duties,
  - e. Training on recent operating experience,
  - f. Observation of on-the-job performances by the Health and Safety Technician Supervisor.
2. Subcontracted technicians who work at the facility for extended time periods (more than 6 months) should receive continuing training commensurate with their assigned duties. This should include successful completion of an oral examination.

## **PART 5 Other Radiological Training**

### **651 Management Training**

Line Managers who manage, supervise, or provide oversight of Radiological Control Programs shall be trained in the principles of this Manual. Such training should be based on DOE standardized core course training materials supplemented by LBL site-specific procedures and be completed by new personnel prior to formally assuming line supervision and management responsibilities. Incumbents should participate in continuing training. The continuing training should emphasize self-assessment and external evaluations including performance indicators, root causes, and lessons learned based on operational experience.

### **652 Technical Support Personnel**

Appropriate technical support personnel (engineers, schedulers, procedure writers) should be trained in the principles of ALARA, basic ALARA techniques and dose reduction techniques. They should also participate in selected portions of job-specific and specialized training, particularly in situations using mock-ups.

### **653 Planners**

Planners who develop detailed work plans involving or associated with radioactivity or radioactive materials should have Radiological Worker training to the level required by the workers using the work plans.

### **654 Radiological Control Personnel**

1. Radiological Control technical staff and management should have:
  - a. A combination of education and experience commensurate with their job responsibilities,
  - b. Continuing training based on an assessment of job responsibilities to maintain and enhance proficiency
  - c. Continuing training to remain cognizant of changes to the facility, operating experience, procedures, regulations, and quality assurance requirements.
2. Radiological support personnel include but are not limited to:
  - a. Dosimetry technicians, instrument technicians, medical personnel, records, clerks, whole body counter technicians, and laboratory personnel.

3. Radiological support personnel should have:
  - a. Training on standardized core course topics from Radiological Worker I and II and Health and Safety Technician training and additional job-specific topics, as applicable,
  - b. Training appropriate to the tasks to be performed,
  - c. Continuing training to provide continued improvement in knowledge and skills.
4. Radiological support personnel who are responsible for implementing the site ALARA program shall receive ALARA training.
5. Certification and involvement with professional industry organizations should be encouraged.

### **655 Radiographers and Radiation Generating Device Operators**

Radiographers shall have training in accordance with 10 CFR 34.31. Radiation Generating Device Operators should have training comparable to that required by 10 CFR 34.31. This will be Radiation Worker I Training for X-Ray Users.

### **656 Emergency Response Personnel**

Provisions shall be in place to accommodate rapid site and radiological area access by on-site and off-site emergency workers such as fire fighters, medical personnel, and security personnel.

1. Emergency response personnel, from both on-site and off-site, may be required to work in radiological areas.
2. Emergency response personnel should receive special radiological worker training commensurate with the situations they are likely to encounter.
3. Such training should be based on the Radiological Worker standardized core course and LBL site-specific training materials.
4. If such workers are not trained, trained escorts should be assigned.
5. Training should make it clear that lifesaving has priority over radiological controls.
6. Records of this training should be maintained.

**657 Training for Tour Groups and Visiting Dignitaries, Scientists, and Specialists**

1. Sites should establish radiological control training for tour groups and visiting dignitaries, scientists, and specialists commensurate with the areas they are to enter.
2. Orientation and the use of trained escorts provide an alternative to training with the concurrence of the Radiological Control Manager.
3. Such training should be based on the Radiological Worker standardized core course and LBL site-specific training materials.
4. If visiting scientists or specialists are to do hands-on radiological work, consideration should be given to providing full Radiological Worker I or II training. In any event, training should be commensurate with the work to be performed. If limited training is provided for limited tasks, methods should be established to limit the approved work and make other staff members aware of the limitation, such as posting a signed-off training card.
5. Records of this training should be maintained.

## **PART 6 Training For Special Applications**

### **661 Transuranic Facilities**

The following topics should be considered in addition to standardized core training requirements at transuranic facilities:

- Properties of transuranics,
- Special radiological surveys and techniques,
- External exposure control (neutrons),
- Internal exposure control,
- Containment and glovebox operations and procedures,
- Special instruments and measurement techniques,
- Personnel protection,
- Inventory control and accountability,
- Criticality safety,
- Biological effects.

### **662 Uranium Facilities**

The following topics should be considered in addition to standardized core training requirements at uranium facilities:

- Properties of uranium,
- Special radiological surveys and techniques,
- External exposure control,
- Toxicological properties and behavior of uranium,
- Release of uranium-contaminated materials,
- Instruments and measurement techniques,
- Personnel protection,
- Inventory control and accountability,
- Criticality safety,
- Biological effects.

### **663 Tritium Facilities**

The following topics should be considered in addition to standardized core training requirements at tritium facilities:

- Properties of tritium,
- Sources of tritium,
- Exposure pathways and forms of tritium,
- Exposure controls,
- Tritium containment,

Special instruments and measurement techniques,  
Personnel protection,  
Inventory control and accountability,  
Airborne tritium measurement,  
Airborne tritium controls,  
Effluent recovery systems,  
Tritium releases,  
Bioassay program,  
Biological effects.

#### **664 Accelerator Facilities**

The following topics should be considered in addition to standardized core training requirements at accelerator facilities:

Activation products,  
Special radiological surveys and techniques,  
Component source terms,  
Interlock and warning devices and systems,  
Access to beam and beam containment,  
Special instruments and measurement techniques,  
Biological effects.

