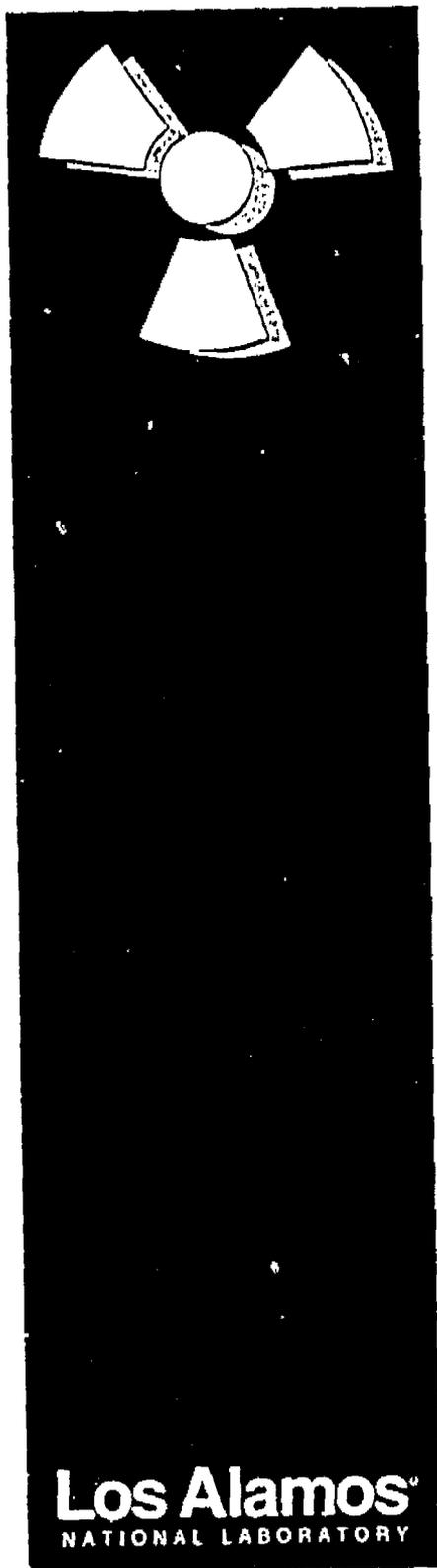


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LM107-01.1

December 23, 1994



Los Alamos National Laboratory

radiological control manual

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LABORATORY MANUAL

**LOS ALAMOS NATIONAL LABORATORY
RADIOLOGICAL CONTROL MANUAL**

LM107-01.1

(LABORATORY DOCUMENT CONTROL NUMBER 162)

Effective Date: December 23, 1994

APPROVALS

Prepared by: William F. Eisele Date: 12/22/94
 William F. Eisele
 ESH-12 Policy and Documentation Team Leader

Approved by: J. M. Graf Date: 12/22/94
 Joseph M. Graf
 Radiation Protection Program Manager

Approved by: Joseph M. Ortega Date: 12/22/94
 Joseph M. Ortega, Director
 Laboratory Policy and Coordination Office

Approved by: Dennis J. Erickson Date: 12/22/94
 Dennis J. Erickson
 Environment, Safety, and Health Division Director

Approved by: James F. Jackson Date: 12/22/94
 James F. Jackson
 Los Alamos National Laboratory Deputy Director

Effective Date: December 23, 1994

DEPARTMENT OF ENERGY
Radiological Health and Safety Policy

It is the policy of DOE 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, DOE 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. The DOE is fully committed to implementing a radiological control program of the highest quality that consistently reflects this policy.

In meeting this policy, DOE shall do the following:

1. Establish and maintain a system of regulatory policy and guidance reflective of national and international radiation protection standards and recommendations. The Assistant Secretary for Environment, Safety and Health (or the Director, Naval Reactors, for that program) has responsibility for promulgating and maintaining policies, standards, and guidance related to radiological protection. Departmental radiological protection requirements are, at a minimum, consistent with the Presidentially approved Radiation Protection Guidance to Federal Agencies developed by the Environmental Protection Agency in accordance with its mandated Federal guidance responsibilities. Departmental requirements often are more stringent and reflect, as appropriate, recommendations and guidance from various national and international standards-setting and scientific organizations, including the International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, the American National Standards Institutes, and others. The DOE requirements related to radiological protection will be set forth, as appropriate, in rules and DOE Orders, and guidance documents will be issued on acceptable means to implement these requirements.
2. Ensure personnel responsible for performing radiological work activities are appropriately trained. Standards shall be established to ensure the technical competency of the DOE work force, as appropriate, through implementation of standardized and mandated radiological training and development programs.
3. Ensure the technical competence of personnel responsible for implementing and overseeing the Radiological Controls 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 the Department's radiological control policy. Qualification requirements commensurate with this objective shall be established for technical and professional radiological control program positions and shall, at a minimum, be consistent with applicable industry standards and promote professional development and excellence in radiological performance.
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 DOE radiological protection requirements, and for minimizing personnel radiation exposure, starts at the worker level and broadens as it progresses upward through the line organization. The Department's line managers are fully responsible for radiological performance within their programs and the field activities and sites assigned to them, and shall take necessary actions to ensure requirements are implemented and performance is monitored and corrected as necessary.
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. Policy, guidance, and quality control programs shall be directed towards ensuring such measurements are appropriate, accurate, and based upon sound technical practices.

6. Conduct radiological operations in a manner that controls the spread of radioactive materials and reduces exposure to the work force and the general public and that utilizes a process that seeks exposure levels as low as reasonably achievable. Radiological operations and activities shall be preplanned to allow for the effective implementation of dose and contamination reduction and control measures. Operations and activities shall be performed in accordance with DOE conduct of operations requirements and shall include reasonable controls directed towards reducing exposure, preventing the spread of radiological contamination, and minimizing the generation of contaminated wastes and the release of effluents.
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 shall 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. Radiological design criteria shall reflect appropriate consensus recommendations of national and international standards setting groups.
8. Conduct oversight to ensure departmental requirements are being complied with and appropriate radiological work practices are being implemented.

All departmental elements shall conduct their radiological operations in a manner consistent with the above policies and objectives.

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- PART 2 Leadership in Radiological Control
- PART 3 Improving Radiological Performance
- PART 4 LANL Radiation Protection Organization
- PART 5 DOE Management

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- PART 1 Administrative Control Levels and Dose Limits
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CHAPTER 1 EXCELLENCE IN RADIOLOGICAL CONTROL

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PART 1 LANL Radiological Control Manual**111 Radiological Control Policy**

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

"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 (DOE), the University of California (UC) at Los Alamos National Laboratory (referred to in this document as LANL or "the Laboratory"), and LANL's subcontractors are firmly committed to having a Radiological Control Program (referred to at LANL as "Radiation Protection Program") of the highest quality. The Radiation Protection Program applies to LANL activities that concern the management of radiation and radioactive materials and that may result in radiation exposure to workers and the public and unplanned releases of radioactive material to the environment.

DOE's radiological control policy, shown below, summarizes the elements of DOE's radiological health and safety policy and is intended to guide the actions of every person involved in radiological work throughout the department and its contractors and subcontractors.

DOE 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 such 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.

LANL Director's Policies DP107, "Radiation Protection," and DP110, "Quality," establish LANL's radiological control policy.

112 Manual Applicability and Control

The *LANL Radiological Control Manual* establishes practices for the conduct of radiation protection activities at all LANL facilities except those at the Nevada Test Site (NTS). NTS has established its own site-specific radiological control manual to ensure consistent, high-quality radiological control for all user organizations at the site. The *LANL Radiological Control Manual* applies to LANL (UC) employees, contractors and subcontractors (e.g., maintenance subcontractors), visiting scientists, DOE or Department of Defense personnel, members of the public, and any other personnel who perform work at LANL or visit LANL in an official capacity. The *LANL Radiological Control Manual* states DOE's positions and views, as adapted by LANL, on the best courses of action currently available in the area of radiological controls. Accordingly, the provisions in the *LANL Radiological Control Manual* should be viewed by all LANL employees and subcontractors as acceptable techniques, methods, or solutions for fulfilling their duties and responsibilities in the area of radiological control. The *LANL Radiological Control Manual* shall be used by DOE, LANL line management, and the Laboratory Audits and Assessments Office (AA) in evaluating the performance of its employees and subcontractors.

Most of the *LANL Radiological Control Manual* is taken verbatim from the *DOE Radiological Control Manual*. As necessary, the *DOE Radiological Control Manual* was modified and supplemented to make it applicable to LANL.

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

1. — The provisions of this manual apply to DOE or DOE-funded activities performed at LANL where radiation or radioactive material is present or being used. Laboratory management is responsible for complying with the requirements of 10 CFR, Part 835, "Occupational Radiation Protection," as delineated in the Laboratory's 10 CFR 835 Radiation Protection Program (RPP). The DOE-approved RPP documents the Laboratory's commitments to and exemptions from the requirements of the 10 CFR 835 rule. ^{10 CFR 835.2(b), 835.21(a)}
2. [Reserved]
 - The lead DOE Headquarters Defense Programs program secretarial officer and the Office of Environment, Safety, and Health shall be included in the review and concurrence process in these situations. In those cases at non-DOE sites or facilities in which a specific radiological activity is being conducted pursuant to an NRC or agreement state license, the provisions of the *LANL Radiological Control Manual* are not binding to that activity. ^{10 CFR 835.2(b), 835.21(a)}
3. The provisions of this manual are not binding upon activities at LANL 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 *LANL Radiological Control Manual* is a living document. LANL, with input from appropriate subcontractor organizations, intends to review and update provisions on a periodic basis to incorporate lessons learned and suggestions for improvement. The Environment, Safety, and Health (ESH) Division is responsible for this task. Recommendations to correct or improve the *LANL Radiological Control Manual* are encouraged and may be sent to the Policy and Program Analysis Group (ESH-12). The recommended wording of the change to the *LANL Radiological Control Manual*, as well as the basis and justification for the change, is requested.

DOE also intends to review and update provisions to the *DOE Radiological Control Manual* 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 Radiological Control Manual* are encouraged and should be sent through ESH-12 to the DOE Radiological Control Program

advisor (Article 151)¹ of the DP program secretarial officer. 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 to the *DOE Radiological Control Manual*, as well as the basis and justification for the change, should be included.

5. DOE has incorporated by reference the provisions in the *DOE Radiological Control Manual* into the LANL contract with the University of California. These incorporated provisions shall be enforceable by DOE pursuant to the contract or underlying regulations. No exception to or interpretation of an incorporated provision shall be provided pursuant to the contract. When incorporating a provision, LANL submits to DOE for approval an implementation plan that includes a compliance schedule. Implementation of the *DOE Radiological Control Manual* is expected, as described in the *LANL Radiological Control Manual* and implementation plan, to take place over a period of time consistent with the schedules and resources identified in the DOE-approved implementation plan. The lead program secretarial officers in DP at DOE Headquarters will be included in the review and concurrence process for the LANL implementation plan.
6. The *DOE Radiological Control Manual* shall be kept current and should be entered into the LANL document control system. The Office of Environment, Safety, and Health shall ensure that a current version of the *DOE Radiological Control Manual* is maintained on the DOE Safety Performance Measurement System (SPMS).
7. The provisions of the *LANL Radiological Control Manual* do not apply to facilities and activities of the Naval Nuclear Propulsion Program, which are covered separately under Executive Order 12344 (42 U.S.C 7158, note), and patients undergoing medical treatment at a DOE or DOE-funded facility.
8. — Nothing in this manual and its implementing documents shall be construed as limiting actions that may be necessary to protect health and safety. ^{10 CFR 103.5(d)}
9. The table in the Appendix of this manual refers to specific hierarchical Laboratory policies, standards, procedures, and other documents that further implement the requirements of the manual. These references are listed for information only; the user is responsible for confirming that the referenced documents can actually be used to implement the requirements.

The table in the Appendix of this manual may be revised without revision of the body of the manual. The Radiation Protection Program manager or designee is responsible for reviewing and approving revisions to the table, and a revision is effective when approved by the Radiation Protection Program manager or designee. The table will carry the same numerical revision number as the body of the manual, with an alphabetical character (a, b, c, etc.) added to track table revisions when the body of the manual is not revised.

For example, revision 1.c of the table corresponds to Revision 1 of the manual, but shows that the table has been revised twice (revisions 1.b and 1.c) since Revision 1 of the manual was issued. When the body of the manual is revised, the numerical revision number of the table shall be set to the manual revision number, and the alpha character indicator of the table will be reset to "a."

¹The 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.

113 Compliance

1. The *DOE Radiological Control Manual* sets forth DOE's views on the proper course of action in the area of radiological control within the scope of DOE-sponsored activities. The *LANL Radiological Control Manual* defines the application of the *DOE Radiological Control Manual* to LANL activities and describes how LANL implements the DOE guidance. When LANL fully implements a provision, LANL shall have complied with, and most likely exceeded, any related statutory, regulatory, or contractual requirement. When incorporated into contracts, the provisions of the *DOE Radiological Control Manual* are binding requirements. The words "shall" and "should" have the meaning defined below when a provision is incorporated into a contract.
2. The word "shall" identifies those elements and requirements that have been considered and found by DOE to be mandatory unless prior approval of an alternative approach is obtained from DOE Headquarters. If LANL wishes to implement an alternative approach, LANL shall submit the internally approved suggested alternative approach to the lead DOE Headquarters DP program secretarial officer for review. Before final approval by the lead DOE Headquarters DP program secretarial officer, other affected program secretarial officials and the Office of Environment, Safety, and Health shall concur on the suggested alternative approach. The submittal shall contain the description of the alternative approach, the technical rationale and basis, the suggested wording, and the justification that the alternative will achieve equal or improved performance employing equal or better techniques, solutions, or methods.

The development of the submittal is jointly coordinated by the originating organization, the Laboratory Policy Coordination Office (LPCO), and ESH-12. The submittal will be approved by the Radiation Protection Program manager and the Laboratory director or designee.

