Radiological Control Manual

May 1996

Environment, Health and Safety Division

Ernest Orlando Lawrence
Berkeley National Laboratory

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Radiological Health and Safety Policy

It is the policy of the Lawrence Berkeley National Laboratory (LBNL) to conduct its radiological operations in a manner that ensures the health and safety of all its employees, contractors, and the general public. In achieving this objective, LBNL shall ensure that radiation exposures to its workers and the public and releases of radioactivity to the environment are maintained below regulatory limits and deliberate efforts are taken to further reduce exposures and releases in accordance with a process that seeks to make any such exposures or releases as low as reasonably achievable. LBNL is fully committed to implementing a Radiological Protection Program (RPP) of the highest quality that consistently reflects this policy.

In meeting this policy, LBNL is committed to:

1. Follow and maintain a system of radiation protection regulatory requirements (10 CFR 835) and guidance standards such as this LBNL Radiological Control Manual (RCM). The LBNL radiological protection requirements are, at a minimum, consistent with 10 CFR 835. The LBNL guidance given in this RCM Reference Document is an acceptable means to implement the requirements of 10 CFR 835. It is the intent that the LBNL RCM provide best practices methodologies to achieve the highest level of radiation protection. Such methodologies are more than is required to satisfy regulatory compliance. Implementation of the LBNL RCM would thus ensure full compliance with 10 CFR 835 requirements.

2. Ensure personnel responsible for performing radiological work activities are appropriately trained. Standards shall be established to ensure the technical competency of the LBNL radiological work force, as appropriate, through implementation of applicable and required radiological training.

3. Ensure the technical competence of personnel responsible for implementing and overseeing the Radiation Protection Program. An appropriate level of technical competence gained through education, experience, and job-related technical and professional training is a critical component for achieving the goals of LBNL radiation protection policy.

4. Establish and maintain, from the lowest to the highest levels, line management involvement and accountability for departmental radiological performance. The responsibility for compliance with 10 CFR 835 radiation protection requirements, and for minimizing personnel radiation
exposure, starts at the worker level and broadens as it progresses upward through the line organization. It is LBNL policy that line managers are fully responsible for radiological performance within their programs, and shall take necessary actions to ensure requirements are implemented and performance is monitored and corrected as necessary. The EH&S organization assists line management in fulfilling their EH&S responsibilities as well as providing necessary and sufficient radiation safety oversight through the various Radiation Protection Programs.

5. Ensure radiological measurements, analyses, worker monitoring results and estimates of public exposures are accurate and appropriately made. The capability to accurately measure and analyze radioactive materials and workplace conditions, and determine personnel radiation exposure, is fundamental to the safe conduct of radiological operations. This is accomplished through recognized accreditation processes, e.g., DOELAP, and through approved procedures which follow recognized industry and laboratory best practices.

6. Conduct radiological operations in a manner that controls the spread of radioactive materials and reduces exposure to the work force, the general public and the environment and that utilizes a process that seeks exposure levels as low as reasonably achievable. Radiological operations and activities should be planned to allow for the effective implementation of dose and contamination reduction and control measures.

7. Incorporate dose reduction, contamination reduction, and waste minimization features into the design of new facilities and significant modifications to existing facilities in the earliest planning stages. Wherever possible, facility design features should be directed towards controlling contamination at the source, eliminating airborne radioactivity, maintaining personnel exposure and effluent releases below regulatory limits and utilizing a process that seeks exposure levels and releases as low as reasonably achievable.

General Information

1. Purpose:

The DOE Radiological Control Manual was established to promulgate practices for the conduct of Department of Energy radiological control activities. The DOE Manual 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 Manual should be viewed by contractors as an acceptable technique, method or solution for fulfilling
their duties and responsibilities. The DOE Manual is not a substitute for Regulations; it is intended to be consistent with all relevant statutory and regulatory requirements. Some of the DOE Manual provisions, however, challenge the user to go well beyond minimum requirements. Contractually the DOE RCM was promulgated as an Order and set forth the requirements for radiological protection for DOE Contractors. With the acceptance of DOE Notice 441.1 as part of Contract 98, the Radiological Control Manual will no longer be an Order, but will become a Standard in the DOE documents system. As a Standard, methods and practices are only recommendations and are not proscriptive, enforceable requirements.

The LBNL Radiological Control Manual interprets the DOE RCM for use at LBNL. It is intended that radiological workers can readily utilize those practices that are applicable to LBNL as an acceptable way for implementing the requirements of 10 CFR 835. In addition, the RCM provides a reference to methodologies that radiological workers can use in achieving excellence in radiological protection over and above the minimum requirements of 10 CFR 835.

2. Usage

The LBNL Radiological Control Manual should be used as a Technical Reference Document It contains all of the 10 CFR 835 requirements and provides work practices that may be used to achieve compliance. In addition there have been several changes and additions to the DOE RCM Rev.1. Those areas that primarily described the DOE functions have been deleted or reduced in scope. It is the intent to make this document more user friendly and readily available by placing it on the WEB.

All requirements in 10 CFR 835 shall be complied with by LBNL Staff.

Those areas in the LBNL RCM shaded and bold italic contain selected requirements of 10 CFR 835 and methods by which compliance is achieved through the practices and implementation of LBNL radiological workers. These selected requirements (shaded areas) are those that the LBNL user will be most directly affected by and therefore, will have the most relevance to the user.

Those areas that are bold but not shaded are direct reference to 10 CFR 835 requirements and the LBNL RCM describes ways to implement directly or provides reference to the LBNL documents that have the implementing methods.
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PART 1 Radiological Control Manual, Technical Reference Document

110 Introduction

This Lawrence Berkeley National Laboratory Radiological Control Manual (LBNL RCM) has been prepared by Lawrence Berkeley National Laboratory (LBNL) to provide guidance for site-specific additions, supplements and interpretation of the DOE Radiological Control Manual. The guidance provided in this manual is one methodology to implement the requirements given in Title 10 Code of Federal Regulations Part 835 (10 CFR 835) and the DOE Radiological Control Manual. Information given in this manual is also intended to provide demonstration of compliance to specific requirements in 10 CFR 835.

The LBNL RCM (Publication 3113) and LBNL Health and Safety Manual Publication-3000 form the technical basis for the LBNL RPP and will be revised as necessary to ensure that current requirements from Rules and Orders are represented. The LBNL RCM will form the standard for excellence in the implementation of the LBNL RPP.

The system of identification of Articles used in the DOE RCM is retained where practical in the LBNL RCM. A copy of the current DOE RCM is available if requested. This document is arranged so that the user may readily identify important 10 CFR 835 requirements that require user compliance and implementation. All 10 CFR 835 requirements are incorporated and are bolded for user reference. The LBNL RCM presents an acceptable way to implement 10 CFR 835 requirements.

111 Radiological Control Policy (DOE 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.

The Department of Energy Radiological Control Policy shown below summarizes the elements of the Department of Energy Radiological
Health and Safety Policy and is intended to guide the actions of every person involved in radiological work throughout the Department.

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 DOE RCM Applicability and Control

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 Manual should be viewed by contractors as an acceptable technique, method or solution for fulfilling their duties and responsibilities.

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.
1. The provisions of the **DOE RCM apply as guidance** to DOE or DOE-funded activities performed at LBNL, where ionizing radiation or radioactive material is present or being used.

2. The provisions of the DOE RCM also apply as guidance in those cases where contractors or subcontractors are used to conduct DOE-funded radiological activities at non-DOE sites or facilities. The provisions of the DOE RCM are not binding upon activities at DOE sites that are mandated by legislation to be performed pursuant to an NRC license including activities certified by the NRC under section 1701 of the Atomic Energy Act.

4. The DOE RCM is a living document. DOE intends to review and update provisions on a periodic basis to incorporate lessons learned and suggestions for improvement. The Assistant Secretary for Environment, Safety and Health is responsible for this task. Recommendations to correct or improve the DOE RCM are encouraged and should be sent to the Radiological Control Program Advisor (Article 151) of the Secretarial Officer responsible for the affected work activity. Information copies should also be sent to the other members of the Radiological Control Coordinating Committee (Article 153). The 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.

6. The DOE RCM shall be kept current and should be entered into the contractor document control system. The Office of Environment, Safety and Health shall ensure that a current version of this Manual is maintained on the DOE Safety Performance Measurement System (SPMS).

7. 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 guidance on the proper course of action in the area of radiological control within the scope

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1 The term "Article" is used to reference portions or sections of this document. For ease of communications, portions of this document should be referred to as Articles. For example, the appropriate reference to the Article containing this footnote is Article 112.4(sic).
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 guidance.

2. The word "shall" identifies those elements and requirements that are requirements set forth in 10 CFR 835 or Orders accepted by the University of California, Contract 98, Appendix G.

3. The word "should" means an acceptable method to demonstrate compliance.

114 Site-Specific LBNL Radiological Control Manual

1. Since LBNL is a single contractor multiple facility site, LBNL has determined that a single site-specific radiological control manual is the most effective method of providing consistent guidance for implementation of specific requirements of the RPP. This LBNL RCM consists of clarifications and reference to 10 CFR 835 requirements and an acceptable methodology to achieve compliance. It is intended that the LBNL RCM address unique situations and provide more detailed and site specific direction.

2. Management policies, requirements, expectations and objectives for the LBNL Radiological Protection Program are clearly and unambiguously stated.

3. The LBNL RCM shall be kept current and entered into the LBNL document control system.

4. LBNL has one site RCM (PUB 3113)(Reference Document) and an integrated Health and Safety Organization.

5. Subcontractors shall comply with the LBNL Radiological Control Manual and PUB-3000 the LBNL, Health and Safety Manual.

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 Operations Office Manager. Controlled copies of such Manuals shall be provided to the lead Secretarial Officer.

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

8. The definitions of 10 CFR 835.2 have been incorporated into the revision and distribution of the LBNL RCM.

115 Application of Requirements

1. LBNL has organizations that generally meet the requirements presented in the DOE RCM. Titles such as Radiological Control Manager and Radiological Control Technician that are used in the DOE RCM may at LBNL be designated differently.

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

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<td>Radiological Control Manager</td>
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<td>Radiological Control Technician</td>
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<td>Radiological Control Technician</td>
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<tr>
<td>Radiological Awareness Reports System</td>
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</tr>
<tr>
<td>Radiological Worker Training (RW)</td>
<td></td>
<td>EH &amp; S 400 and other specific courses in radiation protection</td>
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</table>

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 potential of each LBNL facility. For example, a facility operation with
an annual collective effective dose equivalent of only sev-
eral hundred person mrem or that works with small quantities
of unsealed radioactive material, would not be expected to
have an ALARA program as formalized as for example the
Building 55/56 operations.

116 User Groups

1. LBNL has establish informal working associations that promote
dialogue among the Radiological Control/EH&S 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.

2. Examples of user groups are tritium, accelerators, and
research and development laboratory operations
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 Protection 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 Berkeley Site Office (BSO) Manager and the LBNL Deputy Laboratory Director Operations (DLD Operations) should have a basic knowledge of radiation, its effects and radiological control requirements. The DOE BSO Manager and the LBNL DLD Operations 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 should establish high standards for the performance of radiological control. These standards and management expectations should be frequently communicated to the workforce.

2. Senior managers should state in writing their firm commitment to a radiological protection program of the highest quality. 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 should ensure that orientation, training and indoctrination reinforce rules and guidelines for each worker to minimize radiation exposure and control radiological conditions, such as contamination.

4. Managers should hold workers and their supervisors accountable for radiological protection 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 Protection Program.

5. Senior managers should solicit feedback from their radiological protection professionals, line management and workers on radiological protection performance.
6. Senior managers should adopt and promote a positive attitude toward radiological protection 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 mind set throughout the organization.

8. Senior managers should 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 should review progress toward the goals at least quarterly.

9. A performance indicator program for measuring and trending the effectiveness of the radiological protection program against predetermined goals should be established and maintained.

10. The authority and responsibility to establish a comprehensive and effective radiological protection training program should be assigned to line managers and EH&S. Training, in most cases, should be provided by a dedicated training organization, but the responsibility for quality and effectiveness rests with 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 (LBNL 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 should 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 Environment Health & Safety Organization has to be developed and fostered. The workers should not look upon radiological controls as hurdles or restrictions to be bypassed.

4. EH&S 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 EH&S 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 listed below should be produced and displayed at appropriate access points and work areas.

TO MINIMIZE YOUR RADIATION EXPOSURE AND CONTROL RADIOACTIVE MATERIAL, OBSERVE THE FOLLOWING RULES:

OBEY

- Posted, written and oral radiological control instructions and procedures, including instructions on Radiological Work Permits.

- "Evacuate" and "stop work" orders from radiological control personnel promptly.
DO NOT

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

BE SURE TO

- Wear personnel monitoring devices where required by Radiological Work Permits, Radiological Work Authorizations, 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 EH&S Organization.
- 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 Authorizations, 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 radiological control personnel of alarming or faulty radiological control equipment (x7652).
- Notify radiological control 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 Personal Protective Equipment and Clothing to minimize the spread of contamination.

• Frisk or be frisked for contamination (excluding tritium) when entering an uncontaminated area after exiting posted Contamination, High Contamination or Airborne Radioactivity Areas and associated Radiological Buffer Areas and notify radiological control personnel (x7652) when contamination is found.

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 the following:

   a. Guidance on handling such personnel interactions
   b. Emphasis on being factual
   c. Fundamentals of communicating risks
   d. Importance of keeping management informed.

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 verify worker 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-through, including off-hours and weekends (where appropriate), are essential to reinforce management expectations to the work force.

5. Managers, supervisors and workers should 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 protection 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 protection 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 changes may occur 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 surveys in the course of work and as part of the requirements of the RWA and RWP radiological protection program. This process results in exposure savings and improved contamination control.

Specific examples of surveys that may be effectively performed by workers and result in 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 under an RWA or RWP. The performance of legal record surveys such as release surveys remains the responsibility of the EH&S Organization.

127 Critiques

It is LBNL'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 applied.

A formal critique 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 and Processing System (ORPS). 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 "shoot the messenger."

128 Facility Modifications and Radiological Design Considerations

1. Radiological control performance is affected by human performance and engineered design features. The LBNL RCM primarily addresses the way people operate and use existing facilities and sites. General design criteria for new
facilities and major modifications to existing facilities are contained in 10 CFR 835.1001(a & b) and DOE Order 6430.1A. These requirements specify that the primary methods for maintaining radiation exposure ALARA shall be physical design features (e.g., containment, remote handling, ventilation, and shielding). For specific activities where use of physical design features are demonstrated to be impractical, administrative controls and procedural requirements shall be used to maintain radiation exposures ALARA. In addition, the following radiological control design criteria are provided for new facilities and major modifications to existing facilities:

a. Individual worker dose shall be ALARA. Optimization methods shall be used to assure that occupational exposure is maintained ALARA in developing and justifying facility design and physical controls (10 CFR 835.1002(a)). The design objective for controlling personnel exposure from external sources of radiation in areas of continuous occupational occupancy (2000 hours per year) shall be to maintain exposure levels below an average of 0.5 mrem (5 microsieverts) per hour and as far below this average as is reasonably achievable. The design objectives for exposure rates for potential exposure to a radiological worker where occupancy differs from the above shall be ALARA and shall not exceed 20 percent of the applicable standards in 10 CFR 835.202 (10 CFR 835.1002(b)).

b. The design objectives for the control of airborne radioactivity shall be, under normal conditions, to avoid releases to, the workplace atmosphere and in any situation, to control the annihilation of such material by workers to levels that are ALARA; confinement and ventilation shall normally be used (10 CFR 835.1002(c)).

c. Efficiency of maintenance, decontamination, operations, and decommissioning shall be maximized (10 CFR 835.1002(d)).

d. Discharges of radioactive liquid to the environment are covered by the provisions of DOE 5400.5 and should not degrade the groundwater.

e. Control of contamination should be achieved by containment of radioactive material.

f. Components should be selected to minimize the buildup of radioactivity.

g. Support facilities should be provided for donning and removal of protective clothing and for personnel monitoring, when required.

h. Neutron quality factor of 20 for conditions of unknown spectra (or doubling of the neutron quality factor associated with known neutron energies) should be used.
for design purposes. Design analyses based on these neutron quality factors are intended to be used to estimate the additional construction cost that would result if the neutron quality factor was increased. The results of these analyses should be used to ascertain the economic feasibility for incorporating such modifications in the final design.

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 space that exists within an RMA should be free of radioactive material and posted accordingly.
PART 3 Improving Radiological Performance

131 Radiological Performance 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. Collective Dose (person-rem): This goal should be based upon planned activities and historical performance.

2. Skin and Personal Clothing Contamination Occurrences (number): Personnel contaminations as well as release of radioactivity outside radioactive materials areas may indicate a breakdown of controls intended to prevent the spread of contamination.

3. Intakes of Radioactive Material (number): Personnel intakes of radioactive material should be minimized and management should focus attention on any failure of the controls that results in intakes.

4. Contaminated Area Within Buildings (square feet): 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. Radioactive Waste (cubic meters): 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. Liquid and Airborne Radioactivity Released (curies): Minimizing effluents reduces the environmental impact of DOE operations and reduces the costs associated with remediation.

132 Management of Radiological Performance Goals

1. The LBNL DLD Operations should establish, approve and maintain a radiological performance goals program. Annual LBNL radiological ALARA performance goals are stated in Appendix 1B.

2. The performance goals should be measurable, achievable, auditable challenging, and meaningful in promoting improvement.
3. Goals need to be developed primarily by those responsible for performing the work.

4. Radiological performance 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 the DLD Operations for annual collective dose. This report is suggested to be monthly but should not be less frequent than quarterly. This report should include at least the radiological performance goals (LBNL site ALARA goals) established in accordance with Article 131. Examples of indicators that can provide a more detailed analysis of performance are identified in Table 1-1. These indicators may be used by EH&S for tracking and trending for the twelve-month period.

2. The 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.

3. To promote worker awareness of their radiation exposure status, selected indicators related to their work group should be posted in the workplace.
Table 1-1 Examples of LBNL Radiological Performance Indicators

Exposure control

a. Collective dose in person-rem
b. Average worker dose in rem
c. Maximum dose to a worker in rem
d. Number of unplanned exposures resulting in doses greater than the Administrative Control Level
e. Number of dose assessments for lost or damaged dosimeters

Personnel contamination

a. Number of skin and personal clothing contaminations
b. Number of contaminated wounds
c. Number of facial contaminations

c. Number of internal exposure

a. Number of new confirmed depositions
b. Number of airborne events
c. Number of alarms on airborne monitors (actual and false)

Control of contaminated areas in operational areas

a. Number of Contamination and High Contamination Areas
b. Area of Contamination Areas in square feet
c. Area of High Contamination Areas in square feet
d. Number of wipes in excess of Table 2-2 in areas that radioactive material is not anticipated.

Minimization of radioactive waste

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

Control of radioactive discharges

a. Activity of liquid radioactivity discharges in curies
b. Activity of airborne radioactivity discharges in curies

134 Assessments

Assessment, as used in this Manual, refers to the process of providing independent feedback to senior line managers to indicate the adequacy of the Radiological Protection Program (RPP).
needed in a good Radiological Protection Program: Internal audits of the Radiological Protection Program shall be conducted such that over a 3-year period, all functional elements are assessed for program performance, applicability, content and implementation (10 CFR 835.102). These should be performed by the EH&S Organization, the Quality Assurance Organization and other organizations. This requirement will reflect User and Line Management commitment to excellence in radiation worker protection.

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 protection 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 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 protection program and warrant particular attention. Due to the difficulty of measuring transuranic uptakes that result in low doses, specific actions are required to minimize the risks of internal exposure.