**PART 7 Summary of Responsibilities**

**671 Senior Site Executive**

**672 Line Management**

**673 Radiological Control Manager**

- Concur in site-generated radiological training material. (612.5)
- Verify the effectiveness of radiological control training. (613.6)
- Concur with alternate training methods or escorts. (613.9, 657.2)
- Designate members and Chair of Oral Examination Board. (615.2)

**674 ALARA Committee**

**675 Workers**

**676 Support Organizations**

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## **PART 1 Requirements**

### **711 Purpose**

This chapter contains requirements for preparing and retaining radiologically related records which are part of the LBL Radiological Records Program (LBLRRP). Radiological control records which are needed to demonstrate the effectiveness of the overall program are a part of the LBLRRP. The work force and management are required to use records to document radiological safety afforded to personnel on site. Records of radiological programs may be required to support worker health studies and future disputes or claims. Therefore, these records should be high quality, readily retrievable and managed for the prescribed retention period. Related records should be cross-referenced to aid retrievability. Records should be handled such that personal privacy is protected.

### **712 Records Management Program**

1. The LBLRRP shall be operated to ensure that auditable records and reports are controlled through the stages of creation, distribution, use, arrangement, storage, retrieval, media conversion (if applicable), and disposition. This records management program should include the following:
  - a. Radiological Policy Statements,
  - b. Radiological Control Procedures,
  - c. Individual Radiological Doses,
  - d. Internal and External Dosimetry Policies and Procedures (including Bases Documents),
  - e. Personnel Training (course records and individual records)
  - f. ALARA Records,
  - g. Radiological Instrumentation Test, Repair and Calibration Records,
  - h. Radiological Surveys,
  - i. Area Monitoring Dosimetry Results,
  - j. Radiological Work Permits,
  - k. Radiological Performance Indicators and Assessments,
  - l. Radiological Safety Analysis and Evaluation Reports,
  - m. Quality Assurance Records,
  - n. Radiological Incident and Occurrence Reports (and Critique Reports, if applicable),
  - o. Accountability records for sealed sources,
  - p. Records for release of material to controlled areas,
  - q. Reports of loss of radioactive material.
2. Where radiological services (for example, dosimetry and laboratory analysis) are purchased, the contractual agreement regarding records responsibility during performance of the service should clearly show that records of results shall reside in the custody of LBL, the originating contract organization. Additionally, copies of the procedures used by the services contractor should be included in the LBLRRP.

3. The LBLRRP shall meet DOE 1324.2A requirements for implementation, records inventory, disposition schedules, and provisions for the transfer of records.
4. The conduct of the LBLRRP shall meet the Privacy Act of 1974 requirements to protect the privacy of individual records.

### **713 Recordkeeping Standards**

1. Radiological control records shall be accurate and legible. The records should include the following:
  - a. Identification of the facility, specific location, function and process,
  - b. Signature or other identifying code of the preparer and date,
  - c. Legible entries in black ink,
  - d. Corrections identified by a single line-out, initialed and dated,
  - e. Supervisory signature to demonstrate review and ensure proper completion of forms.
2. The Radiological Control Organization should maintain a file of names, signatures, and initials for future identification of the person who signed or initialed a record.
3. Radiological control records should not include records:
  - a. that were corrected using opaque substances,
  - b. containing shorthand or other nonstandard terms.
4. Similar procedural standards should be established for computerized records.

## **PART 2 Employee Records**

### **721 Employment History**

Records detailing an employee's preemployment and employment occupational radiation exposure history shall be maintained. Where practical, the association between the radiation dose and job function should be preserved for trend analyses and future worker health studies. The following information should be maintained:

1. Previous work history detailing radiological work assignments, to the extent practical, and yearly doses at other DOE and non-DOE facilities. The LBL Radiation Worker Form shall be used to identify this information.
2. Nuclear Regulatory Commission Form 4 or equivalent that documents previous occupational radiation doses.
3. Ongoing work history documenting work assignments and radiation doses; the facility and occupational codes defined in DOE 5484.1 should be used for this process.
4. LBL standardized forms to document previous and ongoing radiation doses.

### **722 Personnel Radiological Records**

1. Occupational Radiation Dose Records shall be maintained for all contractor, subcontractor, and Federal employees who are part of the personnel dosimetry program at LBL.
2. Occupational Radiation Dose Records shall contain information sufficient to identify each person, including social security or employee number. For foreign nationals, the passport numbers or a suitable alternate shall be used.
3. Routine and special records related to radiation doses shall be retained for each person monitored. This shall include records of zero dose. Procedures, data and supporting information as defined in Chapter 5 and appropriate IG's and orders needed to reconfirm a person's dose at a later date should be maintained.
4. External dose records should include the following:
  - a. Extremity, skin, eye, and whole body dose results measured with personnel dosimeters, including all multiple dosimeter badging results,
  - b. Evaluations and dose reconstruction resulting from anomalous dose results such as unexpected high or low doses,
  - c. Dose reconstruction from a lost or damaged dosimeter, or for unbadged workers (as appropriate),
  - d. Evaluations of nonuniform radiation doses.