3. The word "should" means LANL has the responsibility of either following the provision or demonstrating technical equivalency by an alternative solution. The use of "should" recognizes that site- or facility-specific attributes may warrant special treatment and that literal compliance with the elements and requirements of the provision may not achieve the desired level of radiological control performance. In cases in which LANL decides to follow an alternative technique, approach, or method in lieu of the "should" provision, the following actions are required:
 - a. The alternative solution shall be documented by the originating organization, with supporting technical basis, analysis, and justification to demonstrate technical equivalency.
 - b. Before implementation, the approval of the LANL Radiation Protection Program manager and the Laboratory director or designee shall be required. DOE approval is not required or expected.
 - c. The documented justification, including the required LANL approvals, shall be readily retrievable for review and audit by DOE.
 - d. At the conclusion of each calendar year, LANL shall provide to the DOE Los Alamos Area Office (DOE/LAAO) field office manager and the lead DOE Headquarters DP program secretarial officer a tabulation of all such equivalency determinations approved within the past 12 months. For ease of reference, these may be referred to as Article 113 determinations. The tabulation of the Article 113 determinations is maintained by ESH-12. The submittal of the tabulation is made by the LPCO with the approval of the LANL Radiation Protection Program manager and the Laboratory director or designee.
4. ⇒ An arrow indicates *LANL Radiological Control Manual* text that implements a specific 10 CFR 835 requirement. The reference itself, cited in superscript, indicates where the text ends. Outline arrows (⇨), as opposed to filled-in arrows (⇒), indicate 10 CFR 835 material *within* 10 CFR 835 material. Failure to follow the requirements contained in this text could result in civil and/or criminal legal action against the Laboratory, Laboratory employees, or subcontractors. This text may not be modified in any way without consulting ESH-12.
10 CFR 835.3(a)

114 Site-Specific Manual

1. The *LANL Radiological Control Manual* (this document) shall be issued and endorsed by the Laboratory director or designee. The *LANL Radiological Control Manual* does not require review or approval by the DOE. LANL's approach to the development of the *LANL Radiological Control Manual* is to invoke the provisions of the *DOE Radiological Control Manual* as written with site-specific additions clearly indicated, included in the appropriate chapters, and directly referenced to the corresponding article. Additions and supplements to address unique situations or to provide more detailed or prescriptive direction may be included only if these additions do not conflict with or diminish the requirements of the *DOE Radiological Control Manual*. The Laboratory director has final, on-site corporate authority with respect to the *LANL Radiological Control Manual*.
2. LANL management policies, requirements, expectations, and objectives for the LANL Radiation Protection Program should be clearly and unambiguously stated in the *LANL Radiological Control Manual*. Because this manual conveys program requirements for the LANL Radiation Protection Program, a separate program requirements document (PRD) for the program will not be developed and issued.
3. The *LANL Radiological Control Manual* shall be kept current and entered into the LANL document control system.
4. There should be one *LANL Radiological Control Manual* for the entire Laboratory and one radiation protection organization at LANL comprising the Health Physics Operations Group (ESH-1), the Health Physics Measurements Group (ESH-4), and the Policy and Program Analysis Group (ESH-12) (see Article 141). Each facility may have facility-specific programs and procedures that implement the *LANL Radiological Control Manual*, but the intent and requirements in the *LANL Radiological Control Manual* must be maintained. Some of the documents describing these programs and procedures are listed in Appendix 1A.
5. — Subcontractors shall comply with the *LANL Radiological Control Manual*. 10 CFR 835.101(a)
6. Where DOE employees are conducting the transport of nuclear devices or components at LANL, a program-specific radiological control manual, based upon the provisions of the *DOE Radiological Control Manual*, shall be issued and approved by the LAO field office manager. Controlled copies of such DOE program-specific manuals shall be provided to the lead DOE Headquarters DP program secretarial officer.
7. Change bars in the right-hand margin indicate where LANL-specific text has been added or where the DOE manual text has been *significantly* modified.

115 Applying the Requirements

1. The *DOE Radiological Control Manual* assumes that the Laboratory has organizations in place that generally meet the requirements presented in the text. DOE does not intend that the Laboratory create new or separate organizations if those functions can be incorporated into existing ones. For example, the radiological awareness committee functions of Article 132.3 may be performed by an existing safety committee. It is expected, however, that the existing committee charter will be revised to reflect the requirements and emphasis of the *LANL Radiological Control Manual*. Similarly, position titles that are used in the *DOE Radiological Control Manual* may be designated differently in the *LANL Radiological Control Manual*. A phased approach to transition to the use of the titles of positions in the *LANL Radiological Control Manual* should be adopted. Corresponding position descriptions and organizational charts should be revised to accurately reflect required 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. For example, a facility with an annual collective effective dose equivalent of 1 person-rem or less, where people work with small quantities of unsealed radioactive material, would not be expected to have an *as low as reasonably achievable* (ALARA)

program as complex as one required at high-dose facilities. At low-dose facilities, some program elements may be satisfied by brief policy statements.

116 User Groups

1. The *DOE Radiological Control Manual* encourages DOE contractors to establish informal working associations that promote dialogue among the radiation protection organizations from comparable DOE facilities. The DOE recommends that user groups should include representation from various contractors. Members should be assigned to the user groups on a rotating basis.
2. To assist contractors in identifying and adopting proven practices and implementing procedures in a timely manner within the DOE complex, the DOE encourages contractors to develop, through the user groups, radiological work practices handbooks that can be used by a given category or class of facilities associated with the user group.

The DOE's suggested user group categories are as follows:

- a. Reactors
- b. Uranium
- c. Environmental restoration/waste management
- d. Plutonium
- e. Tritium
- f. Accelerators
- g. Large research and development laboratory operations
- h. Small research and development laboratory operations (annual collective effective dose equivalent of 1 person-rem or less)

The development of such handbooks should be coordinated with the DOE Office of Environment, Safety, and Health.

PART 2 Leadership In Radiological Control

Superior, consistent performance is achieved when qualified personnel use approved procedures and managers actively monitor the workplace and assess 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 line managers, the operating divisions, the operating groups, and ESH Division are required to achieve a superior radiation protection program. Managers lead by example. What managers do speaks louder than what managers say. Managers at all levels should emphasize the need for high standards for radiological control through direct communication, instruction, and inspection of the work space. The LAAO field office manager and the Laboratory director should have a basic knowledge of radiation, its effects, and radiological control requirements. The LAAO field office manager and the Laboratory director should also be familiar with LANL's current radiological performance record. Key principles common in a successful, well-managed radiation protection program are provided in this chapter.

121 Senior Management Commitment

1. LANL senior managers should establish high standards for the adherence of their workers to radiological control requirements. These standards and management expectations should be frequently communicated to the work force.
2. Senior management has stated in writing its commitment to a radiation protection program of the highest quality by issuance of Director's Policy DP107, "Radiation Protection." 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 orientations and training 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 control performance. Relevant knowledge and performance should be assessed as a specific part of each person's performance evaluation. This assessment should not be limited to those who work with radiation or radioactive materials, because many other workers have an impact on the radiation protection program.
5. Senior managers should solicit feedback from their radiological control professionals, line managers, and workers on radiological control performance.
6. Senior managers should adopt and promote a positive attitude toward radiological control that encourages initiatives to identify concerns at an early stage, to prevent problem situations from deteriorating, and to promote doing the right job correctly the first time.
7. Preventing the spread of radioactive contamination is less costly than remediation after the fact. Managers should be willing to accept change that will improve radiological control and should foster this mind set throughout LANL.
8. Senior managers shall require and approve radiological performance goals. Goals should be measurable, realistic, auditable, and challenging. Established goals should not be changed without technical justification and senior management approval. Senior managers shall review progress toward the goals at least quarterly.
9. A performance indicator program for measuring the effectiveness of the Radiation Protection Program against predetermined goals and determining trends in the program should be established and maintained by the Laboratory's Appraisal and Performance Analysis Group (AA-1) with support from ESH-12 as part of the quarterly reporting requirement to senior management.

10. Line managers are responsible for identifying the workers in their organization whose duties classify them as radiological workers and ensuring that these workers receive the necessary training. The authority and responsibility for establishing a comprehensive and effective Laboratory-wide radiological control training program should be assigned to line managers and their subordinates. Training, in most cases, should be provided by a dedicated training organization.
11. Senior managers and line 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 members of the public.
12. Reporting a problem to a superior at LANL or DOE does not absolve the line manager or worker from promptly fixing or mitigating a situation.
13. Senior and line managers and the Radiation Protection Program manager should be committed to applying the principles of quality management to the LANL Radiation Protection Program.

122 Worker Attitude

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

1. Each radiological worker should understand that proper radiological control is an integral part of his or her 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 should be developed at all levels of management and in the work force. Cooperation among all workers having potential contact with radioactive materials and radiation-generating devices at LANL (e.g., the work force) and the radiation protection organization has to be developed and fostered. The workers should not look upon radiological controls as hurdles or restrictions to be bypassed.
4. Radiation protection organization personnel should be helpful in showing workers how to follow the rules. This spirit of cooperation needs to be developed without subverting the authority of the radiological control technicians. A situation in which radiological controls are left solely to the radiation protection 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. Personnel shall take precautions to protect themselves, their associates, and the public from unnecessary exposure to radiation and radioactive materials under their control. The following radiological control rules apply 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 RADIOACTIVITY,
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 in accordance with Director's Policy DP116.

DO NOT

- Loiter in radiation areas.
- Smoke, eat, drink, or chew in Controlled Areas and Radiological Buffer Areas (controlled for contamination purposes), Contamination Areas, High Contamination Areas, or Airborne Radioactivity Areas.

BE SURE TO

- Wear personnel monitoring devices where required by radiological work permits, signs, procedures, or radiological control personnel. Report immediately the loss, damage, or unexpected exposure of personnel monitoring devices or off-scale readings of self-reading or electronic dosimeters to the radiation protection organization.
- Keep track of your radiation exposure status and avoid exceeding radiological administrative control levels and RWP-specific exposure limits.
- Wear personal protective equipment and clothing properly whenever required by radiological work permits, procedures, radiological control personnel, or postings.
- Minimize the spread of potential radioactive spills and promptly notify your spill coordinator, the Emergency Management and Response Group, and the spill response team.
- 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 or monitoring equipment.
- Notify radiological control personnel of off-site occupational radiation exposures so that worker dosimetry records can be updated.

BEFORE ENTERING AREA

- Ensure 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.
- Have necessary materials and equipment on hand to complete your task, thereby minimizing time and exposure.
- Notify radiological control personnel of the presence of open wounds, sores, or rashes before entering an area where contamination exists, and exit immediately if you receive a wound while in such an area.

UPON LEAVING AREA

- Properly remove personal protective equipment and clothing to minimize the spread of contamination.
- Frisk or be frisked for contamination when leaving posted Contamination, High Contamination, or Airborne Radioactivity Areas and associated Controlled and Radiological Buffer Areas, and notify radiological control personnel when contamination is found.

124 Radiation and Risk Communication

Because of the continuing concerns many people have about low radiation exposure and health impacts, managers of radiological workers should be trained to deal with the worker's perceptions of 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. ESH-1 personnel (managers, staff, and radiological control technicians) and other appropriate personnel in ESH-4, ESH-12, and the line organizations (e.g., line organization ALARA coordinator) should receive training that is helpful in dealing with workers who have anxiety about radiation. This training should include the following:
 - a. Guidance on handling such personnel interactions
 - b. Emphasizing the facts
 - 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 previous years, are concerned about future exposures. Such instances warrant special attention on the part of the line manager and the radiation protection organization. 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 Conducting Radiological Operations

1. The *LANL Radiological Control Manual* is consistent with the guidance in DOE 5480.19, "Conduct of Operations Requirements for DOE Facilities." The concepts of all chapters in DOE 5480.19 apply to the conduct of radiological control.
2. As appropriate, managers at all levels are expected to be involved in the planning, scheduling, and conduct of radiological work. Ensurance of adequate radiological safety should not be compromised to achieve production, remediation, or research objectives.
3. First-line supervisors of radiological workers 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 of radiological workers should periodically monitor work areas to observe personnel at work and to identify discernible radiological deficiencies (i.e., "walk the spaces"). Frequent inspections and walk-throughs, including those conducted during off-hours and weekends (where appropriate), are essential to reinforce management expectations of the work force.
5. Managers, first-line supervisors, and workers should be involved in developing accurate, clear, written procedures (e.g., safe operating procedures) for performing radiological work. If, while using a procedure, a written requirement cannot be responsibly followed, the work should be stopped and guidance obtained from the cognizant supervisor or line manager.
6. First-line supervisors and managers should encourage the work force to identify radiological control deficiencies and concerns. Prompt action should be taken to address and eliminate identified issues and prevent recurrence. Retraining and procedure review are useful in addressing these issues.

7. Managers and first-line 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 Radiation 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 radiological conditions in the area and be aware of the possibility that unforeseen changes may occur. 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. 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 when entering High Radiation Areas and monitoring of tools and equipment for contamination as a qualitative check during work in Contamination Areas. The performance of legal record surveys such as release surveys remains the responsibility of qualified radiological control technicians or other adequately trained personnel under the oversight of the radiation protection organization.

127 Critiques

DOE and LANL desire and expect, based on concern for the safety and well-being of workers and members of the public, that radiological work practices will 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) of DOE 5000.3B. 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."

LANL has established a Radiological Incident Reporting System (RIRS) to track and determine trends in incidents involving radioactive materials and radiation-generating devices that are below DOE 5000.3B reporting levels ("near misses").

128 Facility Modifications and Radiological Design Considerations

1. Radiological control performance is affected by human performance and engineered design features. Radiation exposure rates in controlled and radiological areas should be reduced to ALARA levels by facility design and control. The *LANL Radiological Control Manual* primarily addresses the way people operate and use existing facilities and sites; however, — the primary means for keeping exposures ALARA in new facilities is through

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engineered controls such as confinement, ventilation, remote handling, and shielding. ^{10 CFR 835.1003(a)(1)} Administrative controls and procedural requirements are considered secondary means of achieving control. The guidelines below apply to the design and modification of facilities. Personal property and programmatic equipment (PP and PE), as defined in the glossary of this manual, should be included in facility design and modification. General design criteria for new facilities and major modifications to existing facilities are contained in 10 CFR 835 and DOE Order 6430.1A. — In addition, the following radiological control design criteria are provided for new facilities and major modifications to existing facilities.

- a. The design objective for limiting individual dose shall be ALARA and shall not exceed 20 percent of the radiological-worker annual dose limits specified in Table 2-1 except that the annual design limit for radiological-worker total effective dose equivalent should not exceed 500 mrem (10 percent of the value in Table 2-1). ^{10 CFR 835.1002(a)(b)}
 - b. Discharges of radioactive liquid to the environment, covered by the provisions of DOE 5400.5, should not degrade the quality of the groundwater.
 - c. Control of contamination should be achieved by containment of radioactive material.
 - d. — Efficiency of maintenance, decontamination, operations, and decommissioning shall be maximized. ^{10 CFR 835.1002(d)}
 - e. Components should be selected to minimize the build-up of induced radioactivity.
 - f. Support facilities shall be provided for donning and removing protective clothing and for personnel monitoring, when required.
 - g. — 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. ^{10 CFR 835.2(b)} 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 were increased. The results of these analyses should be used to ascertain the economic feasibility for incorporating such modifications in the final design.
 - h. DOE Order 6430.1A, "General Design Criteria," shall be used for facility planning, design, and construction.
 - i. — Optimization principles, as discussed in International Commission on Radiological Protection (ICRP) Publications 37 and 55, shall be used in developing and justifying facility design and engineered controls. ^{10 CFR 835.1002(e)}
 - j. [Reserved]
 - k. As a design objective, the exposure of personnel to inhalation, ingestion, absorption, or injection of radioactive materials is to be avoided under normal operating conditions to the extent reasonably achievable. This will usually be accomplished by engineered design features such as confinement and ventilation. Respirators may be considered for use, however, while engineered controls are being instituted or evaluated. To the extent that engineered design features are not reasonably feasible in nonroutine operations, the use of respirators to minimize the inhalation of radioactive materials is appropriate. The use of respirators in lieu of engineered design features may be appropriate during emergencies.
2. Radiological facilities currently under construction should be evaluated by ESH-1, the Facility Risk Management Group (ESH-3), and the ESH-12 Radiological Engineering Team as appropriate, and the above criteria should be applied where practical.
 3. Existing facility designs that have office space and lunch rooms or eating areas within Controlled Areas, Radiation Areas, High and Very High Radiation Areas, Contamination and High Contamination Areas, Airborne Radioactivity Areas, locations designated for the storage of radioactive material, and Radiological Buffer Areas require priority attention.
 - a. In general, locating lunch rooms or eating areas, restrooms, drinking fountains, showers, and similar facilities and devices within these areas is strongly discouraged.
 - b. In general, 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.