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 to avoid the routine use of respiratory protection devices. 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. Collecting representative airborne radioactivity samples and the time required for technicians or automated instruments to determine the airborne concentration of radionuclides may contribute to worker intakes 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 gamma's.

- 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

An ALARA Executive Committee has been established and meets at least annually. The membership includes managers and workers from the line, the technical support organization and the EH&S Organization. The ALARA Executive Committee should make recommendations to management to improve progress toward minimizing radiation exposure and radiological releases. The Committee should receive as minimum the recommendations, reviews and audits of the ALARA Working Committee and should review the overall conduct of the Radiological Protection Program (10 CFR 835.101(c)). It is more effective if a line manager, such as Director of Operations, Research, or Maintenance serves as the Chair.

An ALARA Working Committee has been established and meets at least quarterly. 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 review the results of all reviews and audits, both internal and external (10 CFR 835.101(c)).

The As-Low-As-Reasonably-Achievable (ALARA) process of reducing radiation exposures is a fundamental requirement of every radiological protection 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.
PART 4 LBNL Radiological Protection Organization

141 Radiological Protection Organization

1. A Radiological Protection Program, within the EH&S Organization should be established to provide relevant support to line managers and workers. To effectively function, the radiological programs within the EH&S 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 Protection Program within the EH&S Organization for LBNL should be sufficient. The senior EH&S manager responsible for operations at LBNL should have assigned dedicated radiological protection personnel. Consistency of radiological protection is critical. It is not the intent of this Manual to duplicate organizations but to use personnel in a more effective manner in workplace situations.

2. Radiological protection personnel shall monitor adherence to the requirements of 10 CFR 835 and be available to the facility line manager for radiological support to the workforce. To effectively function in this capacity, they should effectively respond to the day-to-day priorities of facility managers. To ensure independence in making correct radiological decisions, the radiological protection programs should be accountable to the EH&S Manager.

3. The Radiological Protection Program and is responsible for and should establish a high quality radiological protection program.

4. The Radiological Control Manager shall have access to the senior site executive for radiological protection matters.

142 Radiological Control Manager Qualifications

1. The Radiological Control Manager should be an experienced professional in radiological protection and be familiar with the design features and operations of the facility 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 protection programs and the supervisory capability to direct the implementation and maintenance of radiological protection 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 protection 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 consider providing 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 for the Radiological Protection Program 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 questionable or 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.
Workers through their supervisor also have 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 protection performance is less than adequate, performance must be improved. Consideration should be given to strengthening line management and the Radiological Protection Program staff 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 Protection 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

This section is to provide reference information about the DOE and the DOE RCM to LBNL Users

151 Program Office

1. 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 Secretarial Officer shall designate a person who can be the Program Office focal point on radiological control matters with the DOE Operations Office and applicable Field Office Managers, counterparts within DOE and the contractor organizations. This person is referred to in this Manual as the Radiological Control Program Advisor.

152 Operations Offices and Applicable Field Offices

1. Managers of Operations Offices and the Rocky Flats and Fernald Field Offices are responsible for the line management function of conducting day-to-day oversight of contractor activities, including monitoring the quality and performance of radiological work.

2. Managers of Operations Offices and the Rocky Flats and Fernald Field Offices 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 this Manual 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 Radiological Control Manual 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 Environment, Safety and Health carries out its responsibility to provide independent radiological control performance oversight, on behalf of the Secretary of Energy, through various means, including the following:

1. Uses the Radiological Control Manual as its basis document.

2. Assesses DOE Program, Operations, and applicable Field Office performance of their line management responsibilities for implementing and maintaining radiological controls as detailed in 10 CFR 835.

3. Assesses contractor performance against the requirements of 10 CFR 835.

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 Defense Programs, Energy Research, Environmental Restoration and Waste Management and Nuclear Energy along with representatives from the Offices of Environment, Safety and Health and Field Management. A charter for this committee shall be approved and its performance monitored by the Deputy Secretary. A Chairperson shall be designated by the Deputy Secretary and should be appointed for a minimum of one year.

2. The Radiological Control Coordinating Committee is expected to receive and review suggestions, concerns and comments from its individual members, Operations Offices and contractors. The Committee shall function in a collective manner to promote a consistent and uniform emphasis in the direction and implementation of this Manual. 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. Secretary and should be appointed for a minimum of one year.

4. Radiological Control Coordinating Committee meetings should include representatives from Operations 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 at a DOE site or facility are subject to and shall adhere to the provisions of 10 CFR 835.
PART 6 Summary of Responsibilities

161 Department of Energy

1. Assistant Secretary for Environment, Safety and Health (EH)
   a. Review and update RCM provisions and incorporate lessons learned and proposed changes for improvement by Contractors and DOE Field Offices.
   b. Promulgate and maintain the overall DOE policy and standards with regard to radiological health and safety. (153)
   c. Revise the RCM to incorporate corrections or improvements. (153)

2. Office of Environment, Safety and Health
   a. Provide independent oversight for radiological programs. (154)
   b. Assess DOE Program and Field Office performance of their line management responsibility in radiation protection and implementation of the DOE RCM. (154.2)
   c. Assess LBNL performance in radiological protection against the requirements of 10 CFR 835. (154.3)

3. Program Secretarial Officer (PSO)
   a. Establish and maintain radiological control programs for activities under their cognizance. (151.1)
   b. Assume accountability for quality and performance of radiological work performed at LBNL. (151.1)
   c. Designate a Radiological Control Program Advisor. (151.2)

4. DOE Operations Office Manager
   a. Conduct oversight of LBNL activities as line management. (152.1)
   b. Designate a person to provide Radiological Protection Program (RPP) oversight and act as contact and coordinator.

162 LBNL Senior Site Executive or Designee

1. Issue and endorse a site-specific RCM.

3. Maintain and keep in a document control system the LBNL RCM. (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. (132.4)

6. Have an established Radiological Protection Program. (141.1)

7. Ensure access by the Radiological Control Manager for radiological control matters. (141.4)

8. Hold line management accountable for implementation of the Radiation Protection 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 protection. (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 and track progress of radiological improvement. (121.8)

6. Ensure that a comprehensive and effective radiological protection training program is implemented (121.10)

7. Control contamination at site origin. (121.11)

8. Minimize radiation exposures to workers and the public. (121.11)

9. Produce and display the "Worker Responsibilities" rules at appropriate access points and work areas. (123)

10. Periodically monitor work areas, observe work practices, and identify radiological deficiencies and concerns. (125.4)
11. Involve workers in the development of procedures for performing radiological work. (125.5)

12. Encourage the work force to identify radiological control deficiencies and concerns and provide corrective action. (125.6)

13. Ensure that subcontractors and subcontracted employees are treated the same as LBNL staff, that they have comparable training, and that they meet the same requirements and expectations. (125.9)

14. Identify and correct, on a priority basis, conditions that could cause or promote the spread of contamination. (125.10)

15. 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)

16. Implement a self-assessment program and prioritize correct actions to resolve deficiencies. (134.3)

17. Address basic root causes in developing the corrective action plan (CAP) for assessment activities. (134.4)

18. Establish a Radiological Awareness System through Division Safety Committee.

19. Ensure that the EH&S Contamination Control Program is effective in reducing contamination and minimizing radiological areas. (136)

20. Plan work to avoid routine use of respiratory protective equipment. (136)

21. Reduce internal exposure to the minimum practical. (136)

164 Radiological Control Manager

1. Interpret the requirements of the RCM for line managers, workers and radiological protection staff.

2. Use performance indicators and performance measures as tools to inform and to provide focus for management on radiological protection program issues. (131)

3. Provide a periodic report to the LBNL DLD Operations on the status of the radiological performance goals. (133.1)
4. Use radiation exposure data and other pertinent information to evaluate the effectiveness of the radiological protection program.

5. Assist in functional audits for radiological protection of programs and internal audits of the Radiation Protection Program.

6. Be available to line managers for radiological support to the work force. (141.2)

7. Be responsible for assessing the quality of the Radiological Protection Program. (141.3)

8. Establish a continuing training program for the senior staff of the radiological protection organization. (143.1)

**165 ALARA Committees**

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 Protection Program. (138)

**166 Quality Assurance Organization**

1. Oversight of LBNL Assessment Program. (134.1)

2. Participate in LBNL RPP assessment

**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

EH&S Organizational Chart

Environment, Health & Safety Division
### Radiological ALARA Performance Goals FY 96

1. Annual Collective Personnel Exposure
   - < 6 person rem

2. Reportable radiological occurrences
   - < 5 per annum

3. Public Exposure Control Level
   - < 3.0 mrem
     (Pending approval)

4. Cubic meters of Radioactive Waste generated
   - < 20 m³
     (Pending approval)

5. Environmental Emissions from LBNL Normal Operations
   - (Pending Approval)
     - Liquid, Alpha (sanitary sewer): < 1.5x10⁻⁸ μci/ml
     - Liquid, Beta (sanitary sewer, excluding Tritium): < 5x10⁻⁸ μci/ml
     - Liquid, Beta (sanitary sewer, Tritium): < 2x10⁻⁵ μci/ml
     - Aerosol, Alpha: < 5x10⁻⁹ μci/ml
     - Aerosol, Beta (excluding Tritium): < 5x10⁻⁸ μci/ml
     - Aerosol, Beta (Tritium): < 125 curies
## Chapter 2 Radiological Standards

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<td>2-18</td>
<td></td>
</tr>
</tbody>
</table>
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 below the regulatory limits to administratively control and help reduce individual and collective radiation dose. In general, efforts to reduce individual dose should not be allowed to cause a concurrent increase in collective dose. These control levels are multi-tiered with increasing levels of authority required to approve higher Administrative Control Levels.

The committed effective dose equivalent is used to assign internal dose received by personnel at LBNL. The committed effective dose equivalent is the resulting sum of the committed dose equivalents calculated to various tissues in the body, each multiplied by the appropriate weighting factor to be received by a tissue or organ from internally deposited radionuclides over a 50-year period after intake (10 CFR 835.2).

Unless otherwise indicated, administrative, lifetime and special control levels and dose limits are stated in terms of the Total Effective Dose Equivalent which is the sum of the doses received from internal and external sources (10 CFR 835.203(a)).

211 Administrative Control Level

1. A DOE Administrative Control Level of 2,000 mrem per year per person is established for all DOE activities. Approval by the appropriate Secretarial Officer or designee shall be required prior to allowing a person to exceed 2,000 mrem.

2. The Administrative Control Level established by LBNL based upon an evaluation of historical and projected radiation exposures, work load and mission is 500 mrem (5 mSv). This control level is reevaluated annually. The choice of Administrative Control Level is based on LBNL ALARA Goals and programmatic work load and type.

3. For most facilities, an annual facility Administrative Control Level of 500 mrem or less should be challenging and achievable.

4. No person shall be allowed to go above the facility Administrative Control Level without the prior approval of the LBNL DLD Operations.
5. LBND uses Administrative Control Levels as one mechanism for implementation of 10 CFR 835.101 (c), ALARA Program.

Table 2-1 Summary of Administrative Control Levels

<table>
<thead>
<tr>
<th>Maximum Dose Equivalent (Annual)</th>
<th>mrem (msv)</th>
<th>Level/Approval Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Body</td>
<td></td>
<td>Operational Control Level/RWA or RWP</td>
</tr>
<tr>
<td>Skin and Extremity</td>
<td>1,000 (10)</td>
<td>LBNL Admin Level/ DLD Operations, Line Manager, Radiological Control Manager</td>
</tr>
<tr>
<td>Lens of Eye*</td>
<td>500 (5)</td>
<td>DOE Admin Level/ DOE/PSO</td>
</tr>
<tr>
<td>Any Organ*</td>
<td>1,000 (10)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>500 (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10,000 (100)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3,000 (30)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5,000 (50)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2,000</td>
<td></td>
</tr>
</tbody>
</table>

* Worker Exposures in these categories does not normally occur at LBNL.
** The administrative levels (20% of the limit) for extremities and lens of the eye were based on the assumption that non-stochastic effects would dominate as the consequence. Whole body and organ dose are based on potential for stochastic effects (10% of the limit).

212 Lifetime Control Level

1. To administratively control a worker's lifetime occupational dose, a Lifetime Control Level of \( N \) rem shall be established where \( N \) is the age of the person in years. Special Control Levels (Article 216) shall be established for personnel who have doses exceeding \( N \) rem.

2. The internal contribution to lifetime occupational dose from intakes prior to January 1, 1989, should be calculated in terms of either cumulative annual effective dose equivalent or committed effective dose equivalent. The internal contribution to lifetime occupational 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. All occupational exposure received during the current year shall be included when demonstrating compliance with Table 2-2 dose limits (10 CFR 835.202(a) & (b)). In the absence of formal
2. Radiological workers from other DOE or DOE contractor facilities may receive occupational exposure as a radiological worker if they:

   a. Have received documented radiation safety training, such as LBNL General Employee Radiological Training (GERT) (10 CFR 835.901(a)).
   
   b. Provide record of current Radiological Worker training (10 CFR 835.902).
   
   c. Receive site-specific Radiological Worker training at the facilities where they will be working.
   
   d. Provide their radiation dose records for previous years and written estimates, signed by the individual, for the current year.

3. Proposed use of the Planned Special Exposure (PSE) must meet all requirements specified in 10 CFR 835.204. PSE shall be considered only in extraordinary situations, when alternatives are unavailable or impractical, 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 Secretarial Officer for approval.
   
   b. The proposed activity has joint written approved by the Secretarial Officer and the Assistant Secretary for Environment, Safety and Health.
   
   c. The individuals dose from all previous planned special exposures and all does in excess of occupational dose limits shall be determined.

4. Emergency exposure limits are not Planned Special Exposure limits. Guidelines for emergency exposures are provided in Appendix 2A (10 CFR 835.1302).
The radiological worker dose limits provided in Table 2-2 also apply to general employees. However, general employees who have not completed Radiological Worker Training are not permitted unescorted access to any area in which they are expected to receive doses in excess of 100 mrem in one year (For example at LBNL this may include posted Radiation Area or greater or an RMA). General employees who have not received Radiological Worker training are not normally expected to exceed 100 mrem in a year (10 CFR 835.902).

Table 2-2 Summary of Dose Limits (10 CFR 835.202)

<table>
<thead>
<tr>
<th>TYPE OF EXPOSURE</th>
<th>ANNUAL LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiological Worker: Whole Body (Internal + external) (10 CFR 835.202(a)(1))</td>
<td>5 rem</td>
</tr>
<tr>
<td>Radiological Worker: Lens of Eye (10 CFR 835.202(a)(3))</td>
<td>15 rem</td>
</tr>
<tr>
<td>Radiological Worker: Extremity or skin (10 CFR 835.202(a)(4))</td>
<td>50 rem</td>
</tr>
<tr>
<td>Radiological Worker: Any organ or tissue (other than lens of eye) (10 CFR 835.202(a)(2))</td>
<td>50 rem</td>
</tr>
<tr>
<td>Declared Pregnant Worker: Embryo/Fetus (10 CFR 835.205(a))</td>
<td>0.5 rem per gestation period</td>
</tr>
<tr>
<td>Members of the Public: Whole Body (internal + external) (10 CFR 835.208)</td>
<td>0.1 rem</td>
</tr>
</tbody>
</table>

Notes:
1. Internal dose to the whole body shall be calculated as committed effective dose equivalent. The committed effective dose equivalent is the resulting sum of the committed dose equivalents calculated to various tissues in the body, each multiplied by the appropriate weighting factor to be received by a tissue or organ from internally deposited radionuclides over a 50-year period after intake (10 CFR 835.2). See Appendix 2B for the weighting factors to be used in converting organ dose equivalent to effective dose equivalent for the whole body dose (10 CFR 835.203(b)).
2. The annual limit of exposure to "any organ or tissue" is based on the committed dose to that organ or tissue resulting from internally deposited radionuclides over a 50-year period after intake plus any external effective dose equivalent to that organ during the year (10 CFR 835.2).
3. Exposures due to background, therapeutic and diagnostic medical procedures, and voluntary participation in medical research programs shall not be included in either occupational personnel radiation dose records or assessment of dose against the limits in this Table (10 CFR 835.202(c)).
4. See Appendix 2C for guidance on non-uniform exposure of the skin (10 CFR 835.205).
214 Visitor Dose Limit

Public visitors to DOE sites shall be limited to an annual radiation dose of 100 mrem from the sum of internal and external radiation sources (10 CFR 835.208).

215 Embryo/Fetus Dose Limits

After a female worker voluntarily notifies her employer in writing that she is pregnant, for the purposes of fetal/embryo dose protection, she is considered a declared pregnant worker. This declaration may be revoked, in writing, at any time by the declared pregnant worker (10 CFR 835.2).

1. The employer 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 work involving occupational exposure:
   a. The dose limit for the embryo/fetus from conception to birth (entire gestation period) is 500 mrem from the sum of exposures received from external sources, sources inside the mother, and sources inside the embryo/fetus (10 CFR 835.206(a)).
   b. Measures shall be taken to avoid substantial variation above the uniform exposure rate necessary to meet the 500 mrem limit for the gestation period. Efforts should be made to avoid exceeding 50 mrem per month to the declared pregnant worker (10 CFR 835.206(b)).

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 (10 CFR 835.206(c)).

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 contractor senior site executive should obtain advice from professionals in other disciplines such as human resources and legal in establishing Special Control Levels. The contractor senior site executive may wish to establish these Special Control Levels using a radiological health advisory group.
1. A Special Control Level for annual occupational exposure shall be established for each monitored 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 should allow the person's lifetime occupational dose to approach N rem as additional occupational exposure is received.

2. An employer should be attentive to special circumstances of employees, such as those undergoing radiation therapy, and establish Special Control Levels as appropriate.
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.

Appropriate controls shall be maintained and verified which prevent the inadvertent transfer of removable contamination to locations outside of radiological areas under normal operating conditions (10 CFR 835.404(b)). At LBNL the main methodology of achieving contamination control is worker adherence to good housekeeping, personal contamination surveys, release surveys and through controls specified in an RWA or RWP.

221 Personnel Contamination Control

1. Personnel exiting Contamination Areas, High Contamination Areas, Airborne Radioactivity Areas or Radiological Buffer Areas established for contamination control shall frisk for contamination as required by Article 338 (10 CFR 835.404(f)).

In addition at LBNL personnel exiting RMA's or having worked with radioactive material shall survey in accordance with the requirements of the RWA or RWP. These requirements do not apply to personnel exiting areas containing only radionuclides, such as tritium, that cannot be detected using hand-held or automatic frisking equipment.

2. Monitoring for contamination should be performed using frisking 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.

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 and 10 CFR 835.603. Controls shall be implemented commensurate with the physical and chemical characteristics of the
contaminant, the radio nuclides present, and the fixed and removable contamination (10 CFR 835.404(c)(2)).

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, reasonable efforts should be made to decontaminate an area before a coating is applied. A fixative coating should not be applied without the approval of the Radiological Control Manager.

3. The conditions for establishing and maintaining Fixed Contamination Areas exceeding the total radioactivity values specified in Table 2-3, include all of the following (10 CFR 835.404(d)):

a. Radiological surveys shall be routinely performed to detect contamination that may become removable over time (10 CFR 835.404(d)(3)).

b. A formal inventory shall be maintained of Fixed Contamination Areas.

c. Removable contamination levels shall be maintained below the applicable Table 2-3 values (10 CFR 835.404(d)(1)).

d. Markings indicating the status of the area shall be applied (10 CFR 835.404(d)(4) to the surface or at an access point, to provide warning and instructions, e.g., "Fixed Contamination, Notify Radiological Control Personnel Prior to Work". Signs, stencils, or other appropriate markings may be used in accordance with Article 231.2.

e. Markings shall be maintained in legible condition.

f. Appropriate administrative procedures shall be implemented to control areas of fixed contamination (10 CFR 835.404(d)(5)). Issues to be addressed should include access controls, fixative coatings, monitoring techniques and freq.

g. For fixative coatings, two layers of contrasting colors should be used to provide indication of wear and when a more fixative is required.

h. Dose rates shall be, for unrestricted access, an individual is not likely to receive an exposure greater than 100 mrem in a year (10 CFR 835.404(d)(2)).

i. Posting in accordance with Article 234 and 10 CFR 835.603 is not required, if conditions a through h of this article are met (10 CFR 835.404(e)).
4. 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.