5. Internal dose records should include the following:
  - a. In vivo measurements results including whole body, wound, and lung counting, and chest wall thickness measurements (where applicable),
  - b. Urine, fecal, and specimen analysis,
  - c. Dose assessment, as required,
  - d. Reference to any decorporation therapy that was performed.
6. Counseling of persons about radiological concerns should be documented and this documentation retained. It is desirable that the counseled person sign the documentation to acknowledge participation.
7. Records of authorization to exceed Administrative Control Levels shall be retained using the LBL Authorization to Increase Dose Equivalent Limit Form.

#### **723 Other Personnel Radiological Records**

1. The complete records of radiological incidents and occurrences involving personnel dose shall be retained.
2. Records of employee radiological safety concerns that have been formally investigated and documented should be maintained.

#### **724 Medical Records**

1. Preemployment medical records, if available, and reports of periodic medical examinations should be maintained.
2. Physical examination reports and fit testing results for respirator use should be maintained for respirator users.
3. Medical evaluations and treatment performed in support of the radiological program should be documented.
4. Maintenance of records of nonoccupational radiation doses, such as therapeutic or large amounts of diagnostic radiation doses for medical purposes, is encouraged. Where practical, maintenance of records of preemployment nonoccupational radiation doses is encouraged.

#### **725 Radiological Training and Qualification Records**

1. Records of training and qualification in radiological control shall be maintained in the LBLRRP or cross-referenced to where they are permanently maintained to demonstrate that a person received appropriate information to perform the work assignment in a safe manner. Qualification standard records shall be retained for on-the-job and practical factor training as well as for formal classroom training.

2. Formal records of training and qualification shall be readily available to first-line supervision and management of involved personnel to aid in making work assignments.
3. Personnel training records shall be controlled and retained in the LBLRRP. At a minimum, these records shall include:
  - a. Course title,
  - b. Attendance sheets with instructor's name,
  - c. Employee's name, identification number, and signature,
  - d. Date of training,
  - e. Identification of the examination or evaluation form, including sufficient data to identify which test each person completed,
  - f. Verification document of record confirming satisfaction of the training requirement,
  - g. Documentation related to exceptions for training requirements and extensions of qualification,
  - h. Quizzes, tests, responses, and acknowledgments of training, with the date and signature of the person trained,
  - i. Special instructions to females, their supervisors, and coworkers concerning prenatal radiation dose, acknowledged by the worker's signature.
4. Records shall be retained for the following types of training:
  - a. General employee radiological training,
  - b. Radiological worker training,
  - c. Periodic retraining,
  - d. Respiratory protection training,
  - e. Training of radiological control personnel,
  - f. Instructor training,
  - g. Qualifications for special tests or operations,
  - h. Orientation and training for visitors,
  - i. Training of emergency response personnel.
5. The following instructional materials shall be maintained in the LBLRRP historical records:
  - a. Course name, with revision, and approval date,
  - b. Instructor's manuals, course content, or lesson plans containing topical outlines,
  - c. Video and audio instructional materials, including the dates and lessons for which they were used,
  - d. Handouts or other materials retained with the master copy of the course,
  - e. Job-specific training documents, such as instrument use, radiological procedures, Radiological Work Permit special training requirements, pre-job briefings and mock-up training.
6. Documentation of training and qualification received at another DOE location need not be duplicated. Such records should be provided to the person's home office for retention.

**PART 3 Visitors****731 Record Requirements**

For visitors entering an area where radiation monitoring is required, the following records shall be maintained:

1. Documentation of completion of Radiological Orientation.
2. Radiation dose records, including zero dose.

**732 Reports**

All non-zero radiation doses shall be reported within 30 days of the dose determination, but no later than 90 days after the end of the visit, to each visitor who received a dose. It is desirable that all visitors who receive zero dose also be provided a report. Zero dose reports shall be provided to those visitors who request a report.

**PART 4 Radiological Control Procedures****741 Policies, Procedures and Radiological Work Permits**

Records of the Radiological Control Program should consist of policy statements, procedures, Radiological Work Permits, and supporting data. The records should be maintained in a chronological sequence that will allow correlation with the corresponding support information. For example, procedures for performing radiation surveys should be identifiable with the survey results. Radiological Work Permits should be retained as part of the LBLRRP Records or cross-referenced to where they are permanently maintained.

**742 ALARA Records**

Records of As-Low-As-Reasonably-Achievable (ALARA) plans and goals shall be maintained as part of the historical records in the LBLRRP to demonstrate the adequacy of the ALARA program. These records should include the minutes of ALARA committees and other committees where radiological safety issues are formally discussed.

**743 Quality Assurance Records**

Records of quality assurance reviews and audits developed for Radiological Control functions shall be retained to ensure that sufficient records are specified, prepared, reviewed, approved, and maintained to accurately reflect completed work. DOE 5700.6C provides additional information regarding quality assurance records.

## **PART 5 Radiological Surveys**

### **751 Requirements**

Radiological Control Programs include the performance of radiation, airborne radioactivity, and contamination surveys to determine existing conditions in a given location. Maps with sufficient detail to permit identification of original survey and sampling locations should be maintained. Records should contain sufficient detail to be meaningful even after the originator is no longer available. These records shall be cross-referenced in the LBLRRP as to where they are permanently stored. Radiological surveys should be recorded on appropriate standard forms and include the following common elements:

1. Date, time and purpose of the survey.
2. General and specific location of the survey.
3. Name and signature of the surveyor and analyst.
4. Pertinent information needed to interpret the survey results.
5. Reference to a specific Radiological Work Permit if the survey is performed to support the permit.