- c. Wearing protective clothing in an uncontrolled area is not permitted. (This requirement may be allowed on an interim basis if prior approval is obtained from the LANL Radiation Protection Program manager. This approval is granted only for a period of time until necessary facility modifications can be accomplished.) Commingling of personnel in protective clothing and personnel in personal clothing should be phased out in existing areas.
 - d. Elimination of commingling areas shall be emphasized in design of new facilities and shall be a priority in any modification of existing facilities.
4. ESH-3 manages the ES&H (environment, safety, and health) identification process, which is designed to assist the line organizations in identifying ES&H requirements early in facility modification, facility design, or process change.
 5. The ESH-12 Radiological Engineering Team provides radiological engineering services to all radiation protection groups and to all line organizations upon request. These services are of particular value in determining how to reduce exposures in facilities through the use of engineering design principles. This could apply to modification of existing facilities or to the design of new facilities.

PART 3 Improving Radiological Performance

131 Radiological Performance Goals

Goals are intended to be 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 indicators show where goals may be established both throughout LANL and at specific facilities, as appropriate.

1. *Collective dose (person-rem)*: This goal should be based upon planned activities and historical performance. A goal for neutron person-rem should also be established for those facilities and operations where neutron fields are present and are a radiological concern. These collective exposure goals are considered ALARA goals.
2. *Skin and personal clothing contamination occurrences (number)*: Personnel contaminations 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 should be balanced by the recognition that this generates radioactive waste. Goals for both should be correlated.
5. *Radioactive waste generated (cubic feet)*: Minimizing the generation of radioactive waste reduces the environmental impact of LANL operations, helps reduce personnel exposure, and reduces costs associated with handling, packaging, and disposal.
6. *Liquid and airborne radioactivity released (Ci)*: Minimizing effluents reduces the environmental impact of LANL operations and reduces the costs associated with remediation.

132 Managing Radiological Performance Goals

1. The Laboratory director or designee shall establish, approve, and maintain a radiological performance goals program. ESH-12 coordinates this program for the Laboratory director.
2. The performance goals should be measurable, achievable, auditable, challenging, and meaningful in promoting improvement.
3. Goals should be developed primarily by those responsible for performing the work. Each line organization that has some involvement with radioactive materials and radiation-generating devices is encouraged to form a radiological awareness committee that includes the active participation of the work force. The radiological awareness committee may, at the discretion of the line organization, be a newly created entity or may be a function of an existing quality circle, safety committee, ALARA committee, or other functional entity.
4. Radiological performance goals should be reviewed at least annually and revised as appropriate. Normally, more stringent goals should be set each year to reflect the improved radiological performance at the facility. A goal may be made less stringent to accommodate changes in workload or mission.
5. ESH-12 supports the radiological performance indicators program (PIP) maintained by AA-1, which tracks and trends performance with regard to the established goals.

133 Radiological Performance Reports

1. The Radiation Protection Program manager (see Article 141, Paragraph 3), through ESH-12, should provide a summary report to the Laboratory director at least monthly but no less frequently than quarterly. This report should include at least the radiological performance goals established in accordance with Article 131. Indicators that provide a more detailed analysis of performance are identified in Table 1-1. Indicators should be contained in the report for the month as well as tracking and trending information for the previous 12-month period.
2. The Radiation Protection Program manager, through ESH-12, should provide managers with radiological performance information, such as supplemental dosimeter readings or volume of waste generated, 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 workers' awareness of their radiation exposure status, selected indicators related to their work groups should be posted in the workplace by line management.

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Table 1-1 LANL Radiological Performance Indicators

EXPOSURE CONTROL

- a. Collective external effective dose equivalent in person-rem
- b. Average worker external effective dose equivalent in rem
- c. Maximum external effective dose equivalent 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
- f. Collective shallow dose equivalent (skin) in person-rem

PERSONNEL CONTAMINATION

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

CONTROL OF INTERNAL EXPOSURE

- a. Number of new confirmed depositions (positive internal intakes)
- b. Number of unanticipated airborne events
- c. Number of alarms on continuous air monitors (actual and false)
- d. Number of Airborne Radioactivity Areas
- e. Area of Airborne Radioactivity Areas in square feet
- f. Collective committed dose equivalent in person-rem (from intakes in one year)
- g. Number of nasal contaminations

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 radioactive material spills (meeting criteria in LP107-01.0 and subsequent revisions)

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 the *LANL Radiological Control Manual*, refers to the process of providing independent feedback to senior line managers to indicate the adequacy of the Radiation Protection Program.

1. Inspections, audits, reviews, investigations, and self-assessments are part of the numerous checks and balances needed in a good Radiation Protection Program. — Internal audits of the Radiation Protection Program shall be conducted so 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 Laboratory's Internal Assessments Group (AA-2) and other organizations.

The audit shall include, but not be limited to, external dosimetry, internal dosimetry, portable and fixed instrumentation, respirators, contamination control, radiological monitoring, ALARA programs, nuclear accident dosimetry, source material control, x-ray protection, training, posting, and records. The guidelines set forth in DOE Order 5482.1B shall be followed.

2. Line managers, first-line supervisors, and workers should look upon assessments as helpful. Assessments should be approached openly, with nothing to hide. The Radiation Protection Program should be an open book. Results of assessments should be incorporated into the ongoing process of improving radiological control.
3. Line 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 Radiation Protection Program. A prioritization system to implement actions for resolving the deficiencies should be implemented.
4. In developing corrective action plans for assessment findings, line managers should address basic underlying reasons (root causes) 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 line management by the organization performing the assessment.

135 Workplace Awareness

1. Line managers are strongly encouraged to facilitate the expression of concerns on the part of the work force, to address such concerns, and to solve them to ensure the proper respect for and understanding of radiation.
2. A radiological awareness reports system should be established as part of the ALARA program and supported by line management. To enhance work force awareness, the program should encourage continuous evaluation and improvements, track resolution of concerns, provide feedback to workers, and post results and trends. This system may be integrated into AA-1's lessons-learned program.

136 Internal Exposures

Control and prevention of internal exposure from long-lived radionuclides in the workplace present special challenges to a Radiation Protection Program and warrant particular attention. Because of the difficulty in 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.

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To minimize internal exposures, line managers should take deliberate actions to control contamination at the source, thus reducing Airborne Radioactivity, Contamination, and High Contamination Areas. Work should be planned to avoid the routine use of respiratory protection devices where the use of engineered controls is feasible. Internal exposures should be reduced to the minimum practical level and the following should be considered.

1. 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 where continuous air monitors (CAMs) are not in use.
2. If controls fail, internal depositions of radionuclides can occur in a short period of time.
3. Workers may become concerned if they are continuously exposed to airborne radioactivity.
4. 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.
5. Medical intervention, such as the administration of blocking and chelating agents to mitigate internal deposition, adds risks by introducing additional chemicals into the body.
6. 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.

1. The specific biological effects of neutrons are not as well understood as the effects of gammas.
2. Neutron dose equivalent is more difficult to assess than gamma dose equivalent.

As a result, those line organizations with neutron radiation dose should focus particular attention on minimizing collective neutron dose by setting aggressive goals (Article 131).

138 ALARA Programs and Committees

1. A Laboratory-wide ALARA committee (Laboratory ALARA Steering Committee) should be established. The Laboratory director will charter the committee and appoint members to it from senior managers of divisions involved in radiological work and radiological safety. The Radiation Protection Program manager will also sit on the committee and will appoint representatives from radiation protection professional staff to sit on the committee in an advisory capacity, as needed.
2. The Laboratory ALARA Steering Committee has the following responsibilities:
 - a. Oversee and assess/audit the implementation of the Laboratory's ALARA Program in conjunction with AA-2.
 - b. Advise the director or appropriate Laboratory leadership or operations working groups of the effectiveness and progress of the program.
 - c. Ensure that line organization ALARA committees are chartered at the division level when appropriate.
 - d. Review facility-specific ALARA programs.

- c. Approve Laboratory ALARA goals and ensure that authority, accountability, and resources for implementing the program are assigned to the organizational level at which they are needed.
 - f. Provide guidance for future strategic initiatives, new areas of challenge, or activities that may be necessary for improvement of the ALARA Program.
3. The *as low as reasonably achievable* (ALARA) process for optimizing the reduction of radiation exposure is a fundamental requirement of every radiation protection program. There is considerable leeway in determining how far is reasonable. The Laboratory's ALARA policy is an integral part of General Employee Radiological Training, Radiological Worker Training, and Radiological Control Technician Training. Radiological training classes are conducted by the ES&H Training Group (ESH-13). Training requirements and documentation are described in Chapter 6.
4. Members of the line organization ALARA committees are appointed by the line organization and may include personnel from operations, maintenance, radiation protection, and any other support group whose input and assistance is needed. Line organization ALARA committee responsibilities include
 - a. reviewing the organization's overall implementation of the ALARA Program, including results of reviews and audits, trends in radiation exposure for completed work, and ALARA plans and goals for future radiation work;
 - b. making recommendations to the group or division leader on improvements and initiatives that are needed to demonstrate a successful ALARA program; and
 - c. meeting on a predetermined frequency and documenting its business.

The need for a line organization ALARA committee should be determined by the line organization commensurate with the organization's potential for radiation exposure. Large organizations with a high potential for exposure should appoint a line organization ALARA committee. Smaller organizations with a lower potential for exposure may only require an ALARA coordinator. Those organizations of intermediate size may find it best to have the functions of the line organization ALARA committee handled by an already existing safety committee.

PART 4 LANL Radiation Protection Organization**141 Radiation Protection Organization**

1. A radiation protection organization has been established to provide relevant support to line managers and workers. The radiation protection organization is independent of the line organizational element responsible for production, operation, or research activities. At LANL, the Radiation Protection Program has been established as an office in ESH Division. The Radiation Protection Office (RPO) is headed by the Radiation Protection Program manager, who is designated as radiological control manager at LANL. Three groups (ESH-1, -4, and -12) share the major responsibilities of the radiation protection organization. At LANL, where facilities, buildings, or work areas are dispersed, an approach that provides site-wide consistency and individual facility radiological control support is recommended. The senior line manager responsible for operations at a facility should have dedicated radiological control personnel (ESH-1) assigned to the facility. Consistency of radiological control 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.
 - a. The RPO provides program direction and oversight. The RPO serves as the single point of contact for DOE and Laboratory customers, integrates radiation protection into the facility management process, and provides recommendations for investment and institutional resources.
 - b. The Health Physics Operations Group (ESH-1) provides operational radiation protection interface and support to LANL's operating organizations. ESH-1 provides radiological survey, control, and institutional oversight services to LANL. The group works directly with operating groups at the various LANL facilities to ensure the presence of necessary radiation protection practices consistent with the goals, procedures, and requirements of the Radiation Protection Program. ESH-1 also provides the primary focal point and liaison with other participants in the LANL Radiation Protection Program.
 - c. The Health Physics Measurements Group (ESH-4) provides Laboratory-wide radiation measurements to support the Radiation Protection Program. ESH-4 provides and processes personnel dosimeters. Other activities include maintenance and calibration of radiation monitoring instruments, laboratory analysis, and in vivo analysis. ESH-4 also maintains a radiation measurement improvement program.
 - d. The Policy and Program Analysis Group (ESH-12) develops and maintains Laboratory-wide radiation protection policies and programs to meet applicable standards. ESH-12 functions as LANL's point of contact for radiation protection policy and procedures. ESH-12 also provides dose assessment, radiological engineering, occupational ALARA program support, x-ray and source control, data management, and NTS support services.
 - e. Other organizations also contribute to environment, safety, and health (ES&H) activities related to radiation and radioactive materials.
 - (1) LANL's Emergency Management and Response Office (EM&R) oversees and implements the full range of activities necessary for mitigating, preparing for, responding to, and recovering from emergency incidents at LANL. EM&R prepares emergency response plans commensurate with operations.
 - (2) The Occupational Medicine Group (ESH-2) provides examinations and evaluations of employees for the respiratory certification program. ESH-2 is also available to consult with female employees who have declared their pregnancies and those who are planning pregnancies. The attending ESH-2 physician and staff from ESH-12 will cooperatively determine whether any temporary work restrictions are required to keep the dose to the embryo/fetus below the limits declared in Article 215 and Table 2-1. Accommodation of any recommended work restrictions for the pregnant worker will be made in collaboration with her supervisor, ESH-2, and ESH-12 staff (see Article 215). ESH-2 also may provide special physical examinations or evaluations to employees who are involved in an incident or accident resulting in the actual or suspected exposure to radioactive materials or external radiation.