5. 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. Derived Air Concentration (DAC) values from 10 CFR 835 Appendices A and C shall be used with this evaluation (10 CFR 835.209)

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 10 CFR 835.
Table 2-3 Summary of Contamination Values
(10 CFR 835 Appendix D)

<table>
<thead>
<tr>
<th>NUCLIDE (See Note 1)</th>
<th>REMOVABLE (dpm/100 cm²) (See Note 2&amp;4)</th>
<th>TOTAL (FIXED + REMOVABLE) (dpm/100 cm²) (See Note 3&amp;4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-natural, U-235, U-238 and associated decay products</td>
<td>1,000 alpha</td>
<td>5,000 alpha</td>
</tr>
<tr>
<td>Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-129</td>
<td>20</td>
<td>500</td>
</tr>
<tr>
<td>Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-125, I-126, I-131, I-133</td>
<td>200</td>
<td>1,000</td>
</tr>
<tr>
<td>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</td>
<td>1,000 beta-gamma</td>
<td>5,000 beta-gamma</td>
</tr>
<tr>
<td>Tritium, organic compounds, surfaces contaminated by HT, HTO and metal tritide aerosols</td>
<td>10,000</td>
<td>10,000</td>
</tr>
</tbody>
</table>

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 radionuclides exists, the limits established for the alpha- and beta-gamma-emitting radionuclides apply independently.

2. The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping the area with dry filter or soft absorbent paper while applying moderate pressure and then assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. For objects with a surface area less than 100 cm², the entire surface should be wiped, and the activity per unit area should be based on the actual surface area. Except for transuranics, Ra-226, Ac-227, Th-228, Th-230, Pa-231 and alpha emitters, it is not necessary to use wiping 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 1 square meter provided the maximum activity in any area of 100 cm² is less than three times the values in Table 2-3.

4. The values for tritium in the Table in Appendix B 10 CFR 835 are Reserved. In anticipation of the revision to 10 CFR 835 and because these values are generally accepted they have been incorporated in Table 2-3 at this time. If the user has any questions concerning the appropriate use of this Table contact the LBNL Radiological Control Manager at Ext. 4479.
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 approved by the DOE in compliance with 10 CFR 835.601(b) & (c), shall be used.

3. Signs shall be conspicuously posted at each access point (10 CFR 835.603), clearly worded, and, where appropriate, may include radiological control instructions (10 CFR 835.601(d)). 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." At LBNL accelerator areas interlocked for radiation protection shall be posted to reflect probable conditions on entry.

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 shall be identified in compliance with 10 CFR 835.603.

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. Postings at entrance points to areas of ongoing work activities controlled for radiological purposes should state basic entry requirements, such as dosimetry, Radiological Work Permit (RWP) or Radiological Work Authorization (RWA) and respiratory protection requirements.

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 should 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 (10 CFR 835.501(e)).**

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. **Each access point to a Controlled Area (10 CFR 835.2(a) & 602(a)), shall be posted, identifying it as a Controlled Area whenever radioactive materials or radiation fields which would require posting under Articles 234, 235 or 236 may be present in the area. Persons who enter only the Controlled Area without entering Radiation, Contamination, Airborne Radioactivity, Radioactive Materials, 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 (10 CFR 835.602(b)).** This selection should be approved by the DLD operations.

### 233 Posting Radiological Buffer Areas

Radiological Buffer Areas shall be established within Controlled Area to provide a secondary boundaries to minimize the spread of contamination and to limit doses to general employees who have not been trained as radiological workers. The need for Radiological Buffer Areas in conjunction with Radioactive Material 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 or Airborne Radioactivity Areas that are completely within Contamination Areas.

3. A Radiological Buffer Area established to limit exposure to external radiation should surround Radiation, High Radiation and Very High Radiation Areas. The boundary for the Radiological Buffer Area should be established to limit radiation doses to general employees to less than 100 mrem per year. Radiological Buffer Areas need not be posted for external exposure control if other posted boundaries provide equivalent employee protection.

4. Posting of Radiological Buffer Areas shall be in accordance with Article 231 and contain the wording "CAUTION, RADIOLOGICAL BUFFER AREA"

5. The need for Radiological Buffer Areas around Radioactive Material Areas, Soil Contamination Areas, and Underground Radioactive Material Areas should be evaluated based upon the potential for the spread of contamination.

Figure 2-1
Establishing Posted Areas

{Not included here.}

2-15
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 (10 CFR 835.501 and 603(a)).*

2. Dose rate measurements used for posting of Radiation Areas and High 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 need for posting Hot Spots. Measures taken to identify sources of elevated general area radiation levels while conducting routine radiation surveys should be sufficient to identify hot spot locations. Special surveys for the sole purpose of identifying hot spots should not be required.

4. A label marking the location of the Hot Spot should be placed on or as near the spot as practical. The provisions of Article 231.7 through 231.11 do not apply to the Hot Spot posting. Posting of Hot Spots is not required in areas with general area dose rates greater than 1 rem/hr.

5. The requirement for personnel dosimetry should be included on the sign.

6. The requirement for an RWP/RWA 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.
235 Posting Contamination, High Contamination and Airborne Radioactivity Areas

Table 2-4: Criteria for Posting Radiation Areas in accordance with 10 CFR 835.603(a), (b) & (c)

<table>
<thead>
<tr>
<th>AREA</th>
<th>DOSE RATE CRITERIA</th>
<th>POSTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation Area</td>
<td>&gt; 0.005 rem/hr and</td>
<td>&quot;CAUTION, RADIATION AREA&quot;</td>
</tr>
<tr>
<td></td>
<td>≤ 0.1 rem/hr [at 30 cm.]</td>
<td>&quot;Personnel Dosimeter Required for Entry&quot;</td>
</tr>
<tr>
<td>High Radiation Area</td>
<td>&gt; 0.1 rem/hr [at 30 cm.] and ≤ 500 rad/hr [at 100 cm.]</td>
<td>&quot;DANGER, HIGH RADIATION AREA&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;Personnel Dosimeter, Supplemental Dosimeter and RWP Required for Entry&quot;</td>
<td></td>
</tr>
<tr>
<td>Very High Radiation Area</td>
<td>≥ 500 rad/hr [at 100 cm.]</td>
<td>&quot;GRAVE DANGER, VERY HIGH RADIATION AREA&quot;</td>
</tr>
<tr>
<td></td>
<td>&quot;SPECIAL CONTROLS REQUIRED FOR ENTRY&quot;</td>
<td></td>
</tr>
</tbody>
</table>

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

1. **Areas shall be posted to alert personnel to the presence of contamination in accordance with Table 2-5 and Article 231 (10 CFR 835.404(c) and .501).**

2. The requirement for an RWP or RWA should be included either on or in conjunction with each posting as applicable.

3. Derived Air Concentration (DAC) values for use with Table 2-4 are found in 10 CFR 835 Appendix A, and are used for posting Airborne Radioactivity Areas.
Table 2-5 Criteria for Posting Contamination, High Contamination and Airborne Radioactivity Areas in accordance with 10 CFR 835.503(d), (e) & (f)

<table>
<thead>
<tr>
<th>AREA</th>
<th>CRITERIA</th>
<th>POSTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contamination</td>
<td>Contamination levels (dpm/100 cm²) &gt; 1 time but &lt; 100 times Table 2-2 values</td>
<td>&quot;CAUTION, CONTAMINATION AREA&quot;</td>
</tr>
<tr>
<td>High Contamination</td>
<td>Contamination levels (dpm/100 cm²) &gt; 100 times Table 2-2 values</td>
<td>&quot;DANGER, HIGH CONTAMINATION AREA&quot; &quot;RWP Required for Entry&quot;</td>
</tr>
<tr>
<td>Fixed Contamination</td>
<td>Removable Contamination &lt; Table 2-3 levels Total Contamination &lt; Table 2-3 column 3 levels</td>
<td>&quot;Caution, Fixed Contamination&quot;</td>
</tr>
<tr>
<td>Soil Contamination</td>
<td>Contaminated soil not releasable in accordance with DOE 5400.5</td>
<td>&quot;Caution, Soil Contamination Area&quot;</td>
</tr>
<tr>
<td>Airborne Radioactivity</td>
<td>Concentrations (Ci/cc) &gt; 10% of any DAC value</td>
<td>&quot;CAUTION, AIRBORNE RADIOACTIVITY AREA&quot; &quot;RWP Required for Entry&quot;</td>
</tr>
</tbody>
</table>

236 Posting Radioactive Material Areas

1. Areas where radioactive materials are used, handled or stored should be posted "CAUTION, RADIOACTIVE MATERIAL." At LBNL "Radioactive Material Area" is also used for posting the area where radioactive material is located. The posting shall meet the requirements in Article 231.

2. Radioactive Material Areas should be located within Controlled Areas.

3. Radioactive Material Areas are not required when the radioactive material in any one location:

   a. Consists of ten or less sealed sources with half-lives less than 30 days or activities less than those specified in Table 1 of DOE N 5400.9 (Extended by DOE N 5400.10)

   b. Is inside a contamination, high contamination, or Airborne
4. The definition of radioactive material and the requirements for labeling radioactive material are contained in Chapter 4

237 Posting Underground Radioactive Material Areas

1. Underground Radioactive Material 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 Areas shall be posted "UNDERGROUND RADIOACTIVE MATERIAL." Posting should include instructions or special warnings to workers such as "Consult With Radiological Control Organization Before Digging" or "Subsurface Contamination Exists." The posting shall meet the applicable requirements of Article 231.

3. Underground Radioactive Material Areas may be located outside Controlled Areas unless access is likely to result in individual doses greater than 100 mrem/year in a year from underground radioactive material.

4. Underground Radioactive Material Areas are exempt from the entry and exit requirements of Chapter 3 when access is not likely to result in individual doses greater than 100 mrem in a year. Article 333.1 provides entry requirements when access is likely to result in individual doses greater than 100 mrem in a year.

238 Posting Soil Contamination Areas

1. For areas with contaminated soil that is not releasable in accordance with DOE Order 5400.5, a Soil Contamination Area should be established that is posted in accordance with the requirements in Article 231.1 through 231.8. Posting should include the wording "Caution Soil Contamination Area" and instructions or special warnings to workers, e.g., "Consult With Radiological Control Personnel Before Digging" or "Subsurface Contamination Exists."

2. Soil Contamination Areas may be located outside Controlled Areas if exposure to the material in the area is not likely to cause an individual to receive a dose in excess of 100 mrem in a year.
PART 4 Accidents and Emergencies

241 General Provisions (10 CFR 835.1301)

1. A general employee whose occupational exposure has exceeded any of the limits specified in 10 CFR 835.202 or 205 may be permitted to return to work in radiological areas during the current year providing:
   a. Approval is obtained from LBNL management and Program Secretarial Officer
   b. Individual receives counseling on consequences of receiving additional occupational exposure
   c. The employee agrees to return to radiological work.

2. All exposures exceeding the limits specified in 10 CFR 835.202 or 205 shall be recorded in accordance with 10 CFR 835.702, and in accordance with Departmental requirements for occurrence reporting and processing.

3. Operations after an emergency or accidental exposure in excess of the limits specified in 10 CFR 835.202 or 205 may be resumed only with the approval of the DOE.

242 Emergency Exposures (10 CFR 835.1302)

1. The risk of injury to those individuals involved in rescue and recovery operations shall be minimized.

2. Operating management shall weigh actual and potential risks to rescue and recover individuals against the benefits to be gained.

3. Rescue action that might involve substantial risk shall be performed by volunteers.

4. The dose limits for individuals performing these operations are given in Appendix 2A. (10 CFR 835.1302(d).

5. Each individual selected shall be trained in accordance with 10 CFR 835.902 and briefed beforehand of the know or anticipated hazards to which the individual will be subjected.
Part 5 Summary of Responsibilities

251 Department of Energy

1. Program Secretarial Officer (PSO)
   a. provide prior approval for any individual exceeding 2000 mrem in one year (211.1).
   b. approve each use of the 10-rem Planned Special Exposure (10 CFR 835)

2. Assistant Secretary for Environment, Safety and Health (EH) approve each use of the 10-rem Planned Special Exposure (10 CFR 835.204(a)(3)).

3. Oakland Operations Office approve the type of sign used for posting radiological and Controlled Areas (10 CFR 835.601(b)).

252 Senior Site Executive and Associate Laboratory Director for Operations

1. Establish an annual facility Administrative Control Level and reevaluate annually (211.4).

2. Provide prior approval for any individual exceeding the facility Administrative Control Level (211.4).

3. Submit each proposed use of the 10-rem Planned Special Exposure to the lead PSO for approval (10 CFR 835.204(a)(2)).

4. Establish Special Control Levels for use in special circumstances (216).

5. Approve the type of sign used to post Controlled Areas (232.2).

253 Line Management

1. Establish a Lifetime Control Level of N rem to control a worker’s lifetime occupational radiation exposure (212.1).

2. Establish Special Control Levels for personnel who have exceeded N rem lifetime dose (212.1).
254 Radiological Control Manager

1. Review each proposed use of the 10-rem Planned Special Exposure (213.3a).

2. Approve the application of fixative coatings for contamination control (222.2).

3. Provide prior approval for any individual exceeding the facility Administrative Control Level (211.4).

255 Employees

1. Notify the Dosimetry Office of medical exposures to radiation or radioactive material or accidental exposure of dosimeters to medical radiation sources for compliance with 10 CFR 835.202(c). (216.3, 4)

2. Conduct personal monitoring when exiting Contamination Areas, High Contamination Areas, Airborne Radioactivity Areas, Radioactive Materials Areas, or Radiological Buffer Areas (10 CFR 835.404(f)).

3. Verify operability of hand-held survey instrument or automatic personnel contamination monitor prior to use (10 CFR 835.401(c)(4)).
Appendix 2A

Guidelines for Control of Emergency Exposures (10 CFR 835.1302)

In extremely rare cases, emergency exposure to radiation may be necessary to rescue personnel or to protect major property. Emergency exposures may be authorized in accordance with the provisions contained in 10 CFR 835.1302. These doses are in addition to and accounted for separately from the doses received under the limits in Table 2-2. and 10 CFR 835.202 and 205. The dose limits for personnel performing these operations are listed below.

<table>
<thead>
<tr>
<th>DOSE LIMIT (Total Effective Dose Equivalent)</th>
<th>ACTIVITY PERFORMED</th>
<th>CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 rems All</td>
<td></td>
<td>Only on a voluntary basis where lower dose limit not practicable</td>
</tr>
<tr>
<td>10 rems Protecting major property</td>
<td></td>
<td>Only on a voluntary basis where lower dose limit not practicable</td>
</tr>
<tr>
<td>25 rems Lifesaving or protection of large populations</td>
<td></td>
<td>Only on a voluntary basis to personnel fully aware of the risks involved</td>
</tr>
<tr>
<td>&gt;25 rems Lifesaving or protection of large populations</td>
<td></td>
<td>Only on a voluntary basis to personnel fully aware of the risks involved</td>
</tr>
</tbody>
</table>

Notes:

1. The lens of the eye dose limit should be three times the listed values.

2. The shallow 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 (10 CFR 835.2)

<table>
<thead>
<tr>
<th>ORGANS OR TISSUES</th>
<th>WEIGHTING FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonads</td>
<td>0.25</td>
</tr>
<tr>
<td>Breasts</td>
<td>0.15</td>
</tr>
<tr>
<td>Red bone marrow</td>
<td>0.12</td>
</tr>
<tr>
<td>Lungs</td>
<td>0.12</td>
</tr>
<tr>
<td>Thyroid</td>
<td>0.03</td>
</tr>
<tr>
<td>Bone surfaces</td>
<td>0.03</td>
</tr>
<tr>
<td>Remainder</td>
<td>0.30</td>
</tr>
<tr>
<td>Whole Body</td>
<td>1.00</td>
</tr>
</tbody>
</table>

10 CFR 835.2(b) 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, spleen, thymus, adrenal, 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.

3. For the case of uniform external irradiation of the whole body, a weighting factor equal to 1 may be used in the determination of the effective dose equivalent (10 CFR 835.203(c)).
Non-Uniform Exposure of the Skin (10 CFR 835.205)

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:

<table>
<thead>
<tr>
<th>AREA OF SKIN IRRADIATED</th>
<th>METHOD OF AVERAGING, ADDING TO OTHER DOSES RECEIVED, AND RECORDING NON-UNIFORM SKIN DOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 100 cm²</td>
<td>Averaged over the 100 cm² of skin receiving the maximum dose</td>
</tr>
<tr>
<td></td>
<td>Added to any uniform dose equivalent also received by the skin</td>
</tr>
<tr>
<td></td>
<td>Recorded as the annual extremity or skin (shallow) dose equivalent (H)</td>
</tr>
<tr>
<td>≥ 10 cm² and &lt; 100 cm²</td>
<td>Averaged over the 1 cm² of skin receiving the maximum dose (D), reduced by the fraction (f) which is the irradiated area in cm² divided by 100 cm² (i.e., H=fD)</td>
</tr>
<tr>
<td></td>
<td>Added to any uniform dose equivalent also received by the skin</td>
</tr>
<tr>
<td></td>
<td>Recorded as the annual extremity or skin (shallow) dose equivalent</td>
</tr>
<tr>
<td>&lt; 10 cm²</td>
<td>Averaged over the 1 cm² of skin receiving the maximum dose</td>
</tr>
<tr>
<td></td>
<td>Not added to any other dose equivalent, extremity or shallow dose equivalent (skin) recorded for the annual dose equivalent</td>
</tr>
<tr>
<td></td>
<td>Recorded in a person's radiation dose record as a special entry</td>
</tr>
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</table>
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 design, construction, modifications, operations, maintenance and decommissioning, shall incorporate radiological criteria to ensure safety and maintain radiation exposures ALARA. For ALARA to be effective, consideration should be given to both individual as well as collective dose.

The primary methods to maintain exposures ALARA shall be facility and equipment design features. These physical features may be augmented by administrative and procedural requirements to maintain radiation exposure ALARA (10 CFR 835 .1001(a) & (b)).

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 Design, Maintenance, Operations and Modifications

1. Design, 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 EH&S Division.

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 LBNL RCM trigger levels requiring formal radiological review of nonroutine or complex work activities.
   a. Estimated individual or collective dose greater than 1000 mrem (10 mSv).
   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 2-3
   d. Entry into areas where dose rates exceed 1 rem in an hour.
e. Potential radioactive releases to the off-site 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 the following:

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. 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 dose to be incurred for the job
o. Provisions for waste minimization and disposal.
p. Review of potential accident situations or "unusual occurrences".

5. Radiological requirements identified as part of the above radiological review should be documented in the job plans, procedures or work packages.

6. Radiological work anticipated to exceed individual or collective dose criteria established in the LBNL RCM should be reviewed and approved by the ALARA Committee.

7. Optimization methods shall be used to assure that occupational exposure is maintained ALARA in developing and justifying facility design and physical controls (10 CFR 835.1002(a)). These techniques, including cost-benefit analysis, represent a fundamental part of radiological design analysis and work review. For review of
minor activities or design modifications 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 or facilities 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 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 should be controlled by procedure.

2. The effects of the additional weight of temporary shielding on systems and components should 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 should be visibly marked or labeled with the following or equivalent wording: "Temporary Shielding - Do Not Remove Without Permission from the Radiological Control Manager."