### **752 Radiation Surveys**

In addition to the elements provided in Article 751, records of radiation surveys shall include, at a minimum, the following information:

1. Instrument model and serial number.
2. Results of the measurements of area dose rates.

### **753 Airborne Radioactivity**

In addition to the elements provided in Article 751, records of airborne radioactivity shall include, at a minimum, the following information:

1. Model and serial number of the sampler and laboratory counting instrument; locations of fixed samplers may be used as identifiers where model and serial numbers are not available.
2. Air concentrations in general airborne areas and breathing zones.
3. Supporting parameters, including collection efficiency, flow rate, duration of sampling, correction factors, and filter medium.

**754 Contamination Surveys**

In addition to the elements required by Article 751, records of contamination surveys shall include, at a minimum, the following information:

1. Model and serial number of instruments used including counting equipment.
2. Contamination levels (using appropriate units) and appropriate supporting parameters including counting efficiency, counting time, correction factors, type of radiation, and whether the contamination was fixed or removable.
3. Location of areas found to contain hot particles or high concentrations of localized contamination in excess of established action levels.
4. Follow-up survey results for decontamination processes cross-referenced to the original survey.

**PART 6 Instrument and Calibration Records****761 Calibration and Operational Checks**

1. Calibration for fixed, portable, and laboratory radiation measuring equipment shall be maintained and include frequencies, method, dates, personnel, training, and traceability of calibration sources to National Institute of Science and Technology or other acceptable standards.
2. Calibration records should be maintained for the following equipment:
  - a. Portable survey instruments,
  - b. Bioassay measurement equipment,
  - c. Laboratory, counting room and fixed radiation measuring equipment,
  - d. Process and effluent monitors and sampling equipment,
  - e. Radiation area monitors,
  - f. Personnel contamination monitors,
  - g. Pocket and electronic dosimeters,
  - h. Air sampling equipment,
  - i. Tool and waste monitoring equipment,
  - j. Protective clothing and equipment monitors.
3. Maintenance histories, including the nature of any defects and corrective actions taken, and calibration results (both as found and as returned) for each instrument should be created and retained.

**762 Special Calibration Records**

Records of additional tests and checks of instrumentation used in conjunction with a suspected overexposure, questionable indication, or unusual occurrence should be retained. In addition, records of special instrument calibrations and modifications made in accordance with Article 562.6 should be retained.

## **PART 7 Records Management**

### **771 Media**

A combination of media may be used for the LBL Radiological Records Program. For records that have long-term retention requirements and are stored on media subject to degradation or obsolescence, the records program shall include provisions for conversion to a more stable media. All records shall be stored in a manner that ensures their integrity, retrievability, and security.

### **772 Microfilm**

Records may be microfilmed provided the resulting film copy is capable of producing a clear, legible copy after storage for the specified period. The following controls shall be administered:

1. Verification that the resultant copy is legible.
2. Confirmation that printed sides are copied.
3. Periodic quality audits of the final filmed copy.

### **773 Computerization of Records**

1. Records may be transferred to magnetic storage media provided certain precautions are taken to ensure that the information is maintained in a retrievable configuration.
2. Controls for the use and handling of magnetic storage media should include the following:
  - a. A master index of documents on the magnetic storage media,
  - b. A program to ensure back-up and retrievability of information,
  - c. Quality control during data entry and analysis,
  - d. An index identifying software applications used in conjunction with the data,
  - e. Software validation and verification,
  - f. Periodic quality audits of software,
  - g. Prevention of unauthorized manipulation of data,
  - h. Assurance that previously stored information is retrievable and usable after system modifications.
3. It shall be permissible to use optical disks to archive records if the system using optical disks satisfies the following:
  - a. A reliable system to prevent overwriting or erasure of records,
  - b. Software and user controls consistent with Article 773.3,
  - c. Manufacturer recommendations relating to software control, disk life expectancy, environmental storage conditions and maintenance incorporated into policies and procedures,
  - d. Quality controls on the copying and imaging processes consistent with Article 772.

**774 Retention**

1. The retention of LBLRRP Records shall be based on the requirements stated in DOE 1324.2A and DOE 5480.11.
2. Once a record has been created, reviewed, and signed by appropriate supervision, the record should be considered complete and shall not be modified. Subsequent errors identified in a completed record should be corrected by creating a supplemental record that includes traceability for the correction.

**775 Physical Protection of Records**

1. Methods for protecting LBLRRP should include vaults, file rooms with fixed fire suppression, fire rated cabinets, duplicate storage, or combinations of these.
2. In identifying storage arrangements, physical damage that could be caused by temperature extremes, moisture, infestation, electromagnetic fields, excessive light, stacking, theft, and vandalism should be addressed.
3. Records should, as a minimum, be protected from:
  - a. Exposure to fire, equivalent to an Underwriters Laboratories, Inc. 1.5-hour, or greater, fire resistance rating,
  - b. Exposure to water damage caused by a 100-year flood,
  - c. Exposure to windstorm velocities of 100-year recurrence.

## **PART 8 Radiological Reporting**

### **781 Reports to Individuals**

Personnel who are monitored by the personnel dosimetry program shall be provided an annual report of their dose. This requirement shall not apply to visitors covered by Article 732. Upon request, a person should receive a current radiation dose record. Terminating employees shall be provided a report, within 90 days of the last day of employment, that summarizes radiation dose for the total period of employment at the reporting facility.