- (3) The Facility Risk Management Group (ESH-3) provides line and facility managers with expertise in the management and documentation of environment, safety, and health (ES&H) hazards and risks. ESH-3 provides risk assessment services, develops programs for risk management, reviews facility modifications for ES&H compliance, and ensures that ES&H design factors are considered for new and modified facilities.
 - (4) The Nuclear Criticality Safety Group (ESH-6) provides technical support to those LANL groups working with significant quantities of fissile material. The group assists in developing procedures for operations with such material, reviewing operations, and training personnel.
 - (5) The Occurrence Reporting Group (ESH-7) is responsible for managing the internal reporting and documentation system required for various incidents, as defined in Program Requirements Document PRD120-01.0, "Occurrence Investigation and Reporting Program." Under DOE 5000.3B, the office also manages the documentation, sending follow-up reports to DOE/Albuquerque and to DOE Headquarters for reportable occurrences at LANL.
 - (6) The Hazardous Materials Response Group (ESH-10) provides safe, effective, hazardous materials emergency response mitigation services to DOE, the Laboratory, and the surrounding community. ESH-10 provides ES&H expertise for the Accident Response Group and Nuclear Emergency Search Team; participates in the Region 4 Radiological Assistance Program; conducts research and development activities for the DOE's emergency response programs; provides training and consultation services in emergency response, nonproliferation, and weapons safety; and supports nuclear safety, security, and dismantlement activities in the former Soviet Union.
 - (7) The ES&H Training Group (ESH-13) provides radiological worker training, radiological control technician training, general employee radiological training, and other required radiological safety training to workers at LANL.
 - (8) The Air Quality Group (ESH-17), Water Quality and Hydrology Group (ESH-18), Hazardous and Solid Waste Group (ESH-19), and Environmental Assessments and Resource Evaluations Group (ESH-20) provide an ongoing program of environmental measurements and activities to help ensure that LANL operations do not adversely affect the public health and environment and that LANL conforms to all applicable environmental regulatory requirements. The major objectives of these groups are to (1) develop and implement institutional plans and programs for environmental protection in response to specific federal and state regulatory requirements; (2) assist LANL organizations in complying with environmental regulatory requirements; (3) measure, evaluate, and document effects of LANL operations on public health and the environment; and (4) provide emergency response support by evaluating and responding to releases of radioactive and toxic materials.
 - (9) The Environment, Health, and Safety (ESH) Division administers the waste minimization program, in addition to other activities. This program has been established in accordance with LANL's fourfold plan for implementing federal requirements and for managing all types of liquid and solid waste generated at LANL. The plan addresses abatement and substitution, segregation and housekeeping, reuse and recycling, and personnel education.
 - (10) The Analytical Services Group (CST-3) and the Inorganic Trace Analysis Group (CST-9) conduct an ongoing program of chemical measurements in support of regulatory compliance, environmental and workplace monitoring, and research programs. The staff provides state-of-the-art expertise in sampling requirements, analytical chemical measurements, interpretation of chemical data, analytical quality assurance, National Institute of Standards and Technology traceability of chemical measurements, and experimental design. In addition, the group conducts an active research program in analytical chemistry and environmental measurements.
 - (11) CST Division ensures that radioactive and chemical liquid and solid wastes generated by LANL are appropriately processed and disposed of. Division personnel manage all liquid and solid wastes, other than sanitary wastes, generated at LANL.
2. Radiation protection personnel monitor adherence to the *LANL Radiological Control Manual* and are available to the facility line manager for radiological support to the work force. To effectively function in this capacity, day-to-day priorities should be closely coordinated between facility managers and ESH-1, -4, and -12 personnel.

To ensure independence in making correct radiological decisions, the radiation protection organization is accountable to the Radiation Protection Program manager and must not be supervised by line management.

3. The Radiation Protection Program manager heads the radiation protection organization and is responsible for and has established a high-quality radiation protection program.
4. The Radiation Protection Program manager shall have access to the Laboratory director for radiation protection matters.

142 Radiation Protection Program Manager Qualifications

1. The Radiation Protection Program manager should be an experienced professional in radiological control and be familiar with facility design features and operations that affect the potential for human exposure to radiation.
2. The Radiation Protection Program manager should have the technical competence and experience to establish radiation protection programs and the supervisory capability to direct the implementation and maintenance of radiation protection programs.
3. The Radiation Protection Program manager should have a minimum of a bachelor's degree or the equivalent in science or engineering, including some formal training in radiological control. Advanced academic degrees can count as experience where course work related to radiological control is involved. At least three years of professional experience should be in applied radiological control work. Certification by the American Board of Health Physics provides equivalency to the above.
4. In situations in which the most effective manager for this position does not satisfy the above qualifications, special arrangements should be made. In these situations, the assignment of a deputy with the requisite expertise and qualifications can satisfy the requirement.
5. ESH Division management should encourage, promote, and provide the opportunity for people assigned to or being considered for the Radiation Protection Program manager position to achieve certification by the American Board of Health Physics.

143 Radiation Protection Organization Functions and Staffing

1. The senior staff of the radiation protection organization should include health physicists and other professionals with four-year degrees in science or engineering. A continuing training program (for example, through the National Technological University) 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 assist and guide workers in the radiological control aspects of their jobs.

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 supervisors also have stop-work authority in accordance with Article 345 and, on their own, in accordance with Director's Policy DP116, "Stop Work and Restart."
3. The actions or presence of radiological control personnel does not absolve workers of their responsibility for properly conducting radiological aspects of their jobs. Radiological control personnel are not present to compensate for poor management of the work force and should not be required to do so. A poorly trained work force should participate in an accelerated training initiative.

145 Marginal Radiological Control Performance

1. When radiological control performance is less than adequate, performance must be improved. Consideration should be given to strengthening line management and the radiation protection organization to provide adequate radiological control.
2. In cases where the work force does not have the required level of sensitivity for radiological work practices, additional line management attention is needed to ensure the proper outcome. Line management should be held accountable for implementation of the Radiation Protection Program. Initial actions should include the following:
 - a. Increase direct line supervision in the work space.
 - b. Curtail work schedules.
 - c. Defer work.
 - d. Add extra radiological control personnel.
 - e. Conduct additional training.
3. When the line organization workers and supervisors achieve the proper level of radiological performance, the number of radiological control personnel should be reevaluated.

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PART 5 DOE Management**151 Program Office**

1. Program secretarial officers are responsible for establishing and maintaining radiological control programs for activities under their cognizance and are accountable for the quality and performance of radiological work conducted at their assigned sites.
2. Each program secretarial officer shall designate a person who can be the Program Office focal point on radiological control matters with the DOE Operations Office, counterparts within DOE, and the Laboratory. This person is referred to in the *LANL Radiological Control Manual* as the Radiation Protection Program advisor.

152 Operations Offices and Applicable Field Office

1. Managers of operations offices are responsible for the line management function of conducting day-to-day oversight of Laboratory activities, including monitoring the quality and performance of radiological work.
2. Managers of operations offices shall designate a person to be responsible for providing Radiation Protection Program oversight, which includes appraisals, surveillance and monitoring of performance, interacting routinely with the Radiation Protection Program advisors of the affected DOE program offices, assisting the DOE field line organization in the use of the *DOE Radiological Control 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:

- a. Using the *DOE Radiological Control Manual* as its basis document.
- b. Assessing DOE program and field office performance in their line management responsibilities for implementing and maintaining radiological controls as detailed in the *DOE Radiological Control Manual*, and
- c. Assessing LANL performance against the requirements of the *LANL Radiological Control Manual*.

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 DP, Energy Research, Environmental Restoration and Waste Management, and Nuclear Energy, along with a representative 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 the Laboratory. The committee shall function collectively to promote a consistent and uniform emphasis in the direction and implementation of the *DOE Radiological Control 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.
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 LANL are subject to and shall adhere to the provisions of the *LANL Radiological Control Manual*, 18 CFR 8352(a)

Appendix 1A

Facility-Specific Radiological Control Programs

1. Radiological Program for Control of Contamination at NWT Firing Sites, Revision 0

CHAPTER 2 RADIOLOGICAL STANDARDS

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2. The internal contribution to lifetime occupational dose from intakes before 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 2-1 and shall not be exceeded except as specified in Article 213.3 and Appendix 2A. ^{10 CFR 835.202(a)(1)(2)(3)(4)} All occupational exposure received during the current year shall be included when demonstrating compliance with Table 2-1 dose limits. ^{10 CFR 835.202(b), 209(b)} These regulatory limits are consistent with the "Radiation Protection Guidance to Federal Agencies for Occupational Exposure" signed by the president.
2. Radiological workers from other DOE or DOE contractor sites may receive occupational exposure at LANL as radiological workers if they do the following:
 - a. Provide records of current Radiological Worker I or II standardized core training.
 - b. Receive appropriate site/facility-specific Radiological Worker I or II training at the facilities where they will be working.
 - c. Provide their radiation dose records for previous years and — written estimates, signed by the individual, for the current year. ^{10 CFR 835.702(d)}
3. Proposed use of the planned special exposure as specified in 10 CFR 835 shall be applied only in extraordinary situations and when the following requirements have been met.
 - a. — The proposed activity has been reviewed by the Radiation Protection Program manager and submitted in writing by the Laboratory director to the lead DOE Headquarters Defense Programs program secretarial officer for approval. ^{10 CFR 835.204(b)(2)}
 - b. — The proposed activity has been jointly approved by the lead DOE Headquarters Defense Programs program secretarial officer and the DOE assistant secretary for Environment, Safety, and Health. ^{10 CFR 835.204(a)(3)}
4. Emergency exposure limits are not planned special exposure limits. — Guidelines for emergency exposures are provided in Appendix 2A. ^{10 CFR 835.1302(d)} The following requirements shall also be implemented for emergency exposure situations:
 - a. — The risk of injury to those individuals involved in rescue and recovery operations shall be minimized. ^{10 CFR 835.1302(a)}
 - b. — The person with on-site emergency response authority shall weigh actual and potential risks to rescue and recover individuals against the benefits to be gained. ^{10 CFR 835.1302(b)}
 - c. — Rescue action that might involve substantial personal risk shall be performed by volunteers. ^{10 CFR 835.1302(c)}
 - d. — Each individual selected shall be trained as a radiological worker in accordance with Chapter 6, Part 3, of this manual and briefed beforehand on the known or anticipated hazards to which the individual will be subjected. ^{10 CFR 835.1302(e)}
5. The radiological worker dose limits provided in Table 2-1 also apply to general employees. However, general employees who have not completed Radiological Worker I or II 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. General employees who have not received Radiological Worker I or II training are not normally expected to exceed 100 mrem in a year.

Table 2-1 Summary of Dose Limits

Exposures shall be kept well below the limits in this table and shall be maintained as low as reasonably achievable (ALARA). The administrative control levels for limiting exposure are described in Article 211.

TYPE OF EXPOSURE	ANNUAL LIMIT
Radiological Worker ^a : Total effective dose equivalent	5 rem
Radiological Worker: Lens of eye ^b	15 rem
Radiological Worker: Shallow dose equivalent to skin or extremity (hands and arms below the elbow; feet and legs below the knees) ^c	50 rem
Radiological Worker: Sum of deep-dose equivalent for external exposures and committed dose equivalent to any organ or tissue (other than lens of eye)	50 rem
Declared Pregnant Worker: Embryo/fetus	0.5 rem per gestation period
Minors and Students (under age 18): Total effective dose equivalent	0.1 rem
Visitors ^d and public: Total effective dose equivalent	0.1 rem

- a. Radiological workers are general employees authorized unescorted access to radiological areas per Articles 332, 334, and 335.
- b. Because of limitations of the current 4-element configuration of the thermoluminescent dosimeter (TLD) badge system for measuring lens-of-the-eye dose equivalent at 300 mg/cm², measurements for compliance with the 15-rem annual limit will be made at 7 mg/cm². This in no way places limits on the 50-rem-annual-limit shallow dose equivalent for the skin or extremities when measurements are made with extremity dosimetry. The badge may have to be relocated to the head to adequately measure this dose if it is limiting.
- c. The 50-rem annual limit only applies to shallow dose equivalent measured with extremity dosimetry. When the shallow dose equivalent is measured with the whole-body TLD using the chip under 7 mg/cm² filtration, a 15-rem annual limit for the skin and extremities shall apply until an enhanced TLD badge system is implemented.
- d. Applies to visitors who have not completed training in accordance with Articles 632 or 633 or have not met the special consideration of Article 657.

Notes

1. The total effective dose equivalent during a year shall be determined by summing the effective dose equivalent from external exposures and the committed effective dose equivalent from intakes during the year. For purposes of compliance with this part, deep-dose equivalent to the whole body may be used as effective dose equivalent for external exposures. Internal dose to the whole body shall be calculated as committed effective dose equivalent. The committed effective dose equivalent is the resulting dose committed to the whole body from internally deposited radionuclides over a 50-year period after intake. See Appendixes 2D and 2E for the quality factors to be used for determining dose equivalent in rem and Appendix 2B for the weighting factors to be used in converting organ dose equivalent to effective dose equivalent for the whole-body dose.
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.
3. = Exposures that are due to background radiation, therapeutic and diagnostic medical procedures, and voluntary participation in medical research programs shall not be included in either 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 nonuniform exposure of the skin.
5. = For the case of uniform external irradiation of the whole body, a weighting factor (W_T) equal to 1 may be used in determining the effective dose equivalent. ^{10 CFR 835.203(c)}

6. The dose to an embryo/fetus shall be taken as the sum of the effective dose equivalent to the embryo/fetus from external sources of radiation (deep-dose equivalent to the pregnant woman), the committed effective dose equivalent to the embryo/fetus from radionuclides in the embryo/fetus, and the dose equivalent to the embryo/fetus from radionuclides in the declared pregnant woman.
7. — The limiting value for the total effective dose equivalent for any individual under age 18 is 0.1 rem per year. ^{10 CFR 20.207} This includes the effective dose equivalent from internal and external sources of irradiation. This requirement effectively restricts individuals under 18 from entering radiological areas established for contamination control purposes unless an exemption for the area can be supported by documentation that demonstrates compliance with the 0.1-rem-per-year limit. Such documentation shall include administrative controls to be implemented, workplace and personnel monitoring data, and consideration of the minimum detectable effective dose equivalent of the dose assessment process.

214 Visitor Dose Limit

— Visitors to LANL (including members of the public who are on the site) shall be limited to an annual radiation dose of 0.1 rem from the sum of internal and external radiation sources unless they either (1) qualify as radiological workers in accordance with Article 632 or 633, or (2) meet the special considerations of Article 657. ^{10 CFR 20.208}

215 Embryo/Fetus Dose Limits

After a female worker voluntarily notifies her supervisor, the Policy and Program Analysis Group (ESH-12), and/or the Occupational Medicine Group (ESH-2) in writing that she is pregnant, for the purpose 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. She should be referred to ESH-2 for consultation. Dose equivalent limits for the category of declared pregnant worker are set by DOE for the protection of the embryo/fetus. The attending ESH-2 physician and staff from ESH-12 will cooperatively determine whether any temporary work restrictions are required to keep the dose to the embryo/fetus below the limits described in this article and listed in Table 2-1. Any female radiological worker planning a pregnancy may also consult ESH-2. Accommodation of any recommended work restrictions will be made in collaboration with her supervisor, ESH-2, and radiation protection organization staff. The assignment of female workers to tasks in which occupational exposure is not likely should not create a basis for discrimination and should be achieved in conformance with the provisions of Title VII of the Civil Rights Act of 1964. (See pp. 2829-2832 of the Federal Register, Vol. 52, No. 17, 1987.)

1. The supervisor shall provide the option of a mutually agreeable assignment of work tasks, without loss of pay or promotional opportunity, such that further occupational radiation exposure is unlikely.
2. For a declared pregnant worker who chooses to continue working as a radiological worker, the following apply:
 - a. — The dose limit for the embryo/fetus during the entire gestation period (from conception to birth) is 0.5 rem. ^{10 CFR 20.209(a)}
 - b. — Measures shall be taken to avoid substantial variation above the uniform exposure rate necessary to meet the 0.5-rem limit for the gestation period. ^{10 CFR 20.209(b)} This is equivalent to no greater than one and a half times (1.5x) the uniform exposure rate of 50 mrem per month (i.e., no greater than 75 mrem in any one month of the gestation period).
 - c. A LANL administrative control level for pregnant radiological workers has been established. The LANL policy is as follows:

Once pregnancy has been declared, the embryo/fetus is protected by the application of a supplementary external dose equivalent limit to the surface of the declared pregnant radiological worker's abdomen (lower trunk) of 0.2 rem for the remainder of the pregnancy and by the limiting of intakes of radionuclides to 1/25 of an annual limit on intake (ALI). Efforts are made to avoid exceeding 1/10 of these recommended limits during each month of the pregnancy. The principal criterion is that the work assignments of the declared pregnant radiological worker do not carry a significant probability of high accidental doses and intakes.