6. Installed temporary shielding should be periodically evaluated to assess the need for its removal or replacement with permanent shielding.

7. Shielding used as part of bench-top activities (e.g., vial shields, shadow shields used in fume hoods, etc.) are exempt
from the recommendations of this article requirement unless specifically addressed in the RWA or RWP.

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 EH&S Organization.

3. Radiological Control Hold Points should be incorporated into technical work documents for steps that require action by the EH&S Division 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. Physical Design Features and Engineering controls, (e.g., containment of radioactive material at the source wherever practicable), shall be the primary method of minimizing airborne radioactivity and internal exposure to workers (10 CFR 835 1001(a)).

2. Administrative controls (10 CFR 835.1001(b)), which may include, but are not limited to access restrictions and the use of specific work practices designed to minimize airborne radioactivity, shall be used only as a 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 should be used to limit internal exposures. Use of respiratory protection should 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 2-3
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. The use of positive pressure respiratory protection devices is recommended wherever practicable to alleviate fatigue, and increase comfort and protection.

5. In specific situations the use of respiratory protection may limit or reduce worker radiological safety due to physical limitations or the potential for significantly increased external exposure. In such situations, a formal ALARA review should be conducted in accordance with Article 312 to ensure measures are implemented to assess all available options, monitor and minimize worker Effective Dose Equivalent, and provide for follow-up dose assessment, as required. 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 review 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 and Radiological Work Authorization Programs. LBNL implementation of documenting the radiological conditions in the workplace (10 CFR 835.401)

The Radiological Work Permit (RWP) program 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 Radiological Work Authorization (RWA) program is an administrative mechanism used to authorize individuals to work with specified radionuclides and quantities. At LBNL the PI and/or user requests an RWA in writing to the RWA Program Manager. The approved RWP and RWA should include, but not limited to the following information:

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

Access controls for radiological areas shall be established according to Appendix 3B (10 CFR 835.501).

1. RWP/RWA 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. RWP/RWA shall be used to control the following activities:
   a. Entry into Radiation Areas
   b. Entry into Contamination Areas
   c. Handling of materials with removable contamination that exceed the values of Table 2-3.

3. RWPs may 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. RWPs should not be approved for periods longer than 1 year.

4. RWAs may be used to control routine or repetitive activities, such as research work activities using radioactive material in areas with well-characterized and stable radiological work conditions. RWAs should not be approved for periods longer than 1 year.

5. Radiological surveys should be routinely reviewed to evaluate adequacy of RWP/RWA requirements. RWP/RWA shall be updated if radiological conditions change to the extent that protective requirements need modification.

6. RWP should be posted at the access point to the applicable radiological work area. At LBNL RWA's are normally maintained in the Radioisotope Journal.

7. Workers shall acknowledge by signature or through electronic means where automated access systems are in place that they have read, understand and will comply with the RWP/RWA prior to initial entry to the area and after any revisions to the RWP/RWA.

8. Worker pocket or electronic dosimeter readings should be recorded in a format that identifies and provides linkage to the applicable RWP or RWA.
9. An alternative formal mechanism, such as, written procedures or experiment authorizations, may be used in lieu of an RWP/RWA 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 and Work Authorization 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. The Principal investigator for the research activity shall institute in writing a request for an RWA or an amendment to an existing RWA to the RWP Program Manager.

2. RWPs shall be reviewed and approved by the RWP program manager. RWAs shall be reviewed by the RWA Program Manager and approved by the Radiological Control Manager and the Cognizant Line Manager.

3. The RWP shall be based on current radiological surveys and anticipated radiological conditions.

4. The RWP & RWA shall be approved by the supervisor responsible for the work or area and the RWP program manager and Radiological Control Manager respectively. Revisions or extensions to RWPs & RWAs shall be subject to the same approval process.

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. 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 2-3 levels
   b. Work in Contamination, High Contamination and Airborne Radioactivity Areas (10 CFR 835.404(g)).
   c. As directed by the EH&S Organization or as required by the RWP or RWA.

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. Note: Dress-out areas are not normally encountered during routine activities at LBNL.

4. Personal Protective Equipment and Clothing shall be selected as prescribed by the controlling RWP or RWA. General guidelines for protective clothing selection and use are provided in Appendix 3C and in Table 3-1.

5. The use of labcoats 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. Labcoats should not be used as protective clothing for performing physical work activities in Contamination, High Contamination or Airborne Radioactivity Areas.
6. Instructions for donning and removing protective clothing should be posted at the dress-out and step-off pad areas. Note: Dress-out areas are not normally encountered during routine activities at LBNL.

7. The use of Personal Protective Equipment or Clothing (including respiratory protection) beyond that authorized by the EH&S 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

Personnel entry controls shall be maintained for each radiological area in accordance with Appendix 3E (835.501).

331 Controlled Areas

All general employees shall be trained in radiation safety (such as GERT) prior to receiving any occupational radiation exposure (10 CFR 835.901(a)). Successful completion of Visitor Orientation or General Employee Radiological Training (GERT) is required for unescorted entry into Controlled Areas.

332 Radiological Buffer Areas

1. Minimum requirements for unescorted entry into Radiological Buffer Areas shall include the following:
   a. Radiological Worker training
   b. Personnel dosimetry, as appropriate.

2. Personnel who exit a Radiological Buffer Area containing Contamination Areas, High Contamination Areas, or Airborne Radioactivity Areas should monitor as specified in Article 338.

333 Radioactive Material Areas

1. Radiological Worker training shall be required for unescorted entry into Radioactive Material Areas containing either of the following:
   a. Sealed radioactive sources
   b. Radioactive material labeled and packaged in accordance with Articles 412 and 413.

2. Entry into Radioactive Material Areas where whole body dose rates exceed 5 mrem/hr or removable contamination levels exceed Table 2-3 values shall be in accordance with the requirements of Articles 334.1 and 335.1, respectively.
334 Radiation, High Radiation and Very High Radiation Areas

1. Minimum requirements for unescorted entry into Radiation Areas shall include the following:
   a. Radiological Worker training
   b. Worker's signature on the Radiological Work Permit (RWP) or Radiological Work Authorization (RWA), as applicable
   c. Personnel dosimetry.

2. Physical controls to prevent inadvertent or unauthorized access to High and Very High Radiation Areas shall be maintained in accordance with Appendix 3B (835.501).

3. Minimum requirements for unescorted entry into High Radiation Areas shall include the following:
   a. Radiological Worker training with High/Very High Radiation Area access training (in accordance with Article 632.5) and training in the use of a survey meter (or dose rate indicating device), as described in Article 126
   b. Worker's signature on the RWP or RWA.
   c. Personnel and supplemental dosimeters (10 CFR 835.402(a)(4)).
   d. Survey meter or dose rate indicating device available at the work area (10 CFR 835.403(b)).

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 1 rem in one hour shall include those items listed in Article 334.3 and the following:
   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 EH&S 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 (10 CFR 835.502(B)).

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 of radiation 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 and Very High Radiation Areas.

8. The EH&S Organization should maintain an inventory of High and Very High Radiation Areas.

9. Weekly inspections of the physical access controls to High and Very High Radiation Areas should be made to verify controls are adequate to prevent unauthorized entry.

10. Administrative procedures shall be developed as necessary to implement area access controls. These procedures shall address measures implemented to ensure the effectiveness and operability of entry control devices, such as barricades, alarms, and locks (10 CFR 835.501(d)).

335 Contamination, High Contamination and Airborne Radioactivity Areas

1. Minimum requirements for unescorted entry into Contamination Areas shall include the following:
   a. Radiological Worker (EH&S 400) and radiological training for laboratories (EH&S 432).
   b. Worker's signature on the RWP or RWA, as applicable
   c. Protective clothing (10 CFR 835.404(g)).
   d. Personnel dosimetry, as appropriate.

2. Minimum requirements for unescorted entry into High Contamination or Airborne Radioactivity Areas shall include the following:
   a. Radiological Worker training
   b. Worker's signature on the RWP or RWA
   c. Protective clothing (10 CFR 835.404(g)), and respiratory protection when specified by the RWP or RWA
   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. **When entering an uncontaminated area, perform** whole body frisking to detect personnel contamination in accordance with Article 338 (10 CFR 835.404(f)).

4. Exit points from Contamination, High Contamination or Airborne Radioactivity Areas should include the following:
   a. Step-off pad located outside the exit point, contiguous with the area boundary (Note: at LBNL step-off pads are not routinely found because there are currently no designated contamination areas.)
   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. (Note: at LBNL step-off pads are not routinely found because there are currently no designated contamination areas.)

6. Protective clothing and monitoring requirements specific to benchtop work, laboratory fume hoods, sample stations and gloveboxes are identified in Article 347.

7. Tools or equipment being removed from areas posted for surface or airborne radioactivity control shall be monitored for release in accordance with Article 421 or for retention in the contaminated tool crib in accordance with Article 442.5.

8. **Administrative procedures shall be developed as necessary to implement area access controls. These procedures shall address measures implemented to ensure the effectiveness and operability of entry control devices, such as barricades, alarms, and locks (10 CFR 835.501(d)).**
Visitor Entry Requirements

1. LBNL has issued policy and procedures to identify area entry requirements and access restrictions for visitors, e.g., PUB 3000, Chapter 21-24, and ALS Procedure HP 02-01 Rev 2.

2. Visitors with a demonstrated need to enter the following areas may be allowed access if such access is controlled with training such as GERT (10 CFR 835.901(a)), or facility specific safety briefings and the use of escorts trained for the specific area:
   a. Radiological Buffer Areas
   b. Radiation Areas
   c. Contamination Areas
   d. Radioactive Material Areas

3. Visitors may enter Controlled Areas unescorted if they have completed GERT training (10 CFR 835.901(a)).

4. Visitors shall be prevented from entering Very High Radiation Areas in accordance with Article 334.5 and should be prohibited access to High Radiation, High Contamination and Airborne Radioactivity Areas.

5. Additional training/orientation requirements for visitors are identified in Articles 622 and 657.

Controlling the Spread of Contamination

The following measures may be used in part to implement the requirements of 10 CFR 835.404(b) and 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

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 and under the following conditions:
   a. Immediately upon entry into an uncontaminated area after exiting Contamination Areas, High Contamination Areas and Airborne Radioactivity Areas (10 CFR 835.404(f)).
   b. As directed by the RWP, RWA or the EH&S 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 frisk. This frisk is optional if the Radiological Buffer Area exit is immediately adjacent to the location where the exiting worker has already performed a whole body frisk.

3. Where frisking 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 frisk.

4. Personnel frisking shall be performed after removal of protective clothing and prior to washing or showering.

5. Personnel frisking shall be performed using instruments that meet the minimum detection requirements of Article 221.2. Guidelines for personnel frisking are provided in Appendix 3D.

6. The use of automated personnel contamination monitors is encouraged.

7. Personal items, such as notebooks, papers and flashlights, shall be subject to the same frisking requirements as the person carrying them.

8. Instructions for personnel frisking should be posted adjacent to personnel frisking instruments or monitors.

9. The personnel frisking 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 frisking 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 preestablished 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, 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 EH&S 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, or chewing 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 Technicians (RCT) 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 Technicians should review logs and receive a turnover briefing from the personnel they are relieving.

3. Communication systems required by the RWP, RWA or technical work document, should be checked for operability before being brought into the work area and periodically during work.

4. Workers should keep EH&S personnel responsible for radiological protection 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. RCT's and health physicists 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 EH&S 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 or designee.

346 Response to Abnormal Situations

1. The LBNL RCM or procedures for responding to abnormal situations shall establish requirements for alarm response procedures. Site alarm response procedures should address the general actions in items 2 through 6 below, modified as necessary to reflect specific facility conditions.

2. Response to a Continuous Air Monitor alarm should 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, should include the following actions:
   a. Stop work activities
   b. Alert others
   c. Affected personnel immediately exit the area
   d. Notify EH&S personnel.

4. Response to a criticality alarm
   Note: LBNL does not currently have criticality alarms nor the existence of criticality conditions.

5. Response to a personnel contamination monitor alarm should 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.

6. Response to a spill of radioactive material should 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 EH&S personnel.

   For spills involving highly toxic chemicals, workers should immediately exit the area without attempting to stop or secure the spill. They should then promptly call x7911

347 Controls for Benchtop Work, Laboratory Fume Hoods, and Gloveboxes

The following requirements are applicable to radiological work [which has the potential to generate radioactive contamination] in localized benchtop areas, laboratory fume hoods, sample stations and glovebox operations located in areas that are otherwise contamination free.

1. A Radiological Work Permit (RWP) or Radiological Work Authorization (RWA) should 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 labcoats and gloves. Gloves should be secured at the wrist as necessary.
   b. Shoe covers should be considered based on the potential for floor contamination.
   c. Workers should periodically monitor their hands 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 frisk.

3. The following controls apply to glovebox operations:
   a. Gloveboxes should be inspected for integrity and operability 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. Shoe covers should be considered based on the potential for floor contamination.
   e. Workers should periodically monitor their hands during work.
   f. 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 feet. Workers should perform a whole body frisk.

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. The LBNL RCM defines hot particles, as those capable of producing a shallow dose equivalent greater than 100 mrem in one hour, specific to facility operations and source terms.
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 EH&S 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 Technician 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 hot particle areas 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 the following:
   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 which 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 should be evaluated to identify and incorporate appropriate lessons learned.

Analysis of the facts should reveal areas where improvements can be made or where methods can be identified 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 evolution's or events may require multiple critiques.

352 Post-Job Reviews

Performance should be reviewed after completion of nonroutine radiological work. Requirements for post-job reviews should follow the elements in Article 351.4

353 Lessons Learned

Lessons learned are available from post-job reviews and reports of past radiological events on site and at other facilities. The EH&S Organization, in conjunction with line management, should evaluate lessons learned, provide prompt distribution, and incorporate the lessons into the LBNL Site Radiological Protection 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 Site-Specific 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 through 363 of this Part are applicable to those facilities where the majority of the work or operations involve the subject radionuclide as the significant source term. This Part is not intended to apply to facilities that use the subject radionuclides in limited or tracer amounts, such as analytical laboratories.

361 Plutonium Operations

There is the perception that exposure to small quantities of plutonium presents greater risk than exposure to other radionuclides. Low levels of plutonium in the body are difficult to measure and biological removal processes for plutonium are slow. For these reasons:

1. Primary emphasis shall be placed on engineered features to contain plutonium and to prevent airborne and surface contamination.

2. In addition to the provisions of this Manual, guidance contained in the document, "Health Physics Manual of Good Practices for Plutonium Facilities," PNL-6534, should be considered for plutonium operations in preparing the Site-Specific Radiological Control Manual. This manual provides specific guidance related to dosimetry, radiological monitoring, instrumentation, contamination control, and applicable radiological control procedures.

362 Uranium Operations

Natural, depleted, and low-enriched uranium are unusual in that their chemical toxicity is more limiting in the human body than their radioactivity. Also, processed uranium sometimes contains transuranic and other radionuclides from recycled materials.

For these reasons, in addition to the provisions of this Manual, the guidance contained in the document, "Health Physics Manual of Good Practices for Uranium Facilities," EG&G-2530, should be considered for uranium operations in preparing the Site-Specific Radiological Control Manual. This manual provides specific guidance related to management controls, radiological monitoring,
contamination control, and internal and external exposure controls.

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 frisking 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 should 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 for tritium operations in preparing the LBNL Radiological Control Manual. This manual provides specific guidance related to internal dosimetry, contamination and air monitoring, tritium containment practices and techniques and Personal Protective Equipment and Clothing selection.

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 in preparing the Site-Specific Radiological Control Manual. This manual 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 DOE Order 5480.25, "Safety of Accelerator Facilities," in preparing the LBNL Radiological Control Manual.

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 include the presence of extremely high dose rates and the potential for uncontrolled exposures. Operation of these devices requires stringent physical and administrative controls to prevent overexposure to operating and support personnel and those in adjacent work areas. The LBNL Radiological Control Manual shall contain the following provisions for applicable types of radiation generating devices.

1. DOE 5480.4 mandates the use of ANSI N43.3 entitled, "American National Standard for General Radiation Safety-Installations Using Non-Medical x-ray and Sealed Gamma-Ray Sources, Energies up to 10 MeV," for operations involving the irradiation of materials.

2. DOE 5480.4 mandates the use of ANSI N43.2 entitled, "Radiation Safety for x-ray Diffraction and Fluorescence Analysis Equipment," for operations involving the following devices:
   a. Analytical diffraction and fluorescence
   b. Flash x-ray
   c. Sealed source irradiators used for diffraction studies.

3. Line management in conjunction with the EH&S Organization shall establish the radiological control requirements for incidental x-ray devices such as electron microscopes and electron beam welders.

4. Devices for medical use shall be registered with the appropriate regulatory agency.

5. Control requirements for radiographic devices are:
   a. On-site operations with devices containing sealed sources should be conducted in accordance with the requirements contained in Title 10 CFR Part 34 entitled, "Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations."
b. DOE 5480.4 mandates the use of ANSI N43.3 entitled, "American National Standard for General Radiation Safety-Installations Using Non-Medical x-ray and Sealed Gamma-Ray Sources, Energies up to 10 MeV," for on-site operations with devices other than sealed sources.

c. On-site operations conducted by off-site contractors shall be approved by line management in coordination with the site EH&S Organization. This process shall ensure the contractor has a valid Nuclear Regulatory Commission or Agreement State license and that the operational and emergency procedures are current and available.

6. Safety devices and interlocks at fixed installations shall be operational prior to and during generation of a radiation field. Operational status shall be verified by testing.
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 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. LBNL has the responsibility to document the technical equivalency of alternative solutions and to ensure compliance with applicable requirements of 10 CFR 835.

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 in accordance with 10 CFR 835.601(e).**

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 reestablishment 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 or Designee

1. Review infrequent or first-time operations (313.2)
2. Approve LBNL ALARA Goals

382 Line Management

1. Plan for design, maintenance, operation, and modification activities (312.1)
2. Provide enhanced oversight of infrequent or first-time work (313.4)
3. Provide written approval for planned internal exposures (316.5)
4. Approve RWPs and RWA's (323.1)
5. Provide adequate planning and control of work (344.1)
6. Conduct pre-job briefings (324.3)
7. Periodically monitor progress of work (344.1)
8. Periodically monitor collective dose for specific jobs (344.3)
9. Exercise stop-work authority (345.1)
10. Evaluate lessons learned from critiques (353)
11. Establish radiological control requirements for incidental x-ray devices (365.3)

383 Radiological Control Manager

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

384 ALARA Committee

1. Approve radiological tasks anticipated to exceed individual or collective dose criteria (312.3)
2. Review infrequent or first-time operations (313.3)
3. Establish LBNL ALARA Goals.

385 Employees

1. Read and sign RWPs and RWA's (322.7)
2. Attend pre-job briefings (324.3)

3. Perform monitoring for personal contamination (332.2; 338)

4. Keep radiological control personnel informed of changes in work (343.4)
5. Exercise stop-work authority (345.1)

386 Support Organizations

1. 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 person-rem
- Prepare Radiological Work Permits (RWPs)

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 High Radiation Area where radiation levels exist such that a person could exceed a deep dose equivalent to the whole body dose of 1 rem in any one hour at 30 centimeters from the source or from any surface that radiation penetrates (10 CFR 835.502(a)): 
   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.
   f. A control device that automatically generates audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source.

2. In addition to the above requirements, additional measures (10 CFR 835.502(b)) 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 2-4.
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 (10 CFR 835.502(c)).
Appendix 3C

Contamination Control Practices

Selection of Protective Clothing (PC)

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.

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 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 industrial safety equipment in Contamination Areas should be controlled by the RWA or RWP. Industrial safety equipment 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 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.

Recommended 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 frisking
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.
Recommended 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 frisking
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.