### **782 Annual Radiation Report**

The reporting requirements in DOE 5484.1 shall be followed for the "Annual Radiation Dose Summary". This report shall include internal and external radiation dose results for monitored DOE and DOE contractor employees, and for monitored visitors (if their records are maintained at LBL).

**PART 9 Summary of Responsibilities**

**791 Senior Site Executive**

**792 Line Management**

Document radiological safety measures used to protect personnel.

**793 Radiological Control Manager**

Maintain a radiological records management program.

**794 ALARA Committee**

**795 Workers**

Complete all required records as prescribed.

Report all off-site visits where dosimeters are worn to LBL Personal Dosimetry Office.

**796 Support Organizations**

Evaluate radiological exposures and document results in the LBL Radiological Records Program System. (External and internal dosimetry, WBC, etc.)

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**GLOSSARY**

**abnormal situation:** Unplanned event or condition that adversely affects, potentially affects or indicates degradation in the safety, security, environmental or health protection performance or operation of a facility.

**activation:** Process of producing a radioactive material by bombardment with neutrons, protons or other nuclear particles.

**Administrative Control Level:** Level of radiation exposure established well below regulatory limits by management to help reduce individual and collective radiation dose.

**airborne radioactivity:** Radioactive material in any chemical or physical form that is present in ambient air, above natural background.

**Airborne Radioactivity Area:** Area where the measured concentration of airborne radioactivity, above natural background, exceeds either: (1) 10 percent of the Derived Air Concentration (DAC) averaged over 8 hours or (2) a peak concentration of 1 DAC. DAC values are contained in Attachment 1 of DOE 5480.11.

**Annual Limit on Intake (ALI):** The quantity of a single radionuclide which, if inhaled or ingested in 1 year, would irradiate a person, represented by reference man (ICRP Publication 23), to the limiting value for control of occupational exposure.

**As Low As Reasonably Achievable (ALARA):** An approach to radiological control to manage and control 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.

**ALARA Committee:** Multidisciplined forum that reviews and advises management on improving progress toward minimizing radiation exposure and radiological releases.

**assessment:** Evaluation or appraisal of a process, program or activity to estimate its acceptability.

**background radiation:** Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material); 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.

**becquerel (Bq):** 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.

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**bioassay:** Measurement of radioactive material deposited within or excreted from the body. This process includes whole body and organ counting as well as urine, fecal and other specimen analysis.

**company-issued clothing:** Clothing provided by the company, such as work coveralls and shoes. For radiological control purposes, company-issued clothing shall be considered the same as personal clothing.

**containment device:** Barrier such as a glovebag, glovebox or tent for inhibiting the release of radioactive material from a specific location.

**contractor senior site executive:** The person at a DOE contractor-operated facility or site who has final on-site corporate authority and is often called President, General Manager, Site Manager or Director.

**critical mass:** The smallest mass of fissionable material that will support a self-sustaining chain reaction under specified conditions.

**Contamination Area:** Area where contamination levels are greater than the values specified in Chapter 2, Table 2-2, but less than or equal to 100 times those levels.

**Contamination Reduction Corridor:** A defined pathway through a hazardous waste site Contamination Reduction Zone where decontamination occurs.

**contamination survey:** Use of swipes or direct instrument surveys to identify and quantify radioactive material on personnel, on equipment or in areas.

**continuing training:** Training scheduled over a specified time such as over a two-year period for the purpose of maintaining and improving technical knowledge and skills.

**continuous air monitor (CAM):** Instrument that continuously samples and measures the levels of airborne radioactive materials on a "real-time" basis and has alarm capabilities at preset levels.

**Controlled Area:** Any area to which access is controlled in order to protect personnel from exposure to radiation and radioactive materials.

**counseling:** Advice, information exchange and guidance provided to employees on radiologically related topics, such as dose perspectives; potential health effects from radiation exposure; skin contaminations; contaminated wounds; internally deposited radioactivity; pregnancy; and radiation exposure. This advice and guidance is normally provided by knowledgeable, senior professionals from the Radiological Control Organization and other organizations, such as Medical, as appropriate.

**critique:** Meetings of personnel involved in or knowledgeable about an event (either a success or an abnormal event) to document a chronological listing of the facts.

**declared pregnant worker:** A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

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**decontamination:** Process of removing radioactive contamination and materials from personnel, equipment or areas.

**deep dose:** The dose equivalent from external radiation determined at a tissue depth of 1 cm.

**Derived Air Concentration (DAC):** The concentration of a radionuclide in air that, if breathed over the period of a work year, would result in the ALI for that radionuclide being reached. The DAC is obtained by dividing the ALI by the volume of air breathed by an average worker during a working year (2400 m<sup>3</sup>).

**disintegration per minute (dpm):** The rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

**DOELAP:** Department of Energy Laboratory Accreditation Program for personnel dosimetry under DOE 5480.15.

**dose:** The amount of energy deposited in body tissue due to 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.

Some types of radiation, such as neutron and alpha, deposit their energy more densely in affected tissue than gamma radiation and thereby causing more damage to tissue. The term **dose equivalent**, measured in units of rem, is used to take into account this difference in tissue damage. Therefore 1 rem from gamma radiation causes damage **equivalent** to 1 rem from alpha radiation. However, it takes one-twentieth as much energy from alpha radiation, as compared with gamma radiation, to produce this 1 rem **dose equivalent**.