If either of these recommended limits has already been exceeded at the time a pregnant worker notifies her supervisor, the worker will not be assigned to tasks in which additional occupational exposure to radiation is likely during the remainder of the gestation period.

In keeping with the ALARA process, the declared pregnant worker is responsible for keeping her radiation exposure as low as reasonably achievable during the gestation period.

- d. When a radiological worker declares her pregnancy, the ESH-12 Dose Assessment Team performs a radiological workplace evaluation and reports the results to ESH-2, the worker, and the worker's supervisor. An ESH-2 physician reviews the workplace evaluation, provides any necessary counseling, and assigns any medical restrictions to the declared pregnant worker.
3. — If the dose to the embryo/fetus is determined to have already exceeded 0.5 rem when a worker notifies her supervisor of her pregnancy, the worker shall not be assigned to tasks in which additional occupational radiation exposure is likely during the remainder of the gestation period. ¹⁰ CFR 835.204(c)

216 Special Control Levels

Certain situations require lower individualized exposure control levels. In addition to considering recommendations from senior radiation protection personnel (Health Physics Operations, ESH-1; Health Physics Measurements, ESH-4; and ESH-12) and medical officials (ESH-2), the Laboratory director or designee should obtain advice from professionals in other disciplines such as human resources (DHR) and legal counsel (LC) in establishing special control levels. The Laboratory director or designee (for example, Radiation Protection Program manager) may wish to establish these special control levels using the Radiological Health Advisory Group, which consists of senior ESH-1, -4, and -12 technical staff members.

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 be set to eventually reduce the person's lifetime occupational dose to below N rem as additional occupational exposure is received.
2. Supervisors should be attentive to special circumstances of workers, such as those undergoing radiation therapy, and may request through the Radiological Health Advisory Group that the Laboratory director or designee (for example, Radiation Protection Program manager) establish special control levels as appropriate.
3. — When a worker receives a dose in excess of the limits specified in Table 2-1 as a result of an accident or responding to an emergency, the line manager decides when to allow the worker to return to a radiological area based on recommendations from ESH-1, -12, and -2. Concurrence of the worker and approval of the DOE field office are required. ¹⁰ CFR 835.1301(a)(1)(3) — The worker must be counseled by ESH-2 and ESH-12 personnel about the consequences of receiving additional occupational exposure during the year. ¹⁰ CFR 835.1301(a)(2) ESH-12 adds the dose to the exposed individual's radiation exposure record. — Investigating and reporting shall be carried out according to PRD120-01.0, "Occurrence Investigating and Reporting Program." ¹⁰ CFR 835.1301(a) — The line manager must ensure that the workplace conditions that led to the accidental or emergency overexposure are corrected and verify to the DOE field office that these corrections have been made. ¹⁰ CFR 835.1301(c) — The DOE field office, LANL Radiation Protection Program manager, and facility manager must approve the resumption of the operations that led to the excess exposure following an accidental or emergency exposure that is in excess of the occupational limits. ¹⁰ CFR 835.1301(d)

If a worker is involved in an accident or emergency that could result in a dose greater than Table 2-1 limits, the worker should not be allowed to enter a controlled area until a dose assessment has been completed.

4. Those workers who have been administered radionuclides for diagnostic or therapeutic medical purposes are required to report the medical procedure to the ESH-12 Dose Assessment Team before returning to work. Dose Assessment evaluates the need for restrictions and contacts affected organizations and workers (e.g., ESH-1, -2, and -4; Facilities, Security and Safeguards [FSS]; and the worker's supervisor).

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, by reducing existing areas of contamination, and by promptly decontaminating areas that become contaminated.

221 Personnel Contamination Control

1. = Personnel exiting Contamination Areas, High Contamination Areas, Airborne Radioactivity Areas, and Radiological Buffer Areas or Controlled Areas established for contamination control shall frisk for contamination as required by Article 338, ^{10 CFR 835.404(f)}. This does 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 2-2. Use of automatic monitoring units that meet the above requirements is encouraged.
3. Personnel found with detectable contamination on their skin, personal clothing, or company-issued 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 2-2. If an area cannot be decontaminated promptly, then it shall be posted by ESH-1 as specified in Article 235, ^{10 CFR 835.403(e)}. For area surveys where more than 10% of the total number of samples (swipes, smears, or instrument measurements) exceed Table 2-2 values, the affected area shall be decontaminated and/or posted accordingly.
2. Surfaces exceeding the values of Table 2-2 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 shall not be applied without the approval of the Radiation Protection Program manager or designee.
3. In addition to the posting criteria in Article 235, the following conditions for establishing and maintaining areas with fixed contamination are to be met by ESH-1 and affected line organizations.
 - a. = Radiological surveys shall be performed to detect contamination that may become removable over time, ^{10 CFR 835.404(d)(3)}
 - b. A formal inventory shall be maintained of areas with fixed contamination.
 - c. = Markings shall be kept legible, ^{10 CFR 835.404(d)(4)}
 - d. = Removable contamination shall not exceed Table 2-2 values and should be reduced as far below Table 2-2 values as is reasonably achievable before a fixative coating is applied, ^{10 CFR 835.404(d)(1)}
 - e. Fixed contamination should be covered with two layers of fixative coatings having different colors.
 - f. = Markings should include the standard radiation symbol, be clearly visible from all possible directions, and contrast with the colors of the surface coatings, ^{10 CFR 835.404(d)(4)}
 - g. An additional coating should be applied when the bottom color appears.
 - h. A plan for identifying and adding to the inventory of existing areas of fixed contamination not included in the initial inventory should be developed.
4. = An area with fixed contamination may be located outside radiological areas (but within controlled areas) unless unrestricted access is likely to result in a dose greater than 0.1 rem per year to any person ^{10 CFR 835.404(d)(2)} and provided that

- a. — appropriate administrative procedures are established and exercised to maintain control of these areas
10 CFR 835.404(d)(5) and
 - b. — dose rates do not exceed levels that would require posting in accordance with Article 234 of this manual.
10 CFR 835.404(d)(6)
5. — An area with fixed contamination is exempt from the general posting requirements of Article 231 and entry and exit requirements of Chapter 3 provided the requirements of this article are met. 10 CFR 835.404(e), 302(b)
 6. For contaminated soil that is not releasable in accordance with DOE 5400.5, a Soil Contamination Area shall be established that meets the following:
 - a. 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 Articles 231.1 through 231.8.
 7. Soil Contamination Areas may be located outside a Radiological Buffer Area.
 8. No guidance is currently available for releasing material that has been contaminated in depth (i.e., "volume" contamination), such as activated material or smelted contaminated metals with radioactivity per-unit volume or per-unit mass. Such materials may be released if criteria and survey techniques are approved by DOE/EH-1.

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.
2. — Occupied areas with airborne concentrations of radioactivity above natural background that are greater than or potentially greater than 10% of a derived air concentration (DAC) shall be posted by ESH-1 as specified in Article 235. 10 CFR 835.403(d) For most radionuclides, air containing 10% of a DAC results in a committed effective dose equivalent of approximately 0.01 rem if inhaled continuously for one work week. — Values of DACs are provided in 10 CFR 835 and shall be used in controlling occupational exposures to airborne radioactivity. 10 CFR 835.209(a)
3. — With regard to inhalation exposures and external exposures from airborne radionuclides, compliance with 10 CFR 835 requirements shall be demonstrated through conformity with the dose limits of Table 2-1. 10 CFR 835.209(b)

Table 2-2 Summary of Contamination Values

NUCLIDE ^a	REMOVABLE ^{b,c} (dpm/100 cm ²) ^d	TOTAL (FIXED ^e + REMOVABLE ^f) (dpm/100 cm ²) ^g
Natural U, ²³⁵ U, ²³⁸ U, and associated decay products	1,000 alpha	5,000 alpha
Transuranics, ²²⁶ Ra, ²²⁸ Ra, ²³⁰ Th, ²³² Th, ²³¹ Pa, ²²⁷ Ac, ¹²⁹ I, ¹²⁹ X	20	500
Natural Th, ²³² Th, ⁹⁰ Sr, ²²³ Ra, ²²⁴ Ra, ²³² U, ¹³⁶ I, ¹³¹ I, ¹³³ I	200	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except ⁹⁰ Sr and others noted above. ^h	1,000 beta-gamma	5,000 beta-gamma
Tritium organic compounds, surfaces contaminated by HT, HTO, and metal tritide aerosols	10,000	10,000

- a. The values in this table apply to radioactive contamination deposited on, but not incorporated into, the interior of the contaminated item. For purposes of this table only, it is assumed that tritium contamination deposits onto the surface but is not incorporated into the interior of the contaminated item. This table does not apply to personnel contamination. — Where contamination by both alpha- and beta-gamma-emitting nuclides is present, the limits established for the alpha- and beta-gamma-emitting nuclides apply independently. ¹⁰ CFR 83A, Appendix D
- b. — The amount of removable radioactive material per 100 cm² of surface area should be determined by first swiping the area with dry filter paper or soft absorbent paper while applying moderate pressure and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. (Note: the use of dry material may not be appropriate for tritium.) ¹⁰ CFR 83A, Appendix D — For objects with a surface area less than 100 cm², the entire surface should be swiped, and the activity per unit area should be based on the actual surface area. ¹⁰ CFR 83A, Appendix D — Except for transuranics, ²²⁶Ra, ²²⁷Ac, ²³⁰Th, ²³²Th, ²³¹Pa, and alpha emitters, it is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual contamination levels are below the values for removable contamination. ¹⁰ CFR 83A, Appendix D
- c. — The "removable" and "total" levels may be averaged over 1 m² provided the maximum activity in any area of 100 cm² is less than three times the values in Table 2-2. For purposes of averaging, any square meter of surface shall be considered to be above the activity guide G if (1) from measurements of a representative number n of sections it is determined that $1/n \sum_{i=1}^n S_i \geq G$, where S_i is the dpm/100 cm² determined from measurement of section i; or (2) it is determined that the sum of the activity of all isolated spots or particles in any 100-cm² area exceeds 3 G. ¹⁰ CFR 83A, Appendix D
- d. As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute (cpm) observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation. At LANL, the instrument is calibrated so that the meter reading will directly correspond to the alpha or beta surface emission rate. A nominal conversion to activity in dpm is possible by multiplying the instrument contact reading in cpm by a factor of 2.
- e. When measuring fixed contamination during a survey, the active area of the probe used must be taken into account. For example, if the active area is 100 cm² and the nuclide is natural uranium, then the 5000-dpm α /100-cm² limit will apply. For a 40-cm² probe, 2000 dpm α would be the limit because of the reduced active area of the probe.
- f. — This category of radionuclides includes mixed fission products, including the Sr-90 that is present in them. It does not apply to Sr-90 that has been separated from the other fission products or mixtures in which the Sr-90 has been enriched. ¹⁰ CFR 83A, Appendix D

→ PART 3 Posting

231— Posting Requirements [10 CFR 835.601(d)(1), 601(d)(2), implemented by paragraphs 1 through 12 below]

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. ^{10 CFR 835.501(c), 601(a)} 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. ^{10 CFR 835.601(b)(c)} Black is the preferred color over magenta at LANL because of fading problems outdoors. Standardized signs, as described in the standardized core training, shall be used where practicable.
3. — Signs shall be conspicuously posted and clearly worded and, where appropriate, may include radiological control instructions. Radiological postings should be displayed only to signify actual or potential radiological conditions. Signs used for training should be clearly marked, such as "For Training Purposes Only."
4. — Posted areas should be as small as practicable for efficiency.
5. — Postings should be maintained in a legible condition and updated based upon the results of the most recent surveys.
6. — If more than one radiological condition (such as contamination and high radiation) is present in the same area, each condition should be identified.
7. — In areas of ongoing work activities, the dose rate and contamination level or range of each should be included on or in conjunction with each posting as applicable.
8. — Entrance points to areas of ongoing work activities controlled for radiological purposes should state basic entry requirements, such as dosimetry, radiological work permit (RWP), and respirator requirements.
9. — Rope, tape, chain, and similar barriers used to designate the boundaries of posted areas should be either yellow, or yellow and magenta in color. ^{10 CFR 835.501(e)}
10. — Physical barriers should be placed so that they are clearly visible from all directions and at various elevations. ^{10 CFR 835.501(e)} They should not be easily walked over or under, except at identified access points. — These barriers shall be set up in such a way that they do not impede the intended use of emergency exits or evacuation routes. ^{10 CFR 835.501(e), 502(c)}
11. Entrances should be posted so that the postings remain visible when doors are open or closed. For doors that are normally closed, posting on the door is acceptable. For doors that are normally open, the posting is placed on the wall immediately beside the door.
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."
13. The radiological work permit may specify special posting requirements.

232 Definition and Posting of Controlled Areas

1. — Each access point to a Controlled Area shall be posted, identifying it as a Controlled Area, whenever radioactive materials or radiation fields that would require posting under Articles 234 or 235 (except for areas with fixed contamination) may be present in the area. ^{10 CFR 835.602(a)} Persons who enter only the Controlled Area without entering Radiation, High Radiation, Very High Radiation, Contamination, High Contamination, Airborne Radioactivity, or Radiological Buffer Areas are not expected to receive more than 100 mrem per year.

- a. Controlled Areas for external radiation purposes only are established where an individual is not expected to receive in excess of 0.1-rem external exposure in a year above natural background.
 - b. Controlled Areas for contamination purposes only are established where a potential is present for a contamination release within the workplace, but persons entering such an area would not be expected to receive more than 0.1 rem per year from an intake.
2. = LANL may select the type of sign used to avoid conflict with local security requirements, 10 CFR 103.642(b). This selection shall be approved by the Laboratory director or designee.
 3. The posting of a Controlled Area includes both the type of Controlled Area (posted for external radiation or contamination control) and the entry requirements for the area.