Use of Multiple Step-Off Pads

1. Multiple step-off pads should be used to control exit from High Surface Contamination Areas. These pads define interim control measures within the posted area to limit the spread of contamination. The following controls apply:

   a. The inner step-off pad should be located immediately outside the highly contaminated work area, but still within the posted area
   b. The worker should remove highly contaminated outer clothing prior to stepping on the inner step-off pad
   c. Additional secondary step-off pads, still within the posted area, may be utilized as necessary to restrict the spread of contamination out of the immediate area
   d. The final or outer step-off pad should be located immediately outside the Contamination Area.
Table 3-1 Guidelines for Selecting Protective Clothing (PC)

<table>
<thead>
<tr>
<th>WORK ACTIVITY</th>
<th>REMOVABLE CONTAMINATION LEVELS</th>
<th>LOW (1 to 10 times Table 2-3 values)</th>
<th>MODERATE (10 to 100 times Table 2-3 values)</th>
<th>HIGH (&gt; 100 times Table 2-3 values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td>Full set of PCs</td>
<td>Full set of PCs</td>
<td>Full set of PCs, double gloves, double shoecovers</td>
<td></td>
</tr>
<tr>
<td>Heavy work</td>
<td>Full set of PCs, work gloves</td>
<td>Double set of PCs, work gloves</td>
<td>Double set of PCs, work gloves</td>
<td></td>
</tr>
<tr>
<td>Work with pressurized or large volume liquids, closed system breach</td>
<td>Full set of non-permeable PCs</td>
<td>Double set of PCs (outer set non-permeable), rubber boots</td>
<td>Double set of PCs and non-permeable outer clothing, rubber boots</td>
<td></td>
</tr>
</tbody>
</table>

Note: For hands-off tours or inspections in areas with removable contamination at levels 1 to 10 times the values in Table 2-3, labcoats, shoecovers and gloves may be used instead of full PCs.
Appendix 3D

Guidelines for Personnel Contamination 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 frisking.

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 frisking, pause for 5 to 10 seconds over the area to provide adequate time for instrument response. Note: For very low count rates it may be more effective to listen to the audio rather than attempting to visually observe minor instrument meter movement.

5. If the count rate increases to a positive reading on the instrument greater than background (For example a visual reading on the LBNL Alpha survey meter of more than 50 cpm would be considered a positive reading), or the instrument alarms, remain in the area and notify Radiological Control personnel. All personnel who work with portable radiation or contamination survey instruments shall be trained in their proper use.

6. The whole body frisk should take at least two to three minutes.

Performance of Monitoring:

1. Frisk the hands before picking up the probe.

2. Perform the frisk 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)

* Comparable instructions to those presented here should be posted adjacent to monitoring instruments in accordance with Article 338.8.
  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.
Appendix 3E

Access Controls for Radiological Areas
(10 CFR 835.501)

General Requirements

1. Personnel entry control shall be maintained for each radiological area.

2. The degree of control shall be commensurate with existing and potential radiological hazards within the area.

3. Administrative procedures shall be written as necessary to demonstrate compliance with 10 CFR 835.501. These administrative procedures shall include actions essential to ensure the effectiveness and operability of barricades, devices, alarms, and locks. Authorization shall be required to perform specific work within the areas and shall include specific radiation protection measures.

4. No control shall be installed at any radiological area exit that would prevent rapid evacuation of personnel under emergency conditions.

Methods for Control

1. Signs and barricades;
2. Control devices on entrances;
3. Conspicuous visual and/or audible alarms;
4. Locked entrance ways; or
5. Administrative controls
## CHAPTER 4 RADIOACTIVE MATERIALS

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474 ALARA Committee ................................ 4-19
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Table

4-1 DOE Approved Labels for Radioactive Materials ....... 4-4
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 or suspected of being 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. For the purpose of the LBNL RPF and this manual, radioactive material, excluding naturally occurring radioactive material (NORM), with greater than or equal to 10% of the activity in Table 4-2 (DOE N 5400.9), or EH&S Procedure 707, Attachment A, shall require an RWA or RWP as the methodology for partial implementation of 10 CFR 835.401 (a). In addition smaller quantities will be controlled through the radiation protection program and this definition does not apply for determination of radioactive waste.

411  Requirements

1. Materials in Contamination, High Contamination or Airborne Radioactivity Areas shall be considered contaminated until surveyed and released. Any equipment or system component removed from a process that may have had contact with radioactive material should be considered contaminated until disassembled to the extent required to perform an adequate survey, surveyed, and shown to be free of contamination. 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 EH&S Organization shall develop response and notification requirements associated with a loss of radioactive material, including searches, internal investigations, documentation and reporting. The EH&S Organization shall be notified in the event of a loss of radioactive material.
412 Radioactive Material Labeling

1. In accordance with 10 CFR 835.601(a), individual containers of radioactive material and radioactive items shall be labeled if existing postings and control measures do not provide adequate warning to personnel. Radioactive material outside Contamination, High Contamination or Airborne Radioactivity Areas shall be labeled in accordance with Table 4-1.

Table 4-1 DOE Approved Labels for Radioactive Materials

<table>
<thead>
<tr>
<th>ITEM/MATERIAL</th>
<th>REQUIRED LABELING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment, components and other items that are radioactive, potentially</td>
<td>&quot;CAUTION, RADIOACTIVE MATERIAL&quot;*</td>
</tr>
<tr>
<td>radioactive or have been exposed to radioactive contamination or activation</td>
<td></td>
</tr>
<tr>
<td>sources</td>
<td></td>
</tr>
<tr>
<td>Sealed and unsealed radioactive sources or associated storage containers</td>
<td>&quot;CAUTION, RADIOACTIVE MATERIAL&quot; or standard radiation</td>
</tr>
<tr>
<td></td>
<td>symbol</td>
</tr>
<tr>
<td>Equipment, components and other items with actual or potential internal</td>
<td>&quot;CAUTION, INTERNAL CONTAMINATION&quot; or &quot;CAUTION,</td>
</tr>
<tr>
<td>contamination</td>
<td>POTENTIAL INTERNAL CONTAMINATION&quot;*</td>
</tr>
<tr>
<td>Components, equipment or other items with fixed contamination</td>
<td>&quot;CAUTION, FIXED CONTAMINATION&quot;*</td>
</tr>
</tbody>
</table>

* Radiation Symbol tape may be substituted to label contaminated equipment, vials or tools.

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 Area; such items shall be properly labeled when they are removed from a Radioactive Material Area
j. Short-lived (half-life of 2 hours or less) radioactive material generated during an irradiation (i.e., research samples while an experiment is being conducted, etc.) that is immediately used.

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. Items which are too small to be labeled with all of the stated information should be labeled, at a minimum, with the words "CAUTION RADIOACTIVE MATERIAL" and the standard radiation symbol.

5. Packaged radioactive material should have the label visible through the package or affixed to the outside.

413 Radioactive Material Packaging

1. Radioactive material that is outside Contamination, High Contamination or Airborne Radioactivity Areas and is confirmed or suspected of having removable radioactive contamination levels greater than Table 2-3 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 2-3 values should have additional packaging controls such as double-wrapping or the use of plastic bags inside containers.
4. Yellow plastic wrapping material should be used for packaging radioactive material. Yellow plastic sheets or bags should not be used for nonradiological purposes. **LBNL does not designate a particular color for wrapping radioactive material. LBNL relies on proper and visible labeling**

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 Area.

2. Long-term (more than 60 days) storage of radioactive material should be in a specially designated Radioactive Material Area.

3. Decontamination or disposal of radioactive material is the preferred alternative to long-term storage.

4. Each Radioactive Material Area should be approved by the Radiological Control Manager or designee.

5. A custodian should be assigned responsibility for each Radioactive Material Area. A custodian may have responsibility for more than one storage area. At LBNL the custodian in the majority of cases is the Principal Investigator (PI).

6. The custodian should conduct walkthroughs of Radioactive Material Areas to check container integrity.

7. The custodian should conduct annual or more frequent reviews of each Radioactive Material Area, with emphasis on decontamination, movement of material to long-term storage locations and disposal of unneeded material.

8. Storage of nonradioactive material in a Radioactive Material Area is discouraged.

9. Outdoor storage of radioactive material is discouraged. 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 custodian should check container integrity monthly at outdoor Radioactive Material Areas.

10. Radioactive material should 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 Areas.

12. Fire protection measures, such as smoke detectors, water sprinklers and fire extinguishers, should be considered when establishing a Radioactive Material Area.
PART 2 Release and Transportation of Radioactive Material

421 Release to Controlled Areas

1. Radioactive material in Contamination, High Contamination, Airborne Radioactivity Areas, or at LBNL RMA’s shall be surveyed prior to release. Unpackaged radioactive material to be released to Controlled Areas shall be demonstrated to have contamination levels less than Table 2-3 values. Also, if prior use suggests contamination levels on inaccessible surfaces are likely to exceed Table 2-3, the material shall not be released (10 CFR 835.1101(a)(1)). Radioactive material, including induced, to be released to uncontrolled areas shall be surveyed in accordance with Article 422. At LBNL release surveys are performed by qualified EH&S or EH&S approved personnel (Reference EH&S Procedure 708).

2. Material with fixed contamination levels that exceed the total contamination limits specified in Table 2-3, and that have removable contamination less than Table 2-3 levels, may be released for use in controlled areas outside of the radiological areas (10 CFR 835.1101(c)). These items shall be routinely monitored and controlled in accordance with administrative procedures. Controls shall be established to ensure no unmonitored individual is likely to exceed a dose equivalent that would require monitoring in accordance with Article 511 or 521.

3. Radioactive material and equipment with removable contamination levels greater than Table 2-3 values shall be packaged prior to release to Controlled Areas. These items shall be routinely monitored and controlled in accordance with administrative procedures. Controls shall be established to ensure no unmonitored individual is likely to exceed a dose equivalent that would require monitoring in accordance with Article 511 or 521.

4. Material not immediately removed from Contamination, High Contamination, or Airborne Radioactivity Areas after survey shall be controlled to prevent contamination while awaiting release.

5. Records for release of surveyed materials shall describe the property, date of last survey, identity of the person who performed the survey, type and identification number of the survey instruments used, and survey results (10 CFR 835.1101(d)). These records shall be maintained (10 CFR 835.703(c)). At LBNL the current custodian of these records is EH&S.
6. Materials released to Controlled Areas shall be labeled in accordance with Article 412.

422 Release to Uncontrolled Areas

1. Material in Controlled Areas or Radioactive Material Areas, documented to have been released from Contamination, High Contamination, or Airborne Radioactivity Areas, shall be surveyed prior to release to uncontrolled areas.

2. DOE 5400.5 describes radiological criteria for releasing material to uncontrolled areas. Material being released shall also be evaluated for internal contamination and contamination under any coatings.

3. DOE 5400.5 describes criteria for releasing radioactive material that has been contaminated in depth or volume, such as activated material or smelted contaminated material. At LBNL all material released to uncontrolled areas will be done in accordance with EH&S procedure 708.

4. Material not immediately released after survey shall be controlled to prevent contamination while awaiting release.

5. Radiological labeling shall be removed from or defaced on material prior to release 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 2-3 removable 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, by 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 nonpublic thoroughfares or between facilities at LBNL are only allowed if appropriate monitoring control procedures are established and exercised (10 CFR 835.1101(b)). These transfers shall be performed in accordance with written procedures utilizing pre-approved routes. Private vehicles should not be used for
the transport of radioactive material. The procedures shall include requirements to ensure appropriate monitoring and control of the radioactive material and should be approved by the EH&S 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 LBNL RCM 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. Transport conveyances should be radiologically surveyed before loading, especially when using commercial carriers specializing in radioactive transport.

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 LBNL 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 radioactive sources.

1. DOE N 5400.9 (extended by DOE N 5400.10) describes how sealed radioactive 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. Procurement of radioactive sources shall be coordinated with the EH&S Organization.

3. Receipt surveys of radiological material shipments shall be performed by the EH&S Organization.

4. Radioactive sources, including radiography sources, shall not be brought on-site by external organizations without the prior written approval of the EH&S 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 promote minimization and 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 burble 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 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 [and liquid mixed waste]. This program should include aggressive measures to identify and repair leaks.

3. Activities that produce radioactive liquid waste shall 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 whenever appropriate. The requirements of 40 CFR 61 shall be included in the evaluation.

2. The EH&S 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 activities under these conditions 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.

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. Contamination levels should be below Table 2-3 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 cm²
   b. Alpha radioactivity less than 1,000 dpm/100 cm² for transuranics and other alpha emitters in the same Table 2-3 category, and less than 10,000 dpm/100 cm² 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 which 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, Authorizations 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 areas established to control removable surface contamination
or airborne radioactivity (except areas where only tritium is present) shall be equipped with High-Efficiency Particulate Air (HEPA) filters. If the material to be vacuumed is wet enough to preclude resuspension, then HEPA filters are not necessary.

2. HEPA filters used in vacuum cleaner and portable air-handling equipment shall meet the efficiency and construction requirements for HEPA filters in MIL-F-51068. The maximum flow rate of the device shall not exceed the flow rate at which the HEPA filter was efficiency tested. In addition, the device shall be leak tested prior to initial use, when units have been opened, and annually. Leak tests are conducted by injecting DOP or equivalent aerosols into the inlet of the device and measuring the DOP concentration at the inlet and outlet of the device. ERDA 76-21, Section 8.3.1, provides additional information on in-place testing of HEPA filters.

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 highly contaminated 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 or Designee

1. Chairperson ALARA Executive Committee

472 Line Management

1. Designate radioactive material and sealed source custodians. (414.5; 431.3)

2. Conduct periodic reviews of radioactive material storage areas (414.6, 7)

3. Maintain accountability records for sealed sources. (431.2)

4. Coordinate procurement of radioactive sources with the Radiological Control Organization (431.7)

473 Radiological Control Manager

1. Develop response and notification procedures for a loss of radioactive material. (411.4)

2. Approve the establishment of radioactive material storage areas. (414.4)

3. Approve procedures for on-site transfers of radioactive material. (423.3)

4. Perform receipt surveys of radioactive material shipments. (431.8)

5. Provide prior written approval for radiography sources brought on site. (431.9)

474 ALARA Committee

1. Recommend to the ALARA Executive Committee LBNL ALARA Goals

2. Perform ALARA evaluations when required

3. Review radiological audits and conduct of the radiological protection program as defined in the charter
475 Employees

1. Notify the Radiological Control Organization in the event of the loss of radioactive material (411.4).

2. Possess an emergency response plan or emergency response information when operating a vehicle making radioactive material shipments. (423.12)

3. Notify the EH&S Organization of changes in use, storage, transfer, disposal or loss of a sealed source. (431.4)

4. Notify the EH&S Organization in the event that engineering controls that prevent worker exposure to airborne radioactivity, such as barriers, gloveboxes and glovebags, are compromised. (453.2)
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PART 1 External Dosimetry

511 Requirements

 Personnel dosimetry at LBNL will be issued to personnel based on a combination of technical basis assessment, specific nature of work and completion of the "Hazards Questionnaire".

Personnel dosimetry shall be required for the following 10 CFR 835.402(a):

a. Personnel who are expected to receive an annual external whole body dose greater than 100 mrem or an annual dose to the extremities, or organs and other tissues (including lens of the eye and skin) greater than 10 percent of the corresponding limits specified in Table 2-2

b. Declared pregnant workers who are expected to receive from external sources a dose equivalent of 50 mrem or more to the embryo/fetus during the gestation period (10 CFR 835.206).

c. Minors and students, visitors and public expected to receive an annual external whole body dose equivalent of 50 mrem or more in a year. (10 CFR 835.207 & 208)

2. Neutron dosimetry shall be provided when a person is likely to exceed an annual external whole body dose of 100 mrem annually from neutrons.

3. 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.

4. To minimize the number of personnel in the dosimetry program, the issuance of dosimeters is discouraged to other than personnel entering Radiation Areas, High Radiation Areas or Radiological Buffer Areas where there is a potential for external exposure. Although issuing dosimeters to personnel who are not occupationally exposed to radiation can appear as a conservative practice, it creates the impression that the wearers are occupationally exposed to radiation.

5. Personnel shall return dosimeters for processing as scheduled or upon request, and should be restricted by line management from continued radiological work until dosimeters are returned.

6. Personnel shall wear their primary dosimeters on the chest area, on or between the waist and the neck, in the manner prescribed by radiation protection personnel.
7. Film dosimeters shall not be worn or taken off-site unless specifically authorized by the Radiological Control Manager.

8. The practice at some facilities of taking thermoluminescent dosimeters (TLDs) off-site is discouraged and shall not be implemented where not in place.

9. Personnel shall not wear dosimeters issued by their resident facilities while being monitored by a dosimeter at another facility unless authorized by the Radiological Control Manager or designee. Personnel shall not expose their dosimeters to security x-ray devices, excessive heat, or medical sources of radiation.

10. A person whose dosimeter is lost, damaged, or contaminated should place work in a safe condition, immediately exit the area and report the occurrence to the Radiological Control Organization. Reentry of the person into Radiological Buffer Areas should not be made until a review has been conducted and management has approved reentry.

512 Technical Requirements for External Dosimetry

1. The external dosimetry program at LBNL shall be adequate to demonstrate compliance with the Table 2.2 limits for occupational workers and conducted in conformance with the requirements of the DOE Laboratory Accreditation Program for Personnel Dosimetry (10 CFR 835.402(b)). DOE 5480.15 and STD-1095-95 specifies the requirements for accreditation of personnel external dosimetry monitoring programs by the DOE Laboratory Accreditation Program (DOELAP). A technical basis document shall be developed and maintained for the external dosimetry program. Personnel external dosimeters include but are not limited to TLDs, track etch dosimeters and neutron sensitive film.

2. The technical basis document shall also address dosimeters monitoring radiation outside the scope of DOELAP, such as dosimetry associated with high-energy accelerators and extremity dosimeters.

3. Facilities should participate in intercomparison studies for external dosimetry programs.

4. Personnel exposures to the skin, lens of the eye and extremities shall be reported separately when monitored.

5. Multiple dosimeters should be issued to personnel to assess whole body exposure in non-uniform radiation fields or as
required on Radiological Work Permits. Non-uniform radiation fields exist when the dose to a portion of the whole body will exceed the dose to the primary dosimeter by more than 50 percent and the anticipated whole body dose is greater than 100 mrem. The technical basis document should describe the methodology used in determining the dose of record when multiple dosimeters are used.

6. A dose assessment shall be performed for each instance of a lost, damaged or contaminated personnel dosimeter.

513 Pocket and Electronic Dosimeters

Pocket and electronic dosimeters are supplemental dosimeters that 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 High Radiation or Very High Radiation Area (see Article 334 for entry requirements); when a person could exceed 10 percent of an Administrative Control Level from external radiation in 1 work day; or when required by a Radiological Work Permit. 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 located in accordance with Article 511.

3. Supplemental dosimeters shall be read periodically while in use and should not be allowed to exceed 75 percent of full scale.

4. Work authorized by a Radiological Work Permit or Radiological Work Authorization shall be stopped when supplemental dosimeter readings indicate total exposure or rate of exposure substantially greater than planned. The EH&S Organization shall be consulted prior to continuation of work.

5. The energy dependence of supplemental dosimeters, particularly to low-energy beta radiation, should be considered in determining their applicability.

6. Use of electronic dosimeters is encouraged for entry into High Radiation Areas or when planned doses greater than 100 mrem in 1 work day are expected. An electronic dosimeter provides an early warning of elevated exposure through the use of alarm set points at specified dose rates or integrated doses.
7. When the dose results from the pocket or electronic dosimeters differ by more than 50 percent from the primary dosimeter result and the primary dosimeter result is greater than 100 mrem, an investigation should be initiated to explain the difference.