The term **collective dose**, measured in person-rem, is calculated by summing the dose to each person in the group of interest. For example, if 12 workers each have 1 rem, then the collective dose is 12 person-rem.

Technical definitions for dose terms necessary for various exposure calculations and recordkeeping purposes include the following:

**absorbed dose (D):** 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).

**dose equivalent (H<sub>T</sub>):** The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

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**effective dose equivalent ( $H_E$ ):** The sum of the products of the dose equivalent to the organ or tissue ( $H_T$ ) and the weighting factors ( $W_T$ ) applicable to each of the body organs or tissues that are irradiated ( $H_E = \sum W_T H_T$ ).

**committed dose equivalent ( $H_{T,50}$ ):** 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.

**committed effective dose equivalent ( $H_{E,50}$ ):** The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues ( $H_{E,50} = \sum W_T H_{T,50}$ ).

**total effective dose equivalent (TEDE):** The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

**weighting factor:** Factor that represents the proportion of the total stochastic (cancer plus genetic) risk resulting from irradiation to tissue to the total risk when the whole body is irradiated uniformly.

**dose assessment:** Process of determining radiological dose and uncertainty included in the dose estimate, through the use of exposure scenarios, bioassay results, monitoring data, source term information and pathway analysis.

**embryo/fetus:** Developing human organism from conception until birth. Same as unborn child.

**engineering controls:** Use of components and systems to reduce airborne radioactivity and the spread of contamination by using piping, containments, ventilation, filtration or shielding.

**extremities:** Includes hands and feet, arms below the elbow and legs below the knee.

**eye dose equivalent:** Applies to the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 cm.

**filter integrity test:** Test performed on High-Efficiency Particulate Air (HEPA) filters to identify any damage to the filter or leakage around the filter. Techniques used to conduct the test are described in ANSI/UL 586-1990, "High Efficiency Particulate Air Units."

**fixed contamination:** Radioactive material that cannot be readily removed from surfaces by nondestructive means, such as casual contact, wiping, brushing or washing.

**Flash x-ray unit:** Any device that is capable of generating pulsed x-rays.

**frisk or frisking:** Process of monitoring personnel for contamination. Frisking can be performed with hand-held survey instruments, automated monitoring devices or by a Radiological Control Technician.

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**gestation period:** The time from conception to birth, approximately 9 months.

**gray (Gy):** SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule per kilogram (100 rads).

**High-Efficiency Particulate Air (HEPA) filter:** Throwaway 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 percent for thermally generated monodisperse DOP smoke particles with a diameter of 0.3 micrometer, and 3) a maximum pressure drop of 1.0 inch w.g. when clean and operated at its rated airflow capacity.

**High Contamination Area:** Area where contamination levels are greater than 100 times the values specified in Chapter 2, Table 2-2, of this Manual.

**High Radiation Area:** An area, accessible to personnel, in which radiation levels could result in a person receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

**hot particle:** Fuel, activated corrosion product, or other particles of small size that have a high specific activity as a result of nuclear fission or neutron activation.

**hot spot:** Localized source of radiation or radioactive material normally within facility piping or equipment. The radiation levels of hot spots exceed the general area radiation level by more than a factor of 5 and are greater than 100 mrem (1 mSv) per hour on contact.

**infrequent or first-time activities:** Radiological work activities or operations that require special management attention and consideration of new or novel radiological controls. The designation of infrequent or first-time activities is specifically applicable to facilities that conduct routine and recurring process operations, and is not applicable to facilities that routinely conduct first-time activities, such as experimental or research facilities.

**irradiator:** Sealed radioactive material that has the potential to create a radiation level exceeding 500 rad (5 grays) in 1 hour at 1 meter. Although not addressed in this Manual, acceptable radiological controls for irradiator use are specified in Title 10, Code of Federal Regulations, Part 20.1603.

**lifetime dose:** Total occupational exposure over a worker's lifetime, including external and committed internal dose.

**low-level waste:** Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, spent nuclear fuel or byproduct material as defined in Section 11e(2) of the Atomic Energy Act, as amended. Test specimens of fissionable material irradiated only for research and development and not for production of power or plutonium may be classified as low-level waste provided the concentration of transuranic activity is less than 100 nCi/g.

**mixed waste:** Waste containing both radioactive and hazardous components as defined by the Atomic Energy Act and the Resources Conservation and Recovery Act, respectively.

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**nuclear criticality:** a self-sustaining chain reaction, i.e., the state in which the effective neutron multiplication constant of system of fissionable material equals or exceeds unity.

**occupational dose:** The dose received by a person during employment in which the person's assigned duties involve exposure to radiation and to radioactive material. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the public.

**personnel dosimetry:** Devices designed to be worn by a single person for the assessment of dose equivalent such as film badges, thermoluminescent dosimeters (TLDs), and pocket ionization chambers.

**personnel monitoring:** Systematic and periodic estimate of radiation dose received by personnel during working hours. Also, the monitoring of personnel, their excretions, skin or any part of their clothing to determine the amount of radioactivity present.

**Personal Protective Equipment:** Equipment such as respirators, face shields and safety glasses used to protect workers from excessive exposure to radioactive or hazardous materials.

**protective clothing:** Clothing provided to personnel to minimize the potential for skin, personal and company issued clothing contamination. Also referred to as "anticontamination clothing," "anti-Cs" and "PCs."

**Planned Special Exposure:** Preplanned, infrequent exposure to radiation, separate from and in addition to the annual dose limits.