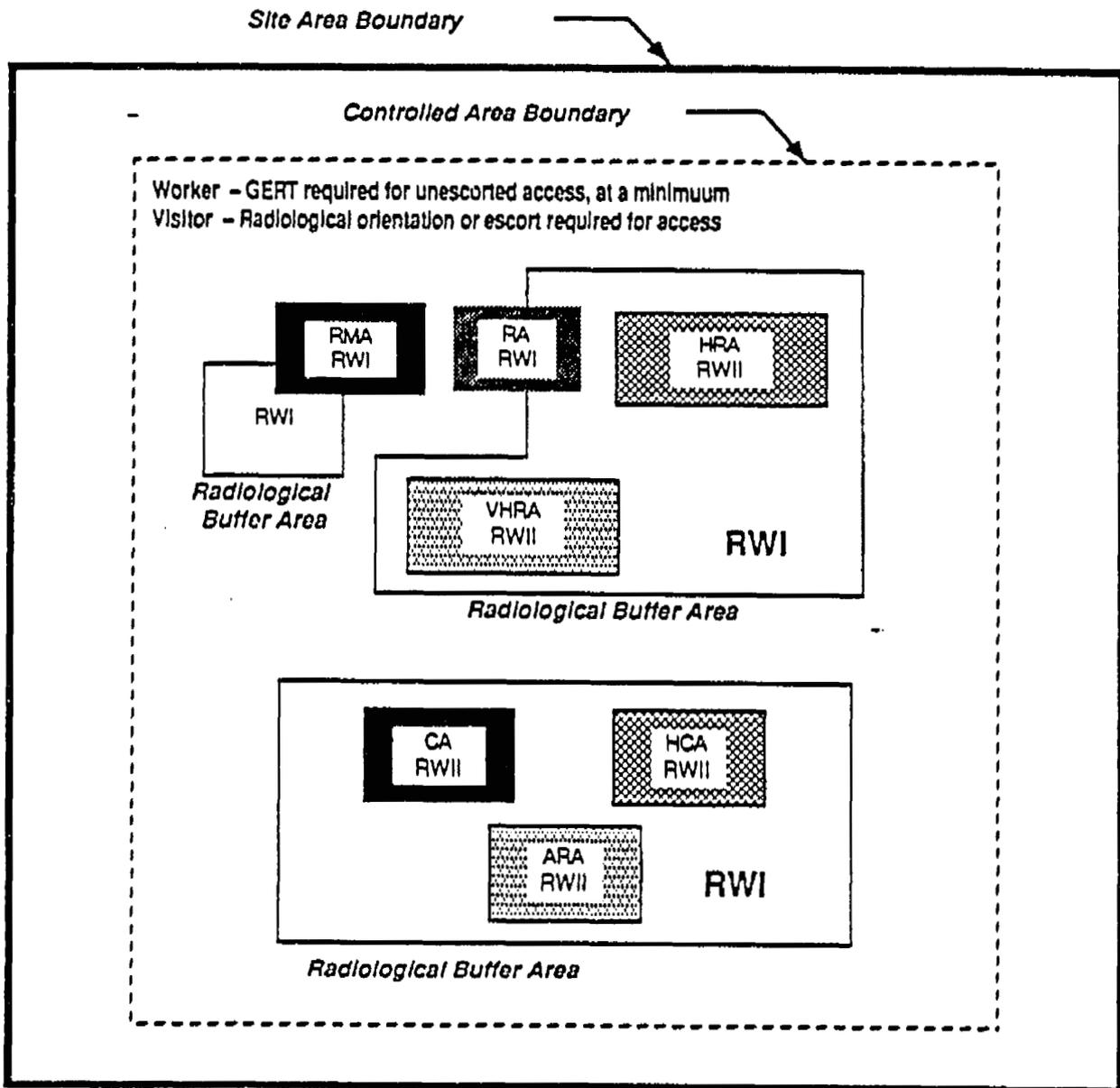
233 Posting Radiological Buffer Areas

A Radiological Buffer Area shall be established within the Controlled Area to provide secondary boundaries to minimize the spread of contamination and to limit doses to general employees who have not been trained as radiological workers. The Radiological Buffer Area is intended for use where ongoing work activities may create airborne radioactivity, the spread of contamination, or elevated external radiation fields. It is not expected that Radiological Buffer Areas would be established around inactive or secured Contamination Areas. The need for Radiological Buffer Areas in conjunction with locations designated for the storage of radioactive material should be evaluated.

For short-term operations such as maintenance activities on contaminated systems (i.e., "hot jobs"), the Radiological Buffer Area may be the same as the exclusion area (i.e., room or roped-off area) established for the job duration. For "permanent" contaminated areas, the Buffer Area may be the same as the step-off area between the Contamination Area and the Controlled Area.

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. Radiological Buffer Areas shall be posted in accordance with Article 231 and shall contain the wording "CAUTION, RADIOLOGICAL BUFFER AREA" or, alternatively, "CAUTION, HOT JOB EXCLUSION AREA" for "hot jobs."

Figure 2-1. Establishing Posted Areas



Legend:

GERT — General Employee Radiological Training
 RWI — Radiological Worker I Training
 RWII — Radiological Worker II Training
 RMA — Radioactive Material Area
 RA — Radiation Area

HRA — High Radiation Area
 VHRA — Very High Radiation Area
 CA — Contamination Area
 HCA — High Contamination Area
 ARA — Airborne Radiation Area

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234 Posting Radiation Areas (includes Radiation Areas, High Radiation Areas, and Very High Radiation Areas)

The following requirements and provisions pertain to photon (including gamma radiation, x-rays, and Bremsstrahlung), neutron, beta radiation, or other external radiation fields normally encountered in radiological work areas.

1. Areas shall be posted to alert personnel to the presence of external radiation fields in accordance with Table 2-3 and Article 231. ^{10 CFR 835.603}
2. Dose rate measurements used to determine criteria for Radiation Areas and High Radiation Areas should be made at a distance of 30 cm from the radiation source or from any surface through which the radiation penetrates. ^{10 CFR 835.603(a)} For Very High Radiation Areas, the measurement should be made at 100 cm. ^{10 CFR 835.603(a)} Measurements to establish Very High Radiation Areas shall be made with remote monitoring radiation survey instruments.
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 spots 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/hour. However, individuals preparing to enter such areas are required to review maps indicating where higher-than-average dose rates may be located.
5. The requirements for personnel dosimetry should be included on the sign.
6. The requirement for a radiological work permit 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 2-3). In this table, the unit "rad" is associated with dose rates that pose an immediate danger.

Table 2-3 Criteria for Posting Radiation Areas

AREA	DOSE RATE CRITERIA	POSTING
→ Radiation Area	> 0.005 rem/hr and ≤ 0.1 rem/hr @30 cm	"CAUTION, RADIATION AREA" ^{10 CFR 835.603(a)} "TLD Required for Entry"
→ High Radiation Area	> 0.1 rem/hr @30 cm and ≤ 500 rad/hr @100 cm	"DANGER, HIGH RADIATION AREA" ^{10 CFR 835.603(b)} "TLD, Supplemental Dosimeter, and RWP Required for Entry" ^a
→ Very High Radiation Area	> 500 rad/hr @100 cm	"GRAVE DANGER, VERY HIGH RADIATION AREA" ^{10 CFR 835.603(c)} "SPECIAL CONTROLS REQUIRED FOR ENTRY" ^a
Hot Spot	5 times general area dose rate	"CAUTION, HOT SPOT"

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

235 Posting Contamination, High Contamination, and Airborne Radioactivity Areas

1. = Areas shall be posted to alert personnel to contamination in accordance with Table 2-4 and Article 231.
10 CFR 835.404(c)(1), 403, 403(e), 403(f)
2. The requirement for a radiological work permit should be included either on or in conjunction with each posting as applicable. Depending on the area and extent of work, only a general radiological work permit may be required and may be so noted on the posting. See Article 322.
3. = DAC values for use with Table 2-4 are found in 10 CFR 835, Appendixes A and C. 10 CFR 835.209(a), 403(d)
4. Areas meeting the criteria for Fixed Contamination Areas specified in Table 2-4 and Article 222.3 do not have to be posted as Contamination or High Contamination Areas.

236 = Posting for Radioactive Material 10 CFR 835.401(a)

1. = Locations where radioactive materials are used, handled, or stored should be posted "CAUTION, RADIOACTIVE MATERIAL." The posting shall meet the requirements in Article 231.
2. = Locations where radioactive materials are used, handled, or stored should be located within Controlled Areas. However, low-level sources, such as sealed instrument-check sources, may be located in properly posted, locked storage locations outside Controlled Areas provided the sources are on a routine inventory and leak-test program.
3. = Posting for radioactive materials is not required when the radioactive material is in any one location and the following conditions prevail:
 - a. = The material consists of
 - ten or fewer sealed sources with half-lives of less than 30 days, or
 - ten or fewer sealed sources with each individual source possessing an activity that is less than the limits specified in Table 1 of DOE NS400.9 (extended by DOE NS400.10), or
 - quantities of unsealed radioactive material properly labeled and packaged that have half-lives of less than 30 days, or
 - quantities of unsealed radioactive material properly labeled and packaged that are less than 10 times (10x) the limits specified in Table 1 of DOE NS400.9 (extended by DOE NS400.10).
 - b. = The material is inside a Contamination, High Contamination, or Airborne Radioactivity Area.
4. = The definition of radioactive material and the requirements for labeling radioactive material are contained in Chapter 4.

Table 2-4 Criteria for Posting Contamination, High Contamination, and Airborne Radioactivity Areas

AREA	CRITERIA	POSTING
→ Contamination	Contamination levels (dpm/100 cm ²) > 1 time but ≤ 100 times Table 2-2 values (See Article 222.1)	"CAUTION, CONTAMINATION AREA" 10 CFR 835.403(e)
→ High Contamination	Contamination levels (dpm/100 cm ²) > 100 times Table 2-2 values (See Article 222.1)	"DANGER, HIGH CONTAMINATION AREA" 10 CFR 835.403(f) "RWP Required for Entry"
Fixed Contamination	Removable contamination levels < Table 2-2 removable values and total contamination levels > Table 2-2 total values	"CAUTION, FIXED CONTAMINATION"
Soil Contamination	Contaminated soil not releasable in accordance with DOE 5400.5	"CAUTION, SOIL CONTAMINATION AREA"
Airborne Radioactivity	Concentrations (μCi/cc) > 10% of any DAC value	"CAUTION, AIRBORNE RADIOACTIVITY AREA" "RWP Required for Entry"

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). 10 CFR 835.401(a)
2. → Underground Radioactive Material Areas shall be posted "UNDERGROUND RADIOACTIVE MATERIAL." Posting should include instructions or special warnings to workers such as "Consult with Radiation Protection Organization Before Digging" or "Subsurface Contamination Exists." The posting shall meet the applicable requirements of Article 231. 10 CFR 835.401(a)
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. 10 CFR 835.501(b), 401(a)
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. When access is likely to result in individual doses greater than 100 mrem in a year, entry requirements in Article 332.1 should be implemented.

Appendix 2A

Guidelines for Control of Emergency Exposures

In extremely rare cases, emergency exposure to radiation may be necessary to rescue personnel or to protect major property. Emergency exposures may be authorized in accordance with the provisions contained in 10 CFR 835. These doses are in addition to and accounted for separately from the doses received that are under the limits specified in Table 2-1. The dose limits for personnel performing these operations are listed below. Further guidelines for the control of emergency exposures are found in the LANL Emergency Management Plan.

DOSE LIMIT (Total Effective Dose Equivalent)	ACTIVITY PERFORMED	CONDITIONS
→ 5 rem	All 10 CFR 835.1302(d)	
→ 10 rem	Protecting major property	Only on a voluntary basis where lower dose limit not practicable 10 CFR 835.1302(d)
→ 25 rem	Saving the lives of individuals or protecting large populations	Only on a voluntary basis where lower dose limit not practicable 10 CFR 835.1302(d)
→ >25 rem	Saving the lives of individuals or protecting large populations	Only on a voluntary basis to personnel fully aware of the risks involved 10 CFR 835.1302(d)

Notes

- The dose limit to the lens of the eye is three times Table 2-1 values, 10 CFR 835.1302(d)
- The shallow dose limit to the skin of the whole body and the extremities is ten times Table 2-1 values, 10 CFR 835.1302(d)

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Appendix 2B

Weighting Factors for Organs and Tissues

ORGANS OR TISSUES	WEIGHTING FACTOR ^a
Gonads	0.25
Breasts	0.15
Red bone marrow	0.12
Lungs	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder ^b	0.30
Whole body ^c	1.00

- a. ⇒ Weighting factors (W_T) as defined in ICRP Publication 26 and NCRP Report 91 shall be 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. ^{10 CFR 835.203(b)} For example, a 5-rem dose to the thyroid would be multiplied by the weighting factor 0.03 to yield 0.15 rem.
- b. "Remainder" means the five other organs or tissues with the highest dose (i.e., liver, kidney, spleen, thymus, adrenal, pancreas, stomach, small intestine, and upper large intestine). The weighting factor of 0.3 for the remainder results from a weighting factor of 0.06 for each of the five remainder organs.
- c. ⇒ For the case of uniform external irradiation of the whole body, a weighting factor (W_T) equal to 1 may be used in the determination of the effective dose equivalent. ^{10 CFR 835.203(c)}

Appendix 2C

Nonuniform Exposure of the Skin

Nonuniform 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. 10 CFR 835.205(a)

AREA OF SKIN IRRADIATED	METHOD OF AVERAGING, ADDING TO OTHER DOSES RECEIVED, AND RECORDING NONUNIFORM SKIN DOSE
area ≥ 100 cm ²	<ol style="list-style-type: none"> 1. Average the dose equivalent over the 100 cm² of skin receiving the maximum dose. 2. Add this average dose to any uniform dose equivalent also received by the skin. 3. Record as the annual extremity or skin (shallow) dose equivalent (H). 10 CFR 835.205(h)(1)
area ≥ 10 cm ² but < 100 cm ²	<ol style="list-style-type: none"> 1. Average the dose equivalent over the 1 cm² of skin receiving the maximum dose (D), and reduce by the fraction (f) that is the irradiated area in cm² divided by 100 cm² (i.e., $H = fD$). In no case shall a value of f less than 0.1 be used. 2. Add this average dose to any uniform dose equivalent also received by the skin. 3. Record as the annual extremity or skin (shallow) dose equivalent. 10 CFR 835.205(h)(2)
area < 10 cm ²	<ol style="list-style-type: none"> 1. Average the dose over the 1 cm² of skin receiving the maximum dose. 2. Do not add to any other dose equivalent, extremity, or shallow dose equivalent (skin) recorded for the annual dose equivalent. 3. Record in the person's radiation dose record as a special entry. 10 CFR 835.205(h)(3)

Appendix 2D

Quality Factors

The quality factor is 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).