514 Area Monitoring Dosimeters

Establishment and maintenance of a comprehensive area monitoring program minimize the number of areas requiring the issuance of personnel dosimeters and demonstrate that doses outside Radiological Areas are negligible. Minimizing the number of personnel dosimeters issued saves in the costs of operating the dosimetry program and reduces costs associated with maintaining personnel with enhanced training and qualifications.

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 when the radiation arises solely from low-energy beta sources (e.g., Carbon-14 or tritium).

2. Area monitoring dosimeter results should be used to support dosimetry investigations where personnel express concerns about their work environments and exposure to ionizing radiation.

3. Area monitoring dosimeters should be used in Controlled Areas to supplement existing monitoring programs and to provide data in the event of an emergency.

515 Nuclear Accident Dosimeters

10 CFR 835.1304 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

Internal dosimetry requirements at LBNL will be based on a combination of technical basis assessment, specific nature of work and completion of the "Hazards Questionnaire".

1. The following personnel shall participate in an internal dosimetry program (10 CFR 835.402(c)):
   a. Personnel who, under typical conditions, have the potential to receive intakes resulting in a committed effective dose equivalent of 100 mrem or more in a year
   b. Declared pregnant workers likely to receive intakes resulting in a dose equivalent to the embryo/fetus of 50 mrem or more during the gestation period
   c. Minors and students, visitors and public likely to receive intakes resulting in a committed effective dose equivalent of 50 mrem or more in a year.

2. The estimation of internal dose shall be based on bioassay data rather than air concentration values unless bioassay data are (10 CFR 835.209(c)):
   a. unavailable
   b. inadequate
   c. internal dose estimates based on representative air concentration values are demonstrated to be as or more accurate.

3. Personnel shall participate in follow-up bioassay monitoring when their routine bioassay results indicate an intake in the current year with a committed effective dose equivalent of 100 mrem or more.

4. Personnel whose routine duties may involve exposure to surface or airborne contamination or to radionuclides readily absorbed through the skin, such as tritium, should be considered for participation in the bioassay program.

5. Personnel shall submit bioassay samples, such as urine or fecal samples, and participate in bioassay monitoring, such as whole body or lung counting, at the frequency required by the bioassay program.
6. **Personnel shall be notified promptly of positive bioassay results and the results of dose assessments and subsequent refinements. Dose assessment results shall be provided in terms of rem or mrem (10 CFR 835.4).**

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 internal dosimetry programs.

1. A technical basis document shall be developed for the internal dosimetry program.

2. Baseline bioassay monitoring of personnel who are likely to receive intakes resulting in a committed effective dose equivalent greater than 100 mrem shall be conducted before they begin 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 resulting in a committed effective dose equivalent greater than 100 mrem. The technical basis for the methods and frequency of bioassay monitoring should be documented.

4. Management shall require termination bioassay monitoring 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. Bioassay analyses shall also be performed when any of the following occurs:
   a. Facial or nasal contamination is detected that indicates a potential for internal contamination
   b. Airborne monitoring indicates the potential for intakes exceeding 100 mrem committed effective dose equivalent
   c. Upon direction of the EH&S 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. Internal dosimetry program personnel should use radionuclide standards from or traceable to the National Institute of Standards and Technology (NIST).

9. Internal dosimetry program personnel should participate in the conduct of intercomparison studies and should use the "DOE Phantom Library."

10. The internal dose evaluation programs shall be adequate to demonstrate compliance with 10 CFR 835.202. (10 CFR 835.402(d))

523 Technical Requirements for Dose Assessment

Interpretations of bioassay results and subsequent dose assessments should include the following:

1. Characteristics of the radionuclide, such as chemical and physical form

2. Bioassay results and the person's previous exposure history

3. Exposure information, such as route of intake and time and duration of exposure

4. Biological models used for dosimetry of radionuclides

5. Models to estimate intake or deposition and to assess dose

6. Intradepartmental coordination between the Radiological Control Organization and the medical organization for doses that may require medical intervention.
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 radioactivity at the source.

2. DOE 5480.4 mandates the requirements contained in ANSI Z88.2 and 29 CFR 1910.134 for implementation of the Respiratory Protection Program and associated training of personnel.

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 respirators.

5. 29 CFR 1910.134 mandates that breathing air meet the specifications of ANSI/CGA G-7.1 Grade D breathing air. 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 cross-connections to other compressed gas systems to prevent contamination.

6. Facility safety analyses should not take credit for the use of respiratory protection for routine work involving potential exposure to airborne radioactive materials. Engineering controls should be designed to control radioactive materials at the source, so that 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 trained to leave the work area when experiencing respirator failure
6. Be trained 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 anti-contamination clothing or plastic suits were in use or strenuous work was required. The planning stages for work in hot environments should address heat stress controls. 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 revised 10 CFR Part 20, effective January 1, 1994, 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 times the...DAC values." This type
of respirator is not suitable for protection against plutonium or other high-toxicity materials."

1. Half-face respirators shall not be used on a routine basis 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.

2. The use of half-face respirators is not prohibited 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.

3. A few DOE facilities use half-face respirators for emergency evacuation purposes. This practice is discouraged and shall not be implemented where not in place.
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 Radiation Protection personnel.

3. The extent of skin contamination should be determined prior to initiating decontamination procedures.

4. Skin decontamination methods should be established for site-specific radionuclides. Skin abrasion should be avoided during the decontamination process. Intrusive decontamination methods, such as tissue removal, require medical assistance.

5. Levels of skin contamination that trigger the need for dose assessments should be established for site-specific radionuclides. These trigger levels should not exceed 100 mrem.

6. Personnel with skin contamination that triggers the need for dose assessment should be informed of the initial dose estimate to 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 2C and, promptly after completion, the results should be explained to the persons affected.

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. 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 and medical professionals.

543 Exposures to Airborne Radioactivity

Potential intakes of radioactive material are indicated when personnel without respiratory protection are exposed to airborne radioactivity or when respiratory protection has been compromised. If intakes of radioactive material are indicated which could result in [an individual receiving] a committed effective dose equivalent greater than 100 mrem, the following actions should be taken:

1. Identify personnel potentially exposed to airborne radioactivity
2. Obtain nasal smears for qualitative indication of intakes where appropriate
3. Analyze air samples to determine airborne concentrations where appropriate
4. Determine duration of potential exposure to airborne radioactivity
5. Perform bioassay appropriate for the type and quantity of radionuclides involved
6. Evaluate dose prior to permitting the worker to return to radiological work.
PART 5 Radiological Monitoring and Surveys

551 Requirements

1. Radiological monitoring of radiation exposure levels, contamination and airborne radioactivity shall be conducted to (10 CFR 835.401(a)):
   a. Characterize workplace conditions
   b. Document radiological conditions
   c. Detect changes in radiological conditions and gradual buildup of contamination
   d. Verify the effectiveness of physical design features and engineering and administrative controls
   e. Identify areas requiring postings.

2. Area monitoring in the workplace shall be routinely performed, as necessary, to identify and control potential sources of personnel exposure to radiation and/or radioactive material (10 CFR 835.401(b)).

3. Monitoring shall be performed only by trained and qualified personnel using instruments that are properly and periodically maintained and calibrated on an established frequency of at least once per year; appropriate for the type, levels, and energies of the radiation encountered; appropriate for existing environmental conditions; and routinely tested for operability (10 CFR 835.401(c)).

4. Surveys for radiation, contamination and airborne radioactive materials shall be performed as specified in Technical Work Documents, RWPs and RWAs (Implementation of 10 CFR 835.401).

5. The Radiological Protection Program staff shall perform and document a review of 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 review should be conducted annually.

6. Instruments used to perform radiation surveys shall be readily available and routinely response-checked (10 CFR 835.401(c)(4)), daily or prior to operation. When response checks are not within ±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 proper instrument performance.

7. Assessment of radiological conditions should include a sufficient number of survey points to characterize the radiation present and to verify boundaries.

8. Surveys should be performed before, during and at the completion of work that has the potential for causing changes in levels of radiation and radioactivity.

9. Survey frequencies should be established based on potential radiological conditions, probability of change in conditions and area occupancy factors.

10. Monitoring results should be reviewed by the cognizant radiological supervisor. The review should ensure that all required surveys have been performed and that the documentation is accurate and complete.

11. Results of current surveys or survey maps should be conspicuously posted to inform personnel of the radiological conditions.

12. Monitoring results should be made available to line management and used in support of pre- and post-job evaluations, ALARA preplanning, contamination control and management of radiological control operations.

13. Monitoring data in each building or area should be compiled and reviewed at least quarterly. Changes or 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 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.

2. The survey frequencies in 552.1 above shall be modified where data from trend analyses or operational changes suggest the radiological conditions are not stable or are not predictable.

3. Performance of 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 dose rates on contact with potential sources of radiation where there is a potential for hands-on work.

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.

5. Radiation monitoring instruments shall be readily available and capable of measuring ambient radiation dose rates for the purpose of controlling radiation exposures. (10 CFR 835.403(b)).

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 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 a workplace.

3. The need and placement of area radiation monitors should be documented and assessed when changes to facilities, systems or equipment occur.
4. In addition to the requirements of Article 562, area radiation monitors should be tested at least quarterly to verify audible alarm system operability and audibility under ambient working conditions and operability of visual alarms when so equipped.

5. If 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.

6. 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.

7. Area radiation monitors should be maintained and calibrated annually in accordance with 10 CFR 835.401(c)(1) at the LBNL, EH&S calibration facility. Calibration to include operability, audibility and visual alarms when so equipped under ambient working conditions.

554 Contamination Surveys

1. In addition to the requirements of Article 551, routine contamination surveys should be conducted [in Radiological Buffer Areas established for the control of contamination and other areas with the potential for spread of contamination] as follows:

   a. Prior to transfer of equipment and material from one Radiological Buffer 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. Daily, in office space located in Radiological Buffer Areas
   e. Daily, in lunch rooms or eating areas near Radiological Buffer Areas
   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.

k. **User surveys at the frequency specified in the RWA or RWP (Implementation of 10 CFR 835.401)**

2. The survey frequencies in 554.1 above shall be modified 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 or RWA based, for example, on operational changes posing high risk of contamination or frequency of spills.

3. Surveys for the release of 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 2-3 values shall 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. (Ref. 10 CFR 835.1101(a)).

6. The requirements 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, are specified in DOE 5400.5.

7. Swipe surveys for removable contamination shall be reported in units of disintegrations per minute per 100 cm$^2$ (dpm/100 cm$^2$). For swipe surveys of small items covering less than 100 cm$^2$, the results shall be reported in units of dpm per area swiped.

8. Large area wipes are encouraged and should be used to supplement standard swipe techniques in areas generally assumed not to be contaminated, such as entrances to Radiological Buffer Areas. If an evaluation indicates that an area wiped is contaminated, a thorough contamination swipe survey should be performed.
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 swipe techniques to collect hot particles, such as tape and large area wipes, should be used.

555 Airborne Radioactivity Monitoring

1. In addition to the requirements of Article 551, air monitoring equipment should be used in situations where airborne radioactivity levels can fluctuate and early detection of airborne radioactivity 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 (10 CFR 835.403(a)(1)).

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 radioactivity in air exceeding 1 DAC or where there is a need to alert potentially exposed workers to unexpected increases in the airborne radioactivity levels 10 CFR 835.403(a)(2). A person exposed continuously to a concentration of radioactivity in air of 1 DAC for 1 work week would generally receive a committed effective dose equivalent of approximately 100 mrem.

4. Air sampling equipment should be positioned to measure air concentrations to which persons are exposed. If this cannot be achieved, a program of personal breathing-zone air sampling should be initiated.

5. Air monitoring equipment shall be routinely calibrated and maintained at a frequency of at least once per year. (10 CFR 835.401(c)(1)). 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 10 CFR 835.403(a)(3).

7. The proper operation of continuous air monitoring equipment should be verified daily by performing an operational check. Operational checks should include positive air-flow indication, non-zero response to background activity, and internal check sources or 60 Hz electronic checks when available. Continuous air monitoring equipment should be verified weekly by checking for instrument response with a check source or with ambient levels of radon and thoron daughters.

8. Preliminary assessments of air samples utilizing field survey techniques should be performed promptly upon removal. In situations where background levels of radon and thoron daughters interfere with evaluation of alpha air samples, prompt field assessments may not be possible.

9. Air sample results should be evaluated 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

Standardization using commercially available radiological instrumentation in the DOE is highly encouraged. To assist in the selection of appropriate instrumentation, DOE intends to establish a formal program to evaluate and test each type of radiological instrumentation used throughout the DOE complex.

562 Inspection, Calibration and Performance Tests

1. Radiological instruments shall be used only to measure the radiation for which their calibrations are valid 10 CFR 835.401(c)(2).

DOE 5480.4 mandates the requirements contained in ANSI N323 for radiological instrumentation calibration. Calibrations shall use National Institute of Standards and Technology (NIST) traceable sources.

2. Calibration procedures shall be developed for each radiological instrument type and include frequency of calibration, precalibration requirements, primary calibration requirements, periodic performance test requirements, calibration record requirements 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.

4. The effects of environmental conditions (10 CFR 835.401(c)(3)), including interfering radiation, on an instrument shall be known prior to use.

5. Functional tests should be used to assess instrumentation designs that include alarms or that involve a process control. A functional test should be developed to test all components involved in an alarm or trip function and performed 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 for use of instrumentation outside manufacturer's specifications. The instrument should be adjusted, calibrated and labeled to identify the special conditions and used only under the special conditions for which it was calibrated.

7. Instruments should bear a label or tag with the date of calibration and date calibration expires.
8. Instruments whose "as found" readings indicate that the instrument may have been used while out of calibration shall be reported to the Radiological Protection Program staff and the EH&S calibration facility staff. The Radiological Protection Program staff should review surveys performed with the instrument while it was out of calibration.

563 Maintenance

1. A program for preventive and corrective maintenance of radiological instrumentation should be established and documented.

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.

3. Radiological instruments shall undergo calibration prior to use following any preventive or corrective maintenance or any adjustment that voids the previous calibration. A battery change is not normally considered maintenance.

564 Calibration Facilities

1. Calibration facilities should perform inspections, calibrations, performance tests, calibration equipment selection and quality assurance in accordance with the recommendations of ANSI N323 and take the following actions:

   a. Locate activities in a manner to minimize radiation exposure to operating personnel and to personnel in adjacent areas

   b. Minimize sources of interference, such as backscatter and non-ionizing radiation, during the calibration of instrumentation and correct for interferences as necessary

   c. Operate in accordance with the referenced standards

   d. Generate records of calibration, functional tests and maintenance in accordance with the referenced standards.

2. For organizations that do not possess or use their own calibration facilities, contracted calibration services should be performed in accordance with the referenced standards.
PART 7 Summary of Responsibilities

571 Department of Energy

572 Line Management

1. 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

1. Authorize use of special dosimeters offsite. (511.9)

2. Perform and document reviews of the adequacy of sampling and monitoring systems. (551.2)

574 Employees

1. Notify the Radiological Control Organization if assigned dosimeters are exposed to security x-ray devices, excessive heat, or medical sources of radiation. (511.8)

2. 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)

3. Participate in bioassay monitoring programs as directed by the Radiological Control Organization. (521.4)

4. Be clean-shaven in the respirator seal area prior to using respiratory protection devices. (533)

5. Immediately notify the nearest co-worker, exit the area, remove personnel protective equipment, notify supervisor and rest in a cool area if heat illness is encountered. (534)

6. Notify the Radiological Control Organization if skin or clothing contamination is detected. (541.2)
## CHAPTER 6 TRAINING AND QUALIFICATION

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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 at LBNL. LBNL is meeting the requirements of 10 CFR 835 Subpart J- Radiation Safety Training through LBNL applicable course material. Specific training curricula and materials as defined in the DOE RCM is for reference and will be so noted.

612 Standardization

Standardized core courses and training materials should be used to achieve consistency throughout DOE complex. In establishing local training programs, the standardized core courses should be presented and site-specific information shall be added. For example, training at accelerator facilities should expand course content for high energy radiation and activation products. Training at plutonium facilities should expand the course content for alpha control. In all cases, the standardized core course materials, as listed in the References section, should be fully implemented.

Standardized core course training material developed and maintained by DOE Headquarters (EH) consists of lesson plans, designated 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 Radiological Control Technicians partially fulfills DOE training accreditation requirements of DOE 5480.18A.

1. Standardized core course training material should be used for General Employee Radiological Training, Radiological Worker training and Radiological Control 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 and Radiological Control Technician at one DOE site shall be recognized by other DOE sites. Documentation of previous training shall include the individual's name, date of training, topics covered, and name of the certifying official. However, site-specific aspects of the
4. At sites where there are multiple facilities, the 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 General Employee Radiological Training, Radiological Worker training and Radiological Control Technician qualification shall be used to demonstrate satisfactory completion of theoretical and classroom material in accordance with 10 CFR 835 Subpart J.

Examinations should be written; however, the Radiological Control Manager may approve alternatives to accommodate special needs. Alternative examinations should be equivalent in content to written examinations. 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 the question bank contain questions that 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 as required by 10 CFR 835.901(a). Changes to the program shall be incorporated as they are identified and a decision made if retraining prior to the 2 year period is needed as required by 10 CFR 835.901(b). 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 retraining shall be completed every 2 years as required by 10 CFR 835.902. In the alternate year when retraining is not performed, refresher training shall be completed. At LBNL these requirements are met through the RWA renewal process.

5. 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. The Radiological Control Manager is authorized to approve alternative temporary training methods for those lacking reading and comprehension skills in the English language until adequate English language skills can be achieved. Training in an alternate language should be equivalent to training in English. Visitor orientation and the use of trained escorts provide an alternate to training with the concurrence of the Radiological Control Manager.

10. Additional requirements for personnel training at Category A reactors are stated in DOE 5480.20.

11. Training records and course documentation shall meet the requirements of Article 725.
614 Qualification Standards for Radiological Control 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 site-specific elements.

4. Qualification Standards for the Radiological Control Technician position shall include on-the-job training (10 CFR 835.903) to provide hands-on experience directly applicable to the job.

5. On-the-job trainees shall be under the control of qualified personnel (10 CFR 835.903).

615 Oral Examination Boards

1. An Oral Examination Board shall determine the qualification of candidates for Radiological Control Technician and Supervisor positions. The Oral Examination Board provides an opportunity to identify areas of Strengths and weakness related to performance of Radiological Control Technician duties and Supervisor functions. The Oral Examination Board also provides the opportunity to identify additional training needs to enhance Radiological Control Technician and Supervisor training programs.

2. The Radiological Control Manager shall designate the Board members and appoint a Chairperson.

3. The Board constituted to evaluate Radiological Control Technician qualification should be composed of at least three persons to include a Radiological Control Technician Supervisor, Radiological Protection Program staff, and line management operations department supervisors and staff personnel, as applicable. Radiological Control 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 Radiological Control Technician Supervisor qualification 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 the Controlled Area and encounter radiological barriers, postings or radioactive materials shall receive General Employee Radiological Training. This training shall be successfully completed prior to potential occupational radiation exposure (10 CFR 835.901(a)).

General Employee Radiological Training is recommended for all employees.

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 site-specific information, such as site-specific radiation types, alarm responses and policies.

3. Workers may challenge General Employee Radiological Training standardized core knowledge requirements by passing a comprehensive examination. If unsuccessful in one attempt, the entire General Employee Radiological Training standardized core training shall be completed. Challenges do not apply to the site-specific portions.

4. Expected time to complete the standardized core and site-specific General Employee Radiological Training is approximately 1 hour.

5. Additional training beyond General Employee Radiological Training is necessary for unescorted entry into Radiological Buffer Areas or areas posted for radiological control other than Controlled Areas.