**prefilter:** Filter that provides first stage air filtration to remove larger particulates and prolong the efficient use of a HEPA filter.

**prenatal radiation exposure:** The exposure of an embryo/fetus to radiation.

**primary dosimeter:** A dosimeter worn on the body used to obtain the formal record of whole body radiation dose.

**Qualification Standard:** A document that states and defines the required physical attributes and the technical, academic and practical knowledge and skills developed through training, education and on-the-job performance for the successful completion of a training program.

**rad:** 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).

**Radiation Area:** An area, accessible to personnel, in which radiation levels could result in a person receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the source or from any surface that the radiation penetrates.

**radiation survey:** Measurement with instrumentation to evaluate and assess the presence of radioactive materials or other sources of radiation under a specific set of conditions.

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**radioactive material:** For the purposes of this Manual, radioactive material includes 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.

**Radioactive Material Area:** An area or structure where radioactive material is used, handled or stored.

**Radioactive Material Management Area:** A controlled area where radioactive material, contaminated or induced activity is used, handled or stored.

**radioactive waste:** Solid, liquid or gaseous material that contains radionuclides regulated under the Atomic Energy Act, as amended, and is of negligible economic value considering the cost of recovery.

**radioactivity:** A natural and spontaneous process by which the unstable atoms of an element emit or radiate excess energy from their nuclei and, thus, change (or decay) to atoms of a different element or to a lower energy state of the same element.

**radiography:** Examination of the structure of materials by nondestructive methods, using a radioactive source or a radiation generating device.

**Radiological Buffer Area (RBA):** A intermediate area established to prevent the spread of radioactive contamination and to protect personnel from radiation exposure. The area surrounds or is contiguous with Contamination Areas, High Contamination Areas, Airborne Radioactivity Areas, Radiation Areas or High Radiation Areas.

**radiological posting:** Sign or label that indicates the presence or potential presence of radiation or radioactive materials.

**radiological work:** Any work that requires the handling of radioactive material or which requires access to Radiation Areas, High Radiation Areas, Contamination Areas, High Contamination Areas or Airborne Radioactivity Areas.

**Radiological Work Permit (RWP):** Permit that identifies radiological conditions, establishes worker protection and monitoring requirements, and contains specific approvals for 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.

**radiological worker:** Worker whose job assignment requires work on, with, or in the proximity of radiation producing machines or radioactive materials. A radiological worker 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 "radworker."

**Radiological Control Hold Point:** Cautionary step in a Technical Work Document requiring the Radiological Control Organization to perform some action or verification. The Radiological Control Hold Point requirements should be satisfactorily completed before the work is continued.

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**refresher training:** Training scheduled on the alternate year when full retraining is not completed for Radiological Worker I and Radiological Worker II personnel.

**release to uncontrolled areas:** Release of material from administrative control after confirming that the residual radioactive material meets the guidelines in DOE 5400.5.

**rem:** Unit of dose equivalent. Dose equivalent in rem is numerically equal to the absorbed dose in rad multiplied by a quality factor, distribution factor and any other necessary modifying factor (1 rem = 0.01 sievert).

**removable contamination:** Radioactive material that can be removed from surfaces by nondestructive means, such as casual contact, wiping, brushing or washing.

**respiratory protective equipment:** Equipment used to protect personnel from inhalation of radioactive or hazardous materials.

**Senior Nuclear Managers Group:** The forum for senior DOE executives involved in nuclear activities to discuss items of mutual concern. Membership includes the Program Secretarial Officials for the Offices of Nuclear Energy, Defense Programs, Energy Research, Civilian Radioactive Waste Management, Environmental Restoration and Waste Management, Environment Safety and Health; the Directors for the Offices of Nuclear Safety and New Production Reactors; and the Department's Defense Nuclear Facility Safety Board (DNFSB) representative. The group has no additional authority beyond that possessed by individual members.

**shallow dose equivalent:** Applies to the external exposure of the skin or an extremity. It is taken as the dose equivalent at a tissue depth of 0.007 centimeter averaged over an area of 1 square centimeter.

**sievert (Sv):** SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rems).

**site:** An area managed by DOE where access can be limited for any reason. The site boundary encompasses Controlled Areas.

**source, sealed:** 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. The confining barrier prevents dispersion of the radioactive material under normal and most accidental conditions related to use of the source.

**step-off pad:** Transition area between contaminated and non-contaminated areas that is used to allow exit of personnel and removal of equipment.

**standard radiation symbol:** Symbols designed and proportioned as illustrated in accordance with ANSI N2.1 for radiation symbols and ANSI N12.1 for fissile material.

**sticky pad:** Step-off pad provided with a tacky surface to reduce the potential for inadvertently tracking contamination out of a contaminated area.

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**technical work document:** A term used to generically identify formally approved documents that direct work, such as procedures, work packages, or job or research plans.

**transuranic waste:** Without regard to source or form, waste that is contaminated with alpha-emitting transuranic radionuclides having half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay.

**thermoluminescent dosimeter (TLD):** Radiation monitoring device used to record the radiological exposure of personnel or areas to certain types of radiation.

**unusual occurrence:** 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 contained in DOE 5000.3A.

**Very High Radiation Area:** An area, accessible to personnel, in which radiation levels could result in a person receiving an absorbed dose in excess of 500 rads (5 grays) in one hour at 1 meter from a radiation source or from any surface that the radiation penetrates.