Radiation Type	Quality Factor
X-rays, gamma rays, positrons, electrons (including tritium beta particles)	1
Neutrons, ≤ 10 keV	3
Neutrons, > 10 keV	10
Protons and singly charged particles of unknown energy with rest mass greater than one atomic mass unit	10
Alpha particles and multiple-charged particles (and particles of unknown charge) of unknown energy	20 10 CFR 835.2(a)

When spectral data are insufficient to identify the energy of the neutrons, a quality factor of 10 shall be used. When spectral data are sufficient to identify the energy of the neutrons, the mean quality factor values in Appendix 2E may be used. 10 CFR 835.2(a)

Appendix 2E

- Quality Factors for Neutrons

(Mean quality factors [maximum value in a 30-cm dosimetry phantom] and values of neutron flux density that deliver in 40 hours a maximum dose equivalent of 100 mrem [0.001 sievert])

Neutron Energy (MeV)	Mean Quality Factor	Neutron Flux Density (cm ⁻² /sec ¹)
2.5 x 10 ⁻⁸ thermal	2	680
1 x 10 ⁻⁷	2	680
1 x 10 ⁻⁶	2	560
1 x 10 ⁻⁵	2	560
1 x 10 ⁻⁴	2	580
1 x 10 ⁻³	2	680
1 x 10 ⁻²	2.5	700
1 x 10 ⁻¹	7.5	115
5 x 10 ⁻¹	11	27
1	11	19
2.5	9	20
5	8	16
7	7	17
10	6.5	17
14	7.5	12
20	8	11
40	7	10
60	5.5	11
1 x 10 ²	4	14
2 x 10 ²	3.5	13
3 x 10 ²	3.5	11
4 x 10 ²	3.5	10

10 CFR 135.2(a)

CHAPTER 3 CONDUCT OF RADIOLOGICAL WORK

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PART 1 Planning Radiological Work**311 Requirements**

— Technical requirements for the conduct of work, including construction, modifications, operations, maintenance, and decommissioning, shall incorporate radiological criteria to ensure safety and maintain radiation exposures as low as reasonably achievable (ALARA). ^{10 CFR 835.1002(d)} The primary methods used to maintain exposures ALARA shall be facility and equipment design features. These features may be augmented by administrative and procedural requirements. ^{10 CFR 835.1601(a)(b)} To accomplish this, the design and planning process should incorporate radiological considerations in the early planning stages. The checklist in Appendix 3A is helpful in reducing occupational radiation exposure.

312 Planning for Maintenance, Operations, and Modifications

1. Maintenance and modification plans and procedures shall be reviewed to identify and incorporate radiological requirements, such as engineering controls and dose and contamination reduction considerations.

Performing this review is the responsibility of line management with support and concurrence from the radiation protection organization.

2. For routine tasks, such as surveillance, tours, and minor nonradiological maintenance, performance of the above review and documentation of identified radiological requirements may be conducted as part of the radiological work permit (RWP) process (see Article 321).
3. The following trigger levels shall require formal radiological review of nonroutine or complex work activities by the involved line organizations and the radiation protection organization, using the radiological/ALARA job-planning review process.
 - a. Estimated individual external dose greater than 100 mrem or collective external dose greater than 500 person-mrem per work activity (as defined by the radiological work permit)
 - b. Actual or predicted airborne radioactivity concentrations in excess of 40 DACs (derived air concentration) hours
 - c. Work area removable contamination greater than 100 times the values in Table 2-2
 - d. Entry into areas where dose rates exceed 500 mrem/hr
 - e. Potential radioactive releases to the environment that are of a nonroutine nature (routine releases from identified sources do not require formal radiological reviews)
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. Include radiological control hold points in the radiological work permit and technical work documents.
 - b. Eliminate or reduce radioactivity through line flushing and decontamination.
 - c. Use work processes and special tooling to reduce time in the work area.
 - d. Use engineered controls to minimize the spread of contamination and generation of airborne radioactivity.
 - e. Specify special radiological training or monitoring requirements.
 - f. Use mock-ups for high-exposure or complex tasks.
 - g. Design, engineer, and use temporary shielding to reduce radiation levels.
 - h. Walk down or perform a dry run of the activity using applicable procedures.
 - i. Stage and prepare necessary materials and special tools.
 - j. Maximize prefabrication and shop work.
 - k. Review abnormal and emergency procedures and plans.
 - l. Identify points where signatures and second-party or independent verifications are required.
 - m. Establish success or completion criteria, with contingency plans to anticipate difficulties.

- n. Develop a pre-job estimate of collective exposure to be incurred for the job.
 - o. Provide for waste minimization and disposal.
5. Radiological requirements identified as a result of the above radiological review should be specified in the radiological/ALARA job-planning review documentation, procedures, or work plans.
 6. Radiological work anticipated to exceed individual or collective dose criteria established above as trigger levels should be reviewed and approved by the line organization ALARA committee or the line organization ALARA coordinator.
 7. — Optimization techniques, including cost-benefit analyses, represent a fundamental part of radiological design analysis and work review. For review of minor activities with low associated doses, a cost-benefit evaluation is an intrinsic part of the engineering review process, and a detailed evaluation is not necessary. For review and planning of major tasks involving higher collective dose expenditures, a detailed and documented evaluation shall be performed by the line organization in coordination with the Health Physics Operations Group (ESH-1), the Policy and Program Analysis Group (ESH-12) ALARA Team, and the Facility, Security and Safeguards (FSS) Division. ^{10 CFR 835.1002(a)}
 8. — The DAC values given in appendixes A and C of 10 CFR 835 shall be used in the control of occupational exposures to airborne radioactive material. ^{10 CFR 835.200(a)}

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 the following:

1. Formal radiological review in accordance with Article 312.4
2. Group leader review directed toward anticipating concerns and emphasizing and specifying protective measures
3. Review and approval by the line organization ALARA committee
4. Enhanced line and radiation protection organization management oversight during the initiation and conduct of the work

314 Temporary Shielding (for Radiological Control Purposes Only)

1. The installation, use, and removal of any materials used to provide radiation shielding on an intentionally temporary basis (hereafter referred to as "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 by ESH-1 to verify effectiveness and integrity.
4. Radiation surveys should be performed by ESH-1 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 ESH-1."
6. Installed temporary shielding should be periodically evaluated by the radiation protection organization to assess the need for its removal or replacement with permanent shielding.
7. Facility procedures may identify specific shielding applications, such as the shielding of low-activity sources or samples, that fall outside the recommendations of this article.

315 Technical Work Documents

1. Technical work documents, such as safe operating procedures, work plans, 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 for 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 radiation protection organization.
3. Radiological control hold points should be incorporated into technical work documents for steps that require action by the radiation protection organization to prevent radiation exposures in excess of administrative control levels, high airborne radioactivity concentrations, or the release of radioactive material to the environment that is of a nonroutine nature.

316 Minimizing Internal Exposure

The minimization and control of internal exposure as discussed in Article 136 should be conducted in accordance with the guidelines of Appendix 3A and the following hierarchy of controls.

1. = Engineering controls, including containment of radioactive material at the source wherever practicable, should be the primary method of minimizing airborne radioactivity and internal exposure to workers. ¹⁰ CFR 835.1001(a)(c)
2. = Administrative controls, including access restrictions and the use of specific work practices designed to minimize airborne contamination, should be used as the secondary method to minimize worker internal exposure. ¹⁰ CFR 835.1001(a)(b)
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 Area
 - b. Breach of contaminated systems or components
 - c. Work in areas or on equipment with removable contamination levels greater than 100 times the values in Table 2-2
 - d. 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.
5. In specific situations, the use of respiratory protection may be contraindicated due to physical limitations or the potential for significantly increased external exposure. In such situations, written authorization should be obtained from the line organization manager and the Radiation Protection Program manager prior to incurring internal exposure. Specific justification of the need to accept the exposure, including a description of measures taken to mitigate the airborne radioactivity, should be documented as part of the authorization process.
6. The following controls shall be 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 (CAMs), portable air samplers, and fixed-head air samplers with expedited assessment and analysis of results.

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7. Workers with open or healing wounds should not enter Controlled Areas and Radiological Buffer Areas established for contamination control purposes and Contamination Areas, High Contamination Areas, or Airborne Radioactivity Areas unless approved by ESH-1.
8. The DAC values given in Appendixes A and C of 10 CFR 835 shall be used in controlling occupational exposures to airborne radioactive material. ^{10 CFR 835.209(a)}

PART 2 Work Preparation**321 Radiological Work Permits**

The radiological work permit is an administrative mechanism used to evaluate and document potential radiological hazards, and establish radiological controls for intended work activities. The radiological work permit informs workers of area radiological conditions and entry requirements and provides a mechanism to relate worker exposure to specific work activities. The radiological work permit should include 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
6. Protective clothing and respiratory protection requirements
7. ESH-1 coverage requirements and stay-time controls, as applicable
8. Limiting radiological conditions that may void the radiological work permit
9. Special dose or contamination reduction considerations
10. Special personnel frisking considerations
11. Technical work document number, as applicable
12. Unique identifying number
13. Date of issue and expiration
14. Authorizing signatures by the radiation protection organization, FSS Division, operating group, or subcontractor as appropriate for the work activities covered by the radiological work permit

322 Using Radiological Work Permits

1. — Radiological work permits shall be used to control the following activities:
 - a. — Entry into High and Very High Radiation Areas ^{10 CFR 835.501(d)}
 - b. — Entry into High Contamination Areas ^{10 CFR 835.501(d)}
 - c. — Entry into Airborne Radioactivity Areas ^{10 CFR 835.501(d)}
2. — Radiological work permits should be used to control the following activities:
 - a. — Entry into Radiation Areas ^{10 CFR 835.501(d)}
 - b. — Entry into Contamination Areas ^{10 CFR 835.501(d)}
 - c. — Handling of materials with removable contamination that exceed the values of Table 2-2 ^{10 CFR 835.501(d)}
3. — Job-specific radiological work permits shall be used to control nonroutine operations or work in areas with changing radiological conditions. ^{10 CFR 835.501(d)} The job-specific radiological work permit shall remain in effect only for the duration of the job.

4. General radiological work permits may be used to control routine or repetitive activities, such as tours and inspections or minor work activities, in areas with well-characterized and stable radiological conditions. General radiological work permits should not be approved for periods longer than one year.
5. — Radiological surveys shall be routinely performed and reviewed to evaluate adequacy of radiological work permit requirements. Radiological work permits shall be updated if radiological conditions change to the extent that protective requirements need modification. ^{10 CFR 835.501(d)}
6. Radiological work permits should be posted at the access point to the applicable radiological work area or acknowledged through electronic means where automated access systems are in place.
7. Workers shall sign (or acknowledge through electronic means in areas where automated access systems are in place) that they have read, understand, and will comply with the radiological work permit before initial entry to the area and after any revisions to the radiological work permit.
8. Worker pocket or electronic dosimeter readings should be recorded in a format that identifies and provides linkage to the applicable radiological work permit.
9. — An alternative formal mechanism, such as safe operating procedures (SOPs) or experiment authorizations, may be used in lieu of a radiological work permit as the administrative control over radiological work activities. ^{10 CFR 835.501(d)} If an alternative mechanism is used, it should meet the requirements of this article and Articles 321 and 323.

323 Preparing Radiological Work Permits

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 radiological work permit.
2. Radiological work permits shall be reviewed and approved by the radiation protection organization and other appropriate line and contractor organizations.
3. The radiological work permit shall be based on current radiological surveys and anticipated radiological conditions.
4. The radiological work permit shall be approved by the supervisor responsible for the work or area and the appropriate ESH-1 radiological control technician (RCT) supervisor. Revisions or extensions to radiological work permits 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. Pre-job briefings should also be conducted for all work activities covered by a radiological work permit in which multiple line organizations, crafts personnel, and support personnel are involved in the work evolution. Pre-job briefings should be held when a radiological work permit is revised or when personnel in the work evolution change.
2. At a minimum, the pre-job briefing should include the following:
 - a. Scope of work to be performed
 - b. Radiological conditions of the workplace
 - c. Procedural and radiological work permit requirements
 - d. Special radiological control requirements
 - e. Radiologically limiting conditions, such as contamination or radiation levels that may void the radiological work permit
 - 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 ESH-1 personnel, and representatives from involved support organizations should attend the briefing.
 5. A summary of topics discussed and attendance at the pre-job briefing should be documented. This documentation should be maintained with the technical work document.

325 Personal Protective Equipment and Clothing

1. — Personnel shall wear protective clothing during the following activities:
 - a. Handling of contaminated materials with removable contamination in excess of Table 2-2 levels
 - b. — Work in Contamination, High Contamination, and Airborne Radioactivity Areas ¹⁹ CFR 135.404(a)
 - c. As directed by the ESH-1 RCT, as specified on the entry posting, or as required by the radiological work permit
2. Protective clothing and shoes designated for radiological control shall be as follows.
 - a. Marked in accordance with Article 461
 - b. Used only for radiological control purposes
3. Protective clothing dress-out areas should be established as close as possible to the work area. Workers should proceed directly to the radiological work area after donning personal protective equipment and clothing.
4. Personal protective equipment and clothing shall be selected as prescribed by the controlling radiological work permit or as specified on the entry posting. General guidelines for protective clothing selection and use are provided in Appendix 3C and in Table 3-1.
5. The use of lab coats as radiological protective clothing is appropriate for limited applications such as those discussed in Appendix 3C where the potential for personal contamination is limited to the hands, arms, and upper front portion of the body. Lab coats should not be used as protective clothing for performing physical work activities in Contamination, High Contamination, or Airborne Radioactivity Areas.
6. In areas where personal protective clothing is routinely worn, instructions for donning and removing the protective clothing should be posted at the dress-out and step-off pad area.
7. The use of protective equipment or clothing (including respiratory protection) beyond that authorized by ESH-1 detracts from work performance and is contrary to ALARA principles and waste minimization practices. Such use should not be authorized.
8. Company-issued clothing (not radiological protective 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. Precautionary clothing is a type of radiological protective clothing.

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

Successful completion of General Employee Radiological Training is required as a minimum 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 I training
 - b. Personnel dosimetry, as appropriate
2. Personnel who exit a Radiological Buffer Area containing Contamination Areas, High Contamination Areas, or Airborne Radioactivity Areas should be monitored as specified in Article 338.

333 Locations Posted for Radioactive Materials

1. Radiological Worker I training shall be required for unescorted entry into locations posted for radioactive materials (see Article 236) containing either of the following:
 - a. Sealed radioactive sources that exceed the trigger level specified in Article 236.3.a
 - b. Radioactive material of a quantity exceeding the trigger level specified in Article 236.3.a labeled and packaged in accordance with Articles 412 and 413
2. Entry into locations posted for radioactive materials where whole-body dose rates exceed 5 mrem/hr or removable contamination levels exceed Table 2-2 values shall be in accordance with the requirements of Articles 334.1 and 335.1, respectively.

334 Radiation, High Radiation, and Very High Radiation Areas

1. Minimum requirements for unescorted entry into Radiation Areas shall include the following:
 - a. Radiological Worker I
 - b. Worker's signature on the radiological work permit, 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, 10 CFR 835.507(a)(b)(c)
3. Minimum requirements for unescorted entry into High Radiation Areas shall include the following:
 - a. Radiological Worker II training and training in the use of a survey meter (or dose-rate-indicating device)
 - b. Worker's signature on the radiological work permit
 - c. Personnel and supplemental dosimeters 10 CFR 835.402(a)(4)
 - d. Survey meter or dose-rate-indicating device available at the work area
 - e. Another worker meeting the above minimum requirements who can observe the worker making the entry from a low-dose-rate, low/no contamination, low/no airborne radioactivity vantage point and who can respond in the event of an emergency

3. Personnel exiting Contamination, High Contamination, or Airborne Radioactivity Areas shall perform the following:
 - 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
 - b. Step-off pads maintained free of radioactive contamination
 - c. Labeled containers inside the area boundary for the collection of protective clothing and equipment, and radwaste, if needed
 - d. Contamination monitoring equipment located as close to the step-off pad as background radiation levels permit
5. Multiple step-off pads should be used at the exits from High Contamination Areas. Use of multiple step-off pads is described in Appendix 3C.
6. Protective clothing and monitoring requirements specific to bench top work, laboratory fume hoods, sample stations, and glove boxes 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. ^{10 CFR 835.501(e)(c)(d)} — 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(e)(d)}
9. No controls shall be installed at any radiological area exit that would prevent rapid evacuation of personnel under emergency conditions. ^{10 CFR 835.501(e)}

336 Visitor Entry Requirements

1. Facility procedures shall identify area entry requirements and access restrictions for visitors.
2. Visitors with a demonstrated need to enter the areas listed below may be allowed access if such access is controlled with a combination of training and the use of escorts trained for the specific areas.
 - a. Controlled Area
 - b. Radiological Buffer Area
 - c. Radiation Areas
 - d. Contamination Area
 - e. Radioactive material storage locations
3. 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.
4. Training requirements for visitors are identified in Articles 622 and 657.