6. Information may be communicated by classroom lecture, videotape, or other applicable methods.

622 Radiological Orientation for Visitors

1. Visitors who enter the 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 posting and labeling

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.

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.

5. Further requirements for Visitors, Tour Groups, Visiting Dignitaries, Scientists and Specialists are addressed in Article 657.
PART 3 Radiological Worker Training

631 Requirements

1. In accordance with 10 CFR 835.902 radiological worker training programs and retraining shall be established and conducted at intervals not to exceed 2 years to familiarize the worker with the fundamentals of radiation protection and the ALARA process. Retaining at LBNL is accomplished and documented through the RWA renewal process.

2. Radiological Worker training is required for unescorted entry into areas as stated in Table 6-1.

3. Radiological Worker 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 per article 634.1.

4. Workers may challenge Radiological Worker standardized core knowledge requirements by passing a comprehensive examination. If unsuccessful in one attempt, the entire standardized core Radiological Worker training shall be completed. Challenges do not apply to the site-specific portions.

5. Basic Radiological Worker training is a prerequisite for accelerator and laboratory Radiological Worker training.

6. Radiological Worker and Radiological Worker II training are self-contained courses. Radiological Worker II training (Not used at LBNL) includes all of the requirements of Radiological Worker training and expands on the topic of hands-on work with radioactive materials.

632 Radiological Worker

1. Workers whose job assignments require access to Radioactive Materials Areas and Radiological Radiation Areas shall complete LBNL Radiological Worker Basic training, either Laboratory and/or Beamline modules and site-specific Radiological Worker training before being permitted to enter these areas without a qualified escort (See Table 6-1). Radiological Worker Training fulfills the requirements of 10 CFR 835.902.

2. Radiological Worker training should use the DOE standardized core course training materials or LBNL equivalent and in addition shall emphasize site-specific information.
3. Radiological Worker training should encompass at a minimum the following site-specific practical factors:
   a. Entering and exiting simulated Radiological Areas and Radiation Areas (and High/Very High Radiation Areas when such training is included) (Beam Line Module)
   b. Performance of frisking for personnel contamination, as applicable (Laboratory Module)
   c. Verification of instrument response and source check
   d. Anticipated response to alarm situations.

4. Expected time to complete the basic course and site-specific Radiological Worker training is approximately 2 hours. Course length will vary dependent upon the amount of site-specific material.

5. Unescorted worker access to High or Very High Radiation Areas is permitted upon successful completion of Basic Radiological Worker training and "Beam Line" module training course. Completion of the "Laboratory" module training authorizes access to RMAs, Contamination, High Contamination, Soil Contamination, or Airborne Radioactivity Areas.

633 Radiological Worker II

The material contained in this article is for information only and is not currently applicable at LBNL and is not used to fulfill the training requirements of 10 CFR 835.902.

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. Radiological Worker II training is not required for access limited to High or Very High Radiation Areas for workers trained in accordance with Article 632.5. Further, 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 site-specific information.

2. Radiological Worker II training shall encompass at a minimum the following site-specific practical factors:
   a. Donning of protective clothing
   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 frisking for personnel contamination
g. Verification of instrument response and source check.

3. Expected time to complete the standardized core and site-specific Radiological Worker II training is approximately sixteen hours. Course length will vary dependent upon the amount of site-specific material.

**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 training and is required for personnel planning, preparing and performing jobs that have the potential for radiological consequences such as entry into High or Very Radiation Areas or work involving unsealed radionuclides. Such jobs may involve special containment devices, the use of mockups, contamination control and ALARA considerations.
### Table 6-1 Radiological Worker Entry Training Requirements

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<td>YES†</td>
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<td>YES†</td>
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<td>Radiation Areas</td>
<td>YES†</td>
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<tr>
<td>Entry into High or Very High Radiation Areas</td>
<td>YES**</td>
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<tr>
<td>Entry into Contamination or High Contamination Areas</td>
<td>NO</td>
</tr>
<tr>
<td>Entry into Contamination or High Contamination Areas</td>
<td>NO</td>
</tr>
<tr>
<td>Entry into Solid Contamination Areas (to perform work that disturbs the soil)</td>
<td>NO</td>
</tr>
<tr>
<td>Entry into Airborne Radioactivity Areas</td>
<td>NO</td>
</tr>
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</table>

* In addition may require Lab. Safety Module if dispersible radioactive material is used.
** Any area other than "A" requires specific facility OJT training.

Entry into Very High Radiation areas is normally prohibited.

X-Ray machine training is currently accomplished through a combination of completing EH&S 410 and OJT training.

Training for M&O personnel is accomplished through completion of EH&S 420.
PART 4 Radiological Control Technician Qualification

641 Requirements

Training and retraining programs to meet the requirements of 10 CFR 835.903 for radiological control technicians shall be established and conducted at intervals not to exceed 2 years to familiarize technicians with the fundamentals of radiation protection and the proper procedures for maintaining exposures ALARA. This program shall include both classroom and applied training. The training shall either precede performance of tasks assigned to RCT's or be concurrent with such task assignments if the individual is accompanied by and under the direct supervision of a trained individual. The required level of knowledge of radiation safety possessed by RCT's shall be verified by examination to include demonstration prior to any unsupervised work assignment. The training program shall include procedures specific to the site or facility where the technician is assigned. The level of training shall be commensurate with the technicians assignment.

Training and qualification of Radiological Control 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 Radiological Control Technician

1. Radiological Control 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. Radiological Control Technician training shall use the standardized core course training materials and in addition should emphasize site-specific information.

3. Radiological Control 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 Radiological Control 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. Radiological Control Technicians are encouraged to pursue registration by the National Registry of Radiation Protection Technologists (NRRPT).

6. Sites are encouraged to give credit toward completion of standardized core training requirements for NRRPT registration.

643 Continuing Training

1. Following successful completion of standardized core course requirements including practical training, the Radiological Control Technician shall pass both a comprehensive written examination and an Oral Examination Board for final qualification.

2. Following Oral Examination Board qualification, the Radiological Control 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 Radiological Control Technician.

4. Continuing training should include 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 Radiological Control Technicians satisfy the requirements of Radiological Worker II training.

644 Radiological Control Technician Supervisors

1. Radiological Control Technician Supervisors shall have qualified as Radiological Control Technicians and should participate in continuing radiological training programs.

2. Radiological Control 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. Radiological Control 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 Radiological Control Technician Supervisor's depth of knowledge should exceed that expected of a Radiological Control Technician.

645 Subcontracted Radiological Control Technicians

1. Subcontracted Radiological Control 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 Radiological Control 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 (DOE and contractors) who manage, supervise or provide oversight of Radiological Protection Programs shall be trained in the principles of this Manual. Such training should be based on DOE standardized core course training materials supplemented by 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 may include but are not limited to: dosimetry technicians, instrument technicians, medical personnel, records clerks, whole body counter technicians and laboratory personnel.
3. Radiological support personnel should have:
   a. Applicable training on standardized core course topics from Radiological Worker and Radiological Control Technician training and additional job-specific topics
   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 (RGD) Operators

Radiographers and RGD operators shall have training in accordance with 10 CFR 34.31. Radiation Generating Device Operators should have training appropriate for the radiation source involved and commensurate with the level described in 10 CFR 34.31. At LBNL this is currently accomplished through a combination of completing EH&S 410 and OJT training.

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 firefighters, 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 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 Specialized Visitor Training for Tour Groups and Visiting Dignitaries, Scientists and Specialists

Tour groups and visiting dignitaries, scientists and specialists who enter posted areas other than Controlled Areas should complete the following training:

1. Sites should establish radiological control training for tour groups and visiting dignitaries, scientists and specialists commensurate with the areas they are to enter. This training is intended for individuals not performing hands-on work.

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 site-specific training materials.

4. If visiting scientists or specialists are to do hands-on radiological work while unescorted, consideration should be given to providing full Radiological Worker 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  Plutonium Facilities (Not Applicable at LBNL)

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

- Properties of plutonium
- 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 (Not Applicable at LBNL)

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 control
- 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
1. Insure site staff have appropriate level of training commensurate with tasks assigned them.
2. Insure a site radiological protection training program

672 Line Management
1. Insure staff has requisite and appropriate training
2. Insure level of training is commensurate with tasks.

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

674 Workers
1. Request required training
2. Receive the appropriate training prior to beginning work. (10 CFR 835.902)
## CHAPTER 7 RADIOLOGICAL RECORDS

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PART 1 Requirements

711 Purpose

This chapter contains the prescribed practices for preparing and retaining radiologically related records. Radiological control records shall be maintained as necessary to document compliance with the requirements of 10 CFR 835. 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. Consideration should be given to cross-referencing related records to aid retrievability. Records should be handled such that personal privacy is protected.

712 Records Management Program

1. A radiological records management program shall be established. This program shall ensure that auditable records and reports are controlled through the stages of creation, distribution, use, arrangement, storage, retrieval, media conversion (if applicable) and disposition. The records management program shall be sufficient to ensure records are maintained as necessary to document compliance with 10 CFR 835 and 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 (audits, findings, corrective actions)
   n. Radiological Incident and Occurrence Reports (and Critique Reports, if applicable)
   o. Accountability records for sealed radioactive sources
2. Where radiological services (for example, dosimetry and laboratory analyses) are purchased, there should be a clear agreement regarding records responsibility during performance of the service. Records of results should reside in the custody of the originating contract organization.

3. DOE 1324.2A provides implementing instructions, records inventory requirements, disposition schedules and provisions for the transfer of records.

4. Detailed information concerning an individual's exposure shall be made available to that individual, upon request, consistent with the Privacy Act of 1974, which contains requirements to protect the privacy of individual records and (10 CFR 835.702(f) and .801(d)).

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 ensure review and proper completion of forms.

2. It is suggested that the Radiological Control Organization 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:

   a. Opaque substances for corrections
   b. Shorthand or other nonstandardized terms.

4. Similar procedural standards should be established for computerized records.
5. In accordance with 10 CFR 835.4, unless otherwise specified, radiological control records shall use the special units of curie, rad and rem, including multiples of these units. Use of the international system of units (becquerel, gray, and sievert) should be limited to calculational scientific, reference, or parenthetical purposes.
PART 2 Employee Records

721 Employment History

Records detailing an employee's preemployment and employment history and the associated radiation dose shall be maintained. Efforts shall be made to obtain records of prior years occupational internal and external exposure (10 CFR 835.702(a) & (e)). Where practical, the association between the radiation dose and job function should be preserved for trending purposes 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

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. When issued, DOE standardized forms to document previous and ongoing radiation doses.

722 Personnel Radiological Records

1. Records of doses received by all individuals for whom individual monitoring was required by 10 CFR 835.402, 204, and 1301 shall be maintained (10 CFR 835.702(a) & (b)). These records shall be sufficient to evaluate compliance with all applicable dose limits and monitoring and reporting requirements of 10 CFR 835.402 and 835.702(c)(1) & (2).

2. Radiation dose records shall contain information sufficient to identify each person, including social security or employee number.

3. Routine and special records related to radiation doses shall be retained for each person monitored (10 CFR.835.702(b)). This shall include records of zero dose. Procedures, data and supporting information needed to reconfirm a person's dose at a later date shall be maintained (10 CFR 835.702(g)).
4. External dose records shall include the following:
   a. Applicable extremity, skin, eye and whole body
dose results measured with personnel dosimeters
   (10 CFR 835.702(c)(3)), including all multiple
dosimeter badging results
   b. Evaluations resulting from anomalous dose results such
as unexpected high or low doses
   c. Dose reconstructions from lost or damaged dosimeters, or
for unbadged workers
   d. Evaluations of nonuniform radiation doses.

5. Internal dose records shall include committed dose to
the affected organs and tissues, committed effective
dose equivalent, and the estimated intake and identity
of radionuclides (10 CFR 835.702(c)(4)). The following
support information shall be included:
   a. Applicable whole body and lung counting results
   (including chest wall thickness measurements where
   applicable)
   b. Applicable urine, fecal and specimen analysis results
   c. Dose assessment, as required.

6. Records of the summation of external dose and
committed dose equivalent to any organ receiving a
reportable dose shall be maintained for the individual
receiving such dose (10 CFR 835.702(c)(5)(ii)).

7. The total effective dose equivalent received by each
monitored individual shall be maintained for each year
the individual is monitored (10 CFR 835.702(c)(5)(i)).

8. The dose equivalent to the embryo/fetus of a declared
pregnant worker shall be maintained with the occupat­
ional exposure records for that worker (10 CFR
835.702(c)(6)).

9. Records of lifetime occupational dose, shall include
cumulative total effective dose equivalent since
January 1, 1989 10 CFR 835.702(c)(5)(iii), and should
be maintained with the individual's occupational exposure
records.

10. 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.
11. Records of authorization to exceed Administrative Control Levels shall be retained.

12. Emergency doses and planned special exposures shall be accounted for separately, but maintained with the individual's occupational exposure records (10 CFR 835.204(f) and 1302(d)).

13. Records of non-uniform dose to the skin caused by contamination on the skin need not be retained in personnel dose records if the dose is less than 2 percent of the limit for the skin in Table 2-2 (10 CFR 835.702(b)). (see Article 723 for requirements for records of radiological incidents and occurrences).

723 Other Personnel Radiological Records

1. The complete records of radiological incidents and occurrences involving personnel dose shall be retained (10 CFR 835.702(a)).

2. Records of employee radiological safety concerns that have been formally investigated and documented should be maintained.

3. Records of the formal written declaration of pregnancy shall be maintained (10 CFR 835.704(d)). Records of revocations of such declarations, as well as records indicating that the pregnancy has concluded (therefore, the conditions of Article 215 do not apply), should also 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 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. At a minimum, these records shall include the following:
   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 or 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 (10 CFR 835.704(a))
   b. Radiological Worker training (10 CFR 835.704(a)). For full implementation this should include applicable OJT training.
   c. Periodic retraining (10 CFR 835.704(a))
   d. Respiratory protection training
   e. Training of radiological control personnel (10 CFR 835.704(a))
   f. Instructor training
   g. Qualifications for special tests or operations
   h. Orientation and training of visitors
   i. Training of emergency response personnel.
5. The following instructional materials shall be maintained:

   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

1. Documentation of completion of Radiological Orientation shall be maintained for visitors entering an area where radiation monitoring is required.

2. Records of doses, including zero dose, received by all visitors for whom monitoring was performed shall be maintained. These records shall be sufficient to evaluate compliance with all applicable dose limits and monitoring and reporting requirements.

732 Reports

Monitoring results, including zero dose, should be reported to each visitor monitored in accordance with Articles 511 or 521 within 30 days, and shall be reported no later than 90 days after the end of the visit.
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, Radiological Work Authorizations 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. Completed RWPs and RWAs should be maintained.

742 ALARA Records

Records of As-Low-As-Reasonably-Achievable (ALARA) action plans and goals shall be maintained in accordance with 10 CFR 835.701(a) to demonstrate the adequacy of the ALARA Program (10 CFR 835.101). 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 (10 CFR 835.704(c)) 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

1. Radiological Protection Programs require 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 shall contain sufficient detail to be meaningful even after the originator is no longer available. Radiological surveys should be recorded on appropriate standard forms and include the following common elements:
   a. Date, time and purpose of the survey
   b. General and specific location of the survey
   c. Meter serial number and calibration date
   d. Name and signature of the surveyor and analyst
   e. Pertinent information needed to interpret the survey results
   f. Reference to a specific RWA or RWP if the survey is performed to support the permit or authorization.

2. Records shall be maintained to document changes in monitoring equipment, techniques, and procedures (10 CFR 835.704(e)).

3. Records shall be maintained to document results of surveys for radiation and radioactive materials required by 10 CFR 835 (10 CFR 835.703(a)).

4. Records shall be maintained to document results of surveys, measurements, and calculations used to determine individual occupational exposures (10 CFR 835.703(b)).

5. Records shall be maintained to document results of surveys for release of materials from radiological areas (10 CFR 835.703(c)).
752 Radiation Surveys

1. In addition to the elements provided in Article 751, records of radiation surveys shall include, at a minimum, the following information:
   a. Instrument model and serial number
   b. Results of the measurements of area dose rates

753 Airborne Radioactivity

1. In addition to the elements provided in Article 751, records of airborne radioactivity shall include, at a minimum, the following information:
   a. Model and serial numbers of the sampler and laboratory counting instrument when available or unique identifier of each sampler and instrument
   b. Location of fixed air samplers
   c. Location of portable air samplers used for a survey
   d. Air concentrations in general airborne areas and breathing zones
   e. Supporting parameters, including collection efficiency, flow rate, duration of sampling, correction factors and filter medium.

754 Contamination Surveys

1. In addition to the elements required by Article 751, records of contamination surveys shall include, at a minimum, the following information:
   a. Model and serial number of counting equipment
   b. 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
   c. Location of areas found to contain hot particles or high concentrations of localized contamination
   d. Follow-up survey results for decontamination processes cross-referenced to the original survey.
PART 6 Instrumentation and Calibration Records

761 Calibration and Operational Checks

1. Calibration records for fixed, portable and laboratory radiation measuring equipment and individual monitoring devices, shall be maintained in accordance with 10 CFR 835.703(d) 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 (10 CFR 835.703(d)(1))
   b. Bioassay measurement equipment (10 CFR 835.703(d)(2))
   c. Laboratory, counting room and fixed radiation measuring equipment (10 CFR 835.703(d))
   d. Process and effluent monitors and sampling equipment
   e. Radiation area monitors (10 CFR 835.703(d)(1))
   f. Portal monitors and other personnel contamination monitors (10 CFR 835.703(d))
   g. Pocket and electronic dosimeters
   h. Air sampling equipment (10 CFR 835.703(d)(1))
   i. Tool and waste monitoring equipment
   j. Protective clothing and equipment monitors.

3. Documentation of instrument operational checks shall be maintained for a period not less than the calibration period of the instrument.

4. Maintenance histories, including the nature of any defects and corrective actions taken, and calibration results for each instrument shall 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 (Ref. 10 CFR 835.703(d)).
PART 7 Records Management

771 Media

A combination of media may be used for a comprehensive records system. For records that have long-term retention requirements (Ref. 10 CFR 835.701(b)) and are stored on media subject to degradation or obsolescence, the records system shall provide for conversion to a more stable medium. 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 medium
   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 useable after system modifications.

3. Optical disks may be used to archive records if the optical disks satisfy the following:
   a. A reliable system to prevent overwriting or erasure of records
b. Software and user controls consistent with Article 773.3[2]
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. DOE 1324.2A and 10 CFR 835 describe procedures for retaining records. **Upon cessation of activities that could result in the occupational exposure of individuals, all required records shall be transferred to DOE (10 CFR 835.702(h)).**

2. Once a record has been created, reviewed and signed by appropriate supervision, the record is considered complete and shall not be modified. Subsequent errors identified in a completed record may be corrected by creating a supplemental record that includes traceability for the correction.

### 775 Physical Protection of Records

1. Methods for protecting documents, consistent with DOE 1324.2A, should include vaults, file rooms with fixed fire suppression, fire rated cabinets, duplicate storage, or combinations of these.

2. Storage arrangements should address physical damage that could be caused by temperature extremes, moisture, infestation, electromagnetic fields, excessive light, stacking, theft and vandalism.

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

1. Personnel who are monitored by the personnel dosimetry program shall be provided an annual report of their dose (10 CFR 835.801(c)). Upon request, an individual shall receive a current radiation dose record (10 CFR 835.801(d)).

2. In accordance with 10 CFR 835.801(b) 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. A written estimate, based upon available information, shall be provided upon termination, if requested.

3. Reports of individual doses shall include the site or facility name, the individual's name and social security or employee number, and all dose information required by Article 722 (10 CFR 835.801(a)).