**visitor:** Person requesting access to Controlled Areas, who has not been trained to the level required to permit unescorted access.

**whole body dose:** The sum of the annual deep dose equivalent for external exposures and the committed effective dose equivalent for internal exposures.

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## References

**REFERENCES**

The following references contain additional information pertinent to the provisions incorporated in this Manual. Those persons responsible for the Site-Specific Manual should have these references readily available. The citing Article is noted in brackets ([ ]) following each reference. See "Additional References" for addresses of organizations.

**INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION**

**ICRP Publication 26** (1977) "Recommendation of the International Commission on Radiological Protection." [App. 2A]

**NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS**

**NCRP Report No. 65** (1980) "Management of Persons Accidentally Contaminated with Radionuclides." [542.1]

**NCRP Report No. 91** (1987) "Recommendations on Limits for Exposure to Ionizing Radiation." [App. 2A]

**FEDERAL**

**FR 87-1716** "Radiation Protection Guidance to Federal Agencies for Occupational Exposure," signed by President Reagan, January 20, 1987. [213.1]

**10 CFR 20** "Standards for Protection Against Radiation." [535]

**10 CFR 34** "Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations." [365.5]

**10 CFR 34.31** "Personal Radiation Safety Requirements for Radiographers and Radiographers Assistants - Training." [655]

**29 CFR 1910.134** "General Industry Standards - Respiratory Protection." [531.2]

**49 CFR 172** "Hazardous Materials Tables, Hazardous Materials Communications, Requirements and Emergency Response Information Requirements." [423.1]

**49 CFR 173** "Shippers - General Requirements for Shipments and Packaging." [423.1]

**DEPARTMENT OF ENERGY**

**DOE 1324.2A** (9-13-88) "Records Disposition." [712.3, 774.1]

**DOE 5000.3A** (5-30-90) "Occurrence Reporting and Processing of Operations Information." [127]

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- DOE 5400.3** (2-22-89) "Hazardous and Mixed Waste Program." [443.1, 443.2]
- DOE 5400.5** (2-8-90) "Radiation Protection of the Public and the Environment." [222.6, Table 2-4, 422.2, 422.3, 451.4, 554.4]
- DOE N 5400.9** (12-24-91) "Sealed Radioactive Source Accountability." [431.1]
- DOE 5480.4** (5-15-84) "Environmental Protection, Safety, and Health Protection Standards." [365.1, 365.2, 365.5, 531.5, 562.1]
- DOE 5480.5** (9-23-86) "Safety of Nuclear Facilities." [515]
- DOE 5480.11** (12-21-88) "Radiation Protection for Occupational Workers." [213.3, 223.2, 235.3, 515, 774.1]
- DOE 5480.15** (12-14-87) "Department of Energy Laboratory Accreditation Program for Personnel Dosimetry." [512.1]
- DOE 5480.18A** (7-19-91) "Accreditation of Performance-Based Training for Category A Reactors and Nuclear Facilities." [612]
- DOE 5480.19** (7-9-90) "Conduct of Operations Requirements for DOE Facilities." [125.1]
- DOE 5480.20** (2-20-91) "Personnel Selection, Qualification, Training and Staffing Requirements at DOE Reactor and Non-Reactor Nuclear Facilities." [612, 613]
- DOE 5480.21** (12-24-91) "Unreviewed Safety Questions"
- DOE 5480.22** (2-25-92) "Technical Safety Requirements"
- DOE 5480.23** (4-30-92) "Nuclear Safety Analysis Reports"
- DOE 5480.24** (8-12-92) "Nuclear Criticality Safety"
- DOE 5480.25** (11-3-92) "Safety of Accelerator Facilities"
- DOE 6430.1A** (4-16-92) "General Design Criteria"
- DOE 5484.1** (2-24-81) "Environmental Protection Safety and Health Protection Information Reporting Requirements." [721, 782]
- DOE 5700.6C** (8-21-90) "Quality Assurance." [743]
- DOE 5820.2A** (9-26-88) "Radioactive Waste Management." [441.1, 443.1, 443.2, 451.1]

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**DEPARTMENT OF ENERGY GUIDES TO GOOD PRACTICES**

**EGG-2530** (1988) "Health Physics Manual of Good Practices for Uranium Facilities," EG&G, Idaho Falls, Idaho 83415. [362]

**MLM-3719** (1991) "Health Physics Manual of Good Practices for Tritium Facilities," (Replaces 1989 Draft - final publication expected 1992) EG&G Mound Applied Technologies, Miamisburg, Ohio 45343. [363]

**PNL-6534** (1988) "Health Physics Manual of Good Practices for Plutonium Facilities," Pacific Northwest Laboratory, Richland, Washington 99352. [361.2]

**SLAC-327** (1988) "Health Physics Manual of Good Practices for Accelerator Facilities," Stanford Linear Accelerator Center, Stanford, California 94305. [364.1]

**NUCLEAR REGULATORY COMMISSION**

**Form 4** "Occupational External Radiation Exposure History." [721.2]

**AMERICAN NATIONAL STANDARDS INSTITUTE**

**CGA G-7.1** (1989) "Commodity Specification for Air." [531.5]

**N43.1** (1978) "Radiological Safety in the Design and Operation of Particle Accelerators." [364.2]

**N43.2** (R1989) "Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment." [365.2]

**N323** (R1983) "Radiation Protection Instrumentation Tests and Calibrations." [562.1, 564]

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