4. Reports of individual exposure to radiation or radioactive material required under DOE 5000.3B (10 CFR 835.1301(b) & (e)) or as a result of a planned special exposure (10 CFR 835.204(e)) shall be submitted to the Department in accordance with departmental occurrence reporting requirements. Copies of the individual dose information contained in these reports shall be provided to the affected individual at a time not later than transmittal of the report to the Department (10 CFR 835.801(e)).

782 Annual Radiation Report

DOE 5484.1 provides reporting requirements for the "Annual Radiation Dose Summary." This report includes internal and external radiation dose results for monitored DOE and DOE contractor employees, and for monitored visitors.
PART 9 Summary of Responsibilities

791 Senior Site Executive

792 Line Management
1. Document radiological safety measures used to protect personnel.

793 Radiological Control Manager
1. Maintain a radiological records management program.

794 ALARA Committee
1. Maintain ALARA Committee records

795 Workers
1. Complete all required records as prescribed (implementation of 10 CFR 701, 703 and 704).
2. Report all off-site visits where dosimeters are worn to LBNL Personal Dosimetry Office.

796 Support Organizations
1. Evaluate radiological exposures, including external and internal dosimetry (invitro and invivo), and document results in the LBNL Radiological Records Program System.
REFERENCES

The following references contain additional information pertinent to the provisions incorporated in the DOE Manual. For the LBNL RCM, LBNL has many of these references readily available. The citing Article is noted in brackets ([ ]) following each reference. See "Additional References" for addresses of organizations.

FEDERAL

Atomic Energy Act of 1954, as amended. Public Law 83-703. [112.1]


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]


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


MIL-F-51068 "Particulate Filters (High Efficiency Fire Resistant)" [464.2]
The following DOE Orders have been referenced. Readers should verify that the latest version of the referenced Order is used. Note the New Order System will be substituted when approved and incorporated into Contract 98.

DOE 1324.2A (4-9-92) "Records Disposition." [712.3, 774.1, 775.1]

DOE 5000.3B (2-22-93) "Occurrence Reporting and Processing of Operations Information." [127, 781.2]

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 N 5400.10 (12-11-92) "Extension of DOE N 5400.9." [236.3, 431.1]]

DOE 5480.4 (1-7-93) "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 N 5480.8 (6-8-93) "Radiological Health and Safety Policy"

DOE 5480.11 (12-21-88) "Radiation Protection for Occupational Workers." [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 5480.25 (11-3-92) "Safety of Accelerator Facilities." [364.2]
DOE 5484.1 (10-17-90) "Environmental Protection Safety and Health Protection Information Reporting Requirements." [721, 782]

DOE 5700.6C (8-21-1) "Quality Assurance." [743]

DOE 5820.2A (9-26-88) "Radioactive Waste Management." [441.1, 443.1, 443.2, 451.1]

DOE 6430.1A (4-6-89) "General Design Criteria." [128.1]

DEPARTMENT OF ENERGY GUIDES TO GOOD PRACTICES


DEPARTMENT OF ENERGY STANDARDIZED CORE TRAINING MATERIALS


DOE/EH-0260T-1 (1992) "Radiological Worker Training, Radiological Worker I, Lesson Plans."

DOE/EH-0260T-2 (1992) "Radiological Worker Training, Radiological Worker I, Study Guides."

DOE/EH-0261T-1 (1992) "Radiological Worker Training, Radiological Worker II, Lesson Plans."
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DOE/EH-0261T-2 (1992) "Radiological Worker Training, Radiological Worker II, Study Guides."


DOE/EH-0262T-3 (1992) "Radiological Control Technician, Phase I, Core Academic Training Lesson Plans."

DOE/EH-0262T-4 (1992) "Radiological Control Technician, Phase I, Core Academic Training Study Guides."

DOE/EH-0262T-5 (1992) "Radiological Control Technician, Phase I, Site Academic Training Lesson Plans."

DOE/EH-0262T-6 (1992) "Radiological Control Technician, Phase I, Site Academic Training Study Guides."

DOE/EH-0262T-7 (1992) "Radiological Control Technician, Phase II, Core/Site Practical Training."


DOE/EH-0262T-9 (1992) "Radiological Control Technician, Phase IV, Facility Practical Training Attachment."

DOE/EH-0262T-10 (1992) "Radiological Control Technician, Training Aids."

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AMERICAN NATIONAL STANDARDS INSTITUTE


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]


Z88.6 (1984) "Physical Qualifications for Respirator Use." [532]

AMERICAN SOCIETY FOR TESTING AND MATERIALS

E 1168 (1987) "Radiological Protection Training for Nuclear Facility Workers." [612]

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION


NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS


ADDITIONAL REFERENCES

Below is a selection of the many references used in developing this Manual:

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION


ICRP Publication 30 (1978-1979) "Limits for Intakes of Radionuclides by Workers."
ICRP Publication 32 (1981) "Limits for Inhalation of Radon Daughters by Workers."


INTERNATIONAL ATOMIC ENERGY AGENCY

Publications are available from the International Atomic Energy Agency, Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria.


NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS

Reports are available from the National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Bethesda, Maryland 20814.


NCRP Report No. 59 (1978) "Operational Radiation Safety Program."

NCRP Report No. 71 (1983) "Operational Radiation Safety Training."

NCRP Report No. 84 (1985) "General Concepts for Dosimetry of Internally Deposited Radionuclides."

NCRP Report No. 87 (1986) "Use of Bioassay Procedures for Assessment of Internal Radionuclide Deposition."

NCRP Report No. 106 (1989) "Limit for Exposure to 'Hot Particles' on the Skin."


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29 CFR 1910 "Occupational Safety and Health Standards."

Federal Guidance Report No. 11 (1988) "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion."

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DOE 5480.3 (7-9-85) "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes."

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N2.1 (1989) "Radiation Symbol." N2.3 (1979) "Immediate Evacuation Signal for Use in Industrial Installations Where Radiation Exposures May Occur."


N8.3 (1979) "Criticality Accident Alarm."


N13.3 (1981) "Dosimetry for Criticality Accidents."


N13.5 (R1989) "Performance Specification for Direct Reading and Indirect Reading Pocket Dosimeters for X- and Gamma Radiation."

N13.6 (R1989) "Practice for Occupational Radiation Exposure Record Systems."
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N42.17C (1989) "Performance Specifications for Health Physics Instrumentation - Portable Instrumentation for use in Extreme Environmental Conditions."


N319 (R1984) "Personal Neutron Dosimeters (Neutron Energies Less Than 20 MeV)."


N322 (1983) "Inspection and Test Specifications for Direct and Indirect Reading Quartz Fiber Pocket Dosimeters."

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Standards are available from the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pennsylvania 19103.

C-986 (1983) "Developing Training Programs in the Nuclear Fuel Cycle."
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Use

Each listing references a particular Article in the LBNL RCM. Those listings that are **Bolded Italic** reference both the applicable LBNL RCM Article Number and the corresponding 10 CFR 835 section.

Those 10 CFR sections that are most applicable to the user (shaded articles in LBNL RCM) will be highlighted in the index by shading for quick reference.

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GLOSSARY

For the purpose of this glossary, definitions with Bold Type or parts thereof represent additions to the DOE RCM Glossary to be consistent with those in 10 CFR 835; and definitions with Bold Italic and shaded are for the purpose of indicating important changes for user reference.

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: A numerical dose constraint established at a level below the regulatory limits to administratively control and help reduce individual and collective dose.

airborne radioactivity: Radioactive material in any chemical or physical form that is dissolved, mixed, suspended, or otherwise entrained in air.

airborne radioactivity area: Area where the measured concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed 10 percent of the derived air concentration (DAC) values. DAC values are contained in Appendices A and C of 10 CFR 835.

annual limit on intake (ALI): The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man (ICRP Publication 23) that would result in a committed effective dose equivalent of 5 rems (0.05 sievert) or a committed dose equivalent of 50 rems (0.5 sievert) to any individual organ or tissue. ALI values for intake by ingestion and inhalation, of selected radionuclides are based on Table 1. of the EPA's Federal Guidance Report No. 11, "Limiting values of radionuclide intake and air concentration and dose conversion factors for inhalation, submersion, and ingestion", published September 1988.

As Low As Reasonably Achievable (ALARA): An approach to radiological protection 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.

Area: For the purpose of contamination control, as any work space accessible to an individual's whole body or only extremities under normal work conditions; for the purpose of radiation exposure control, it is any work space accessible to an individual's body under normal work conditions.

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

background radiation: Radiation from:

(1) Naturally occurring radioactive materials which have not been technologically enhanced;
(2) Cosmic sources;
(3) Global fallout as it exists in the environment (such as from the testing of nuclear explosive devices);
(4) Radon and its progeny in concentrations or levels existing in buildings or the environment which have not been elevated as a result of current or prior activities; and
(5) Consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation.

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.

bioassay: The determination of the kinds, quantities, or concentrations, and, in some cases, locations of radioactive material in the human body, whether by direct measurement or by analysis and evaluation of radioactive materials excreted or removed from the human body.

calibration: The process of adjusting or determining either:

(1) The response or reading of an instrument relative to a standard (e.g., primary, secondary, or tertiary) or to a series of conventionally true values; or
(2) The strength of a radiation source relative to a standard (e.g., primary, secondary, or tertiary) or conventionally true value.

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.

contamination: The existence of radioactive material, as defined in this glossary, in an area not specified for radioactive material use under normal working conditions or which is not under the positive control of personnel conducting authorized work activities, and which exceeds the removable or total radioactivity levels in Table 2-3 of the LBNL Radiological Control Manual.

contamination area: Any area where contamination levels are greater than the values specified in Chapter 2, Table 2-3, but less than or equal to 100 times those levels.

contamination reduction corridor: A defined pathway though a hazardous waste site contamination education zone where decontamination occurs.

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.

contractor: Any entity under contract with the Department of Energy with the responsibility to perform activities at a DOE site or facility.

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.

controlled area: Any area to which access is managed in order to protect individuals from exposure to radiation and/or radioactive materials. Individuals who enter only the controlled area without entering radiological areas are not expected to receive a total effective dose equivalent of more than 0.1 rem (0.001 sievert) in a year.

conventionally true value of a quantity: The commonly accepted, best estimate of the true value of a quantity. The conventionally true value and the associated uncertainty will normally be determined by comparison with a national or transfer standard, using a reference instrument that has been calibrated against a national or transfer standard.
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.

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

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 declared to her employer, in writing, her pregnancy for the purpose of being subject to the occupational exposure limits to the embryo/fetus as provided in Article 215 (Ref. 10 CFR 835.206). This declaration may be revoked, in writing, at any time by the declared pregnant worker. (Ref. 10 CFR 835.1)

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

deposition, new confirmed: A deposition of radioactive material in the body or any organ or tissue of an individual identified during the current reporting period, confirmed through bioassay results to be greater than the site-determined reportable level.

derived air concentration (DAC): For the radionuclides listed in Appendix A of 10 CFR 835, the airborne concentration that equals the ALI divided by the volume of air breathed by an average worker for a working year of 2000 hours (assuming a breathing volume of 2400 m³). For radionuclides listed in Appendix C of 10 CFR 835, the air immersion DACs were calculated for a continuous, non-shielded exposure via immersion in a semi-infinite atmospheric cloud. The values are based upon the derived airborne concentration found in Table 1 of the U. S. Environmental Protection Agency's Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, published September 1988.

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.
DOE activity: An activity taken for or by the DOE that has the potential to result in the occupational exposure of an individual to radiation or radioactive material. The activity may be, but is not limited to, design, construction, operation, decontamination or decommissioning. To the extent appropriate, the activity may involve a single DOE facility or operation or a combination of facilities and operations, possibly including an entire site.

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.

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

absorbed dose (D): Energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).

collective dose: The sum of the total effective dose equivalent values for all individuals in a specified population. Collective dose is expressed in units of person-rem (or person-sievert).

committed dose equivalent (H_{T,50}): The dose equivalent calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem (or sievert).
committed effective dose equivalent \((H_{E,50})\): The sum of the committed dose equivalents to various tissues in the body \((H_{T,50})\), each multiplied by the appropriate weighting factor \((w_T)\) - that is \(H_{E,50} = w_T H_{T,50}\). Committed effective dose equivalent is expressed in units of rem (or sievert).

cumulative total effective dose equivalent: The sum of the total effective dose equivalents recorded for an individual for each year of employment at a DOE or DOE contractor site or facility, effective January 1, 1989.

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

dose equivalent \((H)\): The product of the absorbed dose \((D)\) (in rad or gray) in tissue, a quality factor \((Q)\), and all other modifying factors \((N)\). Dose equivalent is expressed in units of rem (or sievert) \((1 \text{ rem} = 0.01 \text{ sievert})\).

effective dose equivalent \((H_E)\): The summation of the products of the dose equivalent received by specified tissues of the body \((H_T)\) and the appropriate weighting factors \((w_T)\) - that is \(H_E = W_T H_T\). It includes the dose from radiation sources internal and/or external to the body. The effective dose equivalent is expressed in units of rem (or sievert).

external dose or exposure: That portion of the dose equivalent received from radiation sources outside of the body (e.g., "external sources").

internal dose or exposure: That portion of the dose equivalent received from radioactive material taken into the body (e.g., "internal sources").

lens of the eye dose equivalent: The external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 cm.

quality factor: The principal modifying factor used to calculate the dose equivalent from the absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate quality factor \((Q)\). Quality Factors for X-rays, neutrons, beta particles, protons and alpha particles are given in 10 CFR 835.2
Quality Factors

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<tr>
<td>greater than one atomic mass unit</td>
<td></td>
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<tr>
<td>Alpha particles and multiple-charged particles (and particles of unknown</td>
<td>10</td>
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<tr>
<td>charge) of unknown energy</td>
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**shallow dose equivalent:** The dose equivalent deriving from external radiation at a depth of 0.007 cm in tissue.

**total effective dose equivalent (TEDE):** The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). Deep dose equivalent to the whole body may be used as effective dose equivalent for external exposures.

**weighting factor ($W_T$):** The fraction of the overall health risk, resulting from uniform, whole body irradiation, attributable to specific tissue ($T$). The dose equivalent to the affected tissue, $H_T$, is multiplied by the appropriate weighting factor to obtain the effective dose equivalent contribution from that tissue. Weighting factors are given in Appendix 2B of this manual.

**whole body:** For the purposes of external exposure, head, trunk (including male gonads), arms above and including the elbow, or legs above and including the knee.

**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.
**entrance or access point:** Any location through which an individual could gain access to areas controlled for the purposes of radiation protection. This includes entry or exit portals of sufficient size to permit human entry, irrespective of their intended use.

**extremity:** Hands and arms below the elbow or feet and legs below the knee.

**facility:** For the purpose of this Manual, a facility includes systems, buildings, utilities, and related activities whose use is directed to a common purpose at a single location. Examples include: accelerators, storage areas, test loops, nuclear reactors, radioactive waste disposal systems and burial grounds, testing laboratories, research laboratories, and accommodations for analytical examinations of components. Also includes: pipelines, ponds, impoundments, landfills and the like, and motor vehicles, rolling stock, and aircraft.

**filter integrity test:** Test performed on High-Efficiency Particulate Air (HEPA) filters to identify any damage to the filter or leakage around the filter.

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

**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.

**general employee:** An individual who is either a DOE or DOE contractor employee; an employee of a subcontractor to a DOE contractor; or a visitor who performs work for or in conjunction with DOE or utilizes DOE facilities.

**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 monodispersed di-octyl phthalate 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 2-3, of this Manual.

**high radiation area:** An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem (0.001 Sv) 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.

**Individual:** Any human being.

**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 used to irradiate other materials 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.
member of the public: An individual who is not occupationally exposed to radiation or radioactive material. An individual is not a "member of the public" during any period in which the individual receives occupational exposure.

minor: An individual less than 18 years of age.

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

monitoring: Actions intended to detect and quantify radiological conditions.

nonstochastic effects: Effects due to radiation exposure for which the severity varies with the dose and for which a threshold normally exists (e.g., radiation-induced opacities within the lens of the eye).

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: An individual's dose due to exposure to ionizing radiation (external and internal) as a result of that individual's work assignment. Occupational dose does not include planned special exposures, exposure received as a medical patient, background radiation, or voluntary participation in medical research programs.

person: Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency, any State or political subdivision of, or any political entity within a State, any foreign government or nation or other entity, and any legal successor, representative, agent or agency of the foregoing; provided that person does not include the Department of Energy or the United States Nuclear Regulatory Commission.

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.

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.

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."

public: Any individual or group of individuals who is not occupationally exposed to radiation or radioactive material. An individual is not a "member of the public" during any period in which the individual receives an occupational dose.

Qualification Standard: The explicit performance requirements for minimum proficiency in technical, academic, and site-specific knowledge and practical skills used in determining satisfactory completion of training programs. The qualification standard is used to qualify radiological control technicians (RCTs) at DOE facilities.

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 or ionizing radiation: Alpha particles, beta particles, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation as used in this manual does not include non-ionizing radiation, such as radio-, or micro-waves, or visible, infrared, or ultraviolet light.

radiation area: An area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.005 rem (0.05 mSv) in one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.
radioactive material: Is defined as any material which emits radiation spontaneously, including source, byproduct, special nuclear, or activated material regulated by the Department of Energy. For the purpose of this definition, naturally occurring radioactive material (NORM) (not regulated) is excluded. For the purpose of unsealed radioactive material control, material with less than 10% of the activity values in Table 1 of DOE-N-5400.9 is excluded under the RWP and RWA programs but is still subject to controls commensurate with the hazard. (The values listed in DOE-N-5400.9 Table 1 were based upon a dose yield of 10 mrem (CEDE) for a credible accident to members of the public.)

radioactive material area: An area or structure where radioactive material 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 area: Any area within a controlled area (but not including the controlled area) which must be posted as a "radiation area," "high radiation area," "very high radiation area," "contamination area," "high contamination area," or "airborne radioactivity area" in accordance with 10 CFR 835.603.

radiological buffer area (RBA): A intermediate area established to prevent the spread of radioactive contamination and to protect personnel from radiation exposure.

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.

radiological control technician: Is defined as an individual who is either an LBNL employee or an employee of an LBNL subcontractor who is qualified to perform site wide radiological surveillance, monitor adherence to radiological control requirements and is accountable.
**radiological label:** Label on an item which indicates the presence of radiation or radioactive materials.

**radiological materials management area (RMMA) and radioactive materials area (RMA):** Are defined as "controlled areas" where radioactive material, contaminated material or material with induced activity is used, handled or stored.

**radiological posting:** Sign, marking, 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 authorization (RWA):** The document which specifies authorized amount and isotope, precautions required for worker protection and the monitoring requirements for routine radiological work within specified guidelines. The Radiological Work Authorizations serve as an administrative control for planning, inventorying, re-training, reviewing radiological work processes, and informing the worker of radiological safety requirements for the authorized work.

**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 workers:** General employees who are required to complete Radiological Worker training because their 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." Individuals who complete LBNL Radiological Worker Training are considered radiological workers.

**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.

representative sample: A sample that closely approximates both the concentration of activity and the physical and chemical properties of material (e.g., particle size and solubility in case of air sampling of the aerosol to which workers may be exposed).

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

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.

sealed radioactive source: Radioactive material that is contained in a sealed capsule, sealed between layer(s) 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. Sealed sources with greater than or equal to activity values in Table I of DOE-N-5400.9 require inventory and leak testing semiannually.

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

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

sticky pad: Step-off pad provided with a tacky surface to reduce the potential for inadvertently tracking contamination out of a contaminated area.
stochastic effects: Malignant and hereditary diseases for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose without a threshold for radiation protection purposes.

survey: An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

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.

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

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.

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 individuals, in which radiation levels could result in an individual 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.

year: The period of time beginning on or near January 1 used to determine compliance with the provisions of this Manual. The starting date of the year used to determine compliance may be changed provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years.
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