337 Controlling the Spread of Contamination

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

1. → Use solid barriers to enclose areas wherever practicable. 10 CFR 835.404(b)
2. → Mark and secure items such as hoses and cords that cross the boundary. 10 CFR 835.404(b)
3. → Control and direct airflow from areas of lesser to greater removable contamination. 10 CFR 835.404(b)
4. → Use engineering controls and containment devices such as glove bags, glove boxes, and tents. 10 CFR 835.404(b)
5. → Consider the physical and chemical characteristics of the contaminant, the radionuclides present, and the fixed and removable contamination levels. 10 CFR 835.404(e)(2)

338 Monitoring for Personnel Contamination

1. Personnel shall perform a whole-body frisk under the following conditions:
 - a. Immediately upon entry into an uncontaminated area after exiting Contamination Areas, High Contamination Areas, and Airborne Radioactivity Areas
 - b. As directed by the radiological work permit, the ESH-1 RCT, or the area exit posting
2. In addition to the above, personnel exiting a Controlled Area or 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 Controlled Area or 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 perform the following:
 - 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 before 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. 10 CFR 835.404(f)
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, 19 CFR 105.941(e)
2. Prerequisite conditions, such as tagouts and system isolation, should be verified.

342 Work Conduct and Practices

1. Contamination levels caused by ongoing work shall be monitored and maintained ALARA. Work should be curtailed and decontamination performed at pre-established contamination levels, taking into account worker exposure.
2. Tools and equipment should be inspected to verify applicability and 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 contaminated work area should be secured to prevent the spread of contamination and to prevent them from becoming 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 all types of radiological areas.
8. Where practicable, parts and components should be removed to areas with low dose rates before they are worked on.
9. Upon identification of radiological concerns, such as inappropriate work controls or procedural deficiencies, workers should immediately report the concern to line supervision or ESH-1.
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 pre-work status.
11. To minimize intakes of radioactive material by personnel, smoking, eating, drinking (except as noted below), applying cosmetics or lip balms, or chewing shall not be permitted in Contamination, High Contamination, or Airborne Radioactivity Areas. Smoking, eating, drinking (except as noted below) applying cosmetics or lip balms, or chewing is also not allowed in Controlled or Radiological Buffer Areas established for potential contamination purposes. When a potential exists for personnel heat stress, drinking may be permitted within a Controlled, Radiological Buffer, and Contamination Area if all the following conditions and controls are met.
 - 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, workers' hands and faces shall be monitored for contamination prior to drinking.
 - d. Participating workers shall be monitored as part of the bioassay program.
 - e. The applicable requirements and controls shall be described in approved procedures.

343 Logs and Communications

1. Radiological control personnel should maintain logs to document radiological occurrences, status of work activities, and other relevant information.
2. During continuous or extended daily operations, incoming ESH-1 personnel should review logs and receive a turnover briefing from the personnel they are relieving.
3. Communication systems required by the radiological work permit or technical work document should be checked for operability before being brought into the work area and periodically during work.
4. Workers should keep radiological control personnel informed of the status of work activities that affect radiological conditions.
5. Conduct of the operations described in this article should follow DOE Order 5480.19, "Conduct of Operations."

344 Reviewing Work in Progress

1. As part of their normal work review, work supervisors should periodically review ongoing jobs to ensure prescribed radiological controls are being implemented.
2. Radiological control personnel should conduct frequent tours of the workplace to review the adequacy of radiological work practices, posting, and area controls.
3. During the performance of jobs for which a pre-job dose estimate was made, ESH-1 and -12 (as appropriate), 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 his or her supervisor have 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 Radiation Protection Program manager.

346 Responding to Abnormal Situations

1. The *LANL Radiological Control Manual* establishes requirements for responding to alarms as described below.
2. Response to a continuous air monitor alarm should include the following actions:
 - a. Stop work activities.
 - b. Immediately exit the area.

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- c. Notify ESH-1 personnel and line supervisor.
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 ESH-1 personnel and line supervisor.
 4. Response to a criticality alarm should include the following actions:
 - a. Immediately evacuate the area without stopping to remove protective clothing or perform exit monitoring.
 - b. Report to designated assembly area.
 - c. Notify ESH-1 personnel and line supervisor.
 5. Response to a personnel contamination monitor alarm should include the following actions:
 - a. Remain in the immediate area.
 - b. Notify ESH-1 personnel and line supervisor.
 - 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 non-HEPA-filtered ventilation.
 - f. Notify ESH-1 personnel and line supervisor.
 7. Response to a spill involving highly toxic chemicals should include the following actions:
 - a. Immediately exit the area without attempting to stop or secure the spill.
 - b. Promptly notify the line supervisor, group/division/facility spill coordinator, and Hazardous Materials Response Group (ESH-10); and ESH-1 personnel in the event of a radiological concern.

347 Controls for Bench Top Work, Laboratory Fume Hoods, Sample Stations, Open-Front Boxes, and Glove Boxes

The following requirements are applicable to radiological work that has the potential to generate radioactive contamination in localized bench top areas, open-front boxes, laboratory fume hoods, sample stations, and glove box operations located in areas that are otherwise contamination free.

1. Radiological work permits or other controlling work documents (for example, SOPs) should be issued to control radiological work in localized bench top areas, open-front boxes, laboratory fume hoods, sample stations, and

glove boxes. Personnel dosimetry (as appropriate) and Radiological Worker II are required for work in these areas.

2. The following controls apply to localized bench top, open-front box, and laboratory fume hood operations:
 - a. Protective clothing shall, at a minimum, include lab coats and gloves. Gloves should be secured at the wrist as necessary. Eye and face protection must be worn, as appropriate, as specified in AR 12-1, "Personal Protective Equipment"
 - 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 bodies 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 sample station operations:
 - a. Protective clothing shall, at a minimum, include lab coats 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. If there is a potential for splashing or airborne radioactivity, as there is when taking pressurized samples, additional controls such as rubber aprons, full protective clothing, or respiratory protection should be instituted. Eye and face protection must be worn, as appropriate.
 - d. Workers should periodically monitor their hands during work.
 - e. Upon completion of work or prior to leaving the area, workers shall monitor those areas of their bodies that may be potentially contaminated. At a minimum, this includes hands, arms, and front portions of the body. Workers should perform whole-body frisks.
4. The following controls apply to glove box operations:
 - a. Glove boxes should be inspected for integrity and operability prior to use.
 - b. Glove boxes should be marked or survey measurements should be posted to identify whole-body and extremity dose rates.
 - c. Protective clothing shall, at a minimum, include lab coats and gloves. Gloves should be secured at the wrist as necessary. Eye and face protection must be worn, as appropriate.
 - 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 bodies that are potentially contaminated. At a minimum, this includes hands, arms, and feet. Workers should perform whole-body frisks.

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 may be generated when contaminated systems are opened or when operations such as machining, cutting, or grinding are performed on highly radioactive materials.

1. At LANL, hot particles are defined as those particles capable of producing a shallow dose equivalent greater than 100 mrem in 1 hr.
2. Measures for controlling hot particles, as identified in items 3 through 7 of this article, should be implemented under any of 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

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- c. Upon direction of the radiation protection 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 radiological work permit. The following controls should be considered for inclusion on the radiological work permit:
 - 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 personnel 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 prior to 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
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PART 5 Evaluation of Performance

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

Analysis of the facts may reveal areas where improvements can be made or where methods can be identified to prevent the recurrence of events leading to 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 members of operating groups, the Occurrence Investigation Group (ESH-7), or the radiation protection organization staff members who have been 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. The general critique process should include the following elements:
 - a. Formal meetings, chaired by a critique leader
 - b. Attendance by all who can contribute
 - c. Personal statement forms completed by selected personnel before the meeting
 - d. Attendance records
 - e. Minutes, recorded and signed by the critique leader and all contributors
 - f. Personal statements, signed and attached to the meeting minutes
 - g. A listing of the facts in chronological order
 - h. Supporting materials, including documents, records, photographs, parts, and logs, maintained by the critique leader
5. Evaluation of complex evolutions or events may require multiple critiques.

352 Post-Job Reviews

Performance should be reviewed after completion of nonroutine radiological work (work that would trigger the levels specified in Article 312.3). Requirements for post-job reviews include documentation of the following information:

- a. Specific job performed, including location
- b. Original dose estimate for completing the job and how it was calculated
- c. Resources required
- d. Precautions taken
- e. Names and titles of people performing job
- f. Problems encountered
- g. Solutions to problems

- h. Abnormal occurrences
- i. Time required for job
- j. Number of people required
- k. Individual and total dose for job

353 Lessons Learned

Lessons learned are available from post-job reviews and reports of past radiological events on site and at other facilities. The radiation protection organization, in conjunction with line management, should evaluate lessons learned, provide prompt distribution, and incorporate the lessons into the Radiation Protection Program, the radiological training program, related operations, and program documentation, including this manual.

PART 6 Special Applications

This part provides supplemental information to augment the basic requirements of the *LANL Radiological Control Manual*. Articles 361 through 365 provide information to be used in enhancing the LANL Radiation Protection Program. 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 apply 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

Exposure to small quantities of plutonium is perceived to present greater risk than exposure to other radionuclides. While this is not true, low levels of plutonium in the body are difficult to measure and biological removal processes for plutonium are slow. For these reasons, the following requirements shall be met.

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 the *LANL Radiological Control Manual*, guidance contained in the document, "Health Physics Manual of Good Practices for Plutonium Facilities," PNL-6534, should be considered for plutonium operations at LANL. The "Health Physics Manual of Good Practices for Plutonium Facilities" 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 the *LANL Radiological Control 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 at LANL. The "Health Physics Manual of Good Practices for Uranium Facilities" 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 LANL Radiation Protection Program at tritium facilities.

1. Tritium emits low-energy beta particles, which cannot be monitored using external dosimeters. Consequently, the use of bioassay measurements is required to evaluate worker dose.
2. Worker exposure to tritium as water vapor results in 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. Because of 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 at LANL. The "Health Physics Manual of Good

"Practices at Tritium Facilities" 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 extremely high dose rates, high-energy and heavy particles, generation of activation products, and detection and monitoring difficulties associated with pulsed- or high-energy radiation.

1. In addition to the provisions of the *LANL Radiological Control Manual*, guidance contained in the document, "Health Physics Manual of Good Practices for Accelerator Facilities," SLAC-327, should be considered for accelerator operations at LANL. The "Health Physics Manual of Good Practices for Accelerator Facilities" provides specific guidance related to radiological monitoring, dosimetry, shielding design, use of interlocks, and procedures and administrative controls.
2. The requirements specified in DOE Order 5480.25, "Safety of Accelerator Facilities," must be followed at accelerator facilities and should be incorporated into LANL Radiation Protection Program documentation. In the event of any lexical, semantic, or definitional differences in and between the requirements of this manual and DOE Order 5480.25, contractors are delegated the discretionary authority to amalgamate where possible and evolve radiation safety procedures to locally constitute the best compromise.
3. Safety devices and interlocks shall be operational prior to and during operation of a beam. Operational status shall be verified by testing.
4. Consideration should be given to the information provided in ANSI N43.1, "Radiological Safety in the Design and Operation of Particle Accelerators," for accelerator operations at LANL.

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 of operating and support personnel and those in adjacent work areas. The following are provisions for applicable types of radiation-generating devices.

1. DOE 5480.4 mandates the use of ANSI N43.3, "American National Standard for General Radiation Safety for 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, "Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment," for operations involving one or more of the following devices.
 - a. Analytical diffraction and fluorescence devices
 - b. Sealed source irradiators used for diffraction studies
3. Line management, in conjunction with ESH-12, shall establish the radiological control requirements for incidental x-ray devices and indirectly ionizing radiation devices such as electron microscopes, electron beam welders, flash x-ray generators, experimental/prototype accelerator and radio-frequency structures, high-power microwave systems/generators, and field emission electron beam diodes.
4. Devices for medical use shall be registered with the appropriate regulatory agency, if required. The state of New Mexico has requested that LANL not register its medical x-ray devices.
5. For radiographic devices, the following control requirements apply.
 - a. On-site operations with devices containing sealed sources should be conducted in accordance with the requirements contained in Title 10 CFR Part 34, "Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations." However, the licensing requirements of the part do not apply for on-site DOE operations.

- b. DOE 5480.4 mandates the use of ANSI N43.3, "American National Standard for General Radiation Safety for 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 ESH-1 and the ESH-12 source registrar. 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.
 7. In the event of any lexical, semantic, or definitional differences in and between the radiation safety procedures and posting/labeling requirements of this manual and similar requirements contained in the ANSI N43.2 and N43.3 national consensus x-ray standards, contractors are delegated the discretionary authority to amalgamate where possible and evolve radiation safety procedures and posting/labeling solutions considered to locally constitute the best compromise between otherwise conflicting radiation safety and posting/labeling guidance. Such radiation safety procedures and posting/labeling conflict resolution must be oriented toward the primary goal of achieving the greatest procedural and semantic positive radiation safety impact.

PART 7 Construction and Restoration Projects and Activities Involving Energetic Materials

Construction and restoration projects, including decontamination and decommissioning (D&D), remedial action, or other actions involving materials that 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 the Formerly Utilized Sites Remedial Action Program (FUSRAP), Uranium Mill Tailings Remedial Action (UMTRA) projects, other restoration projects, and activities involving energetic materials.

371 Requirements

— Radiological operations and work activities at construction and environmental restoration projects and activities involving energetic materials shall be conducted in accordance with this manual and facility-specific radiation protection programs (see Appendix 1A). In light of the special nature of these activities, which typically involve low levels of radioactivity, the use of heavy construction or earth-moving equipment, and/or the handling of energetic materials, these projects require some radiological considerations different from other activities governed by the *LANL Radiological Control Manual*, 10 CFR 835.601(e).

— For the following specific subject areas, the radiological requirements of the *LANL Radiological Control Manual* may be modified by the limited application of the provisions of Article 113.3. The Radiation Protection Program manager is authorized to change mandatory "shall" requirements to "should" to facilitate implementation of radiological controls in the following specific subject areas. The affected line organization has the responsibility to document the technical equivalency of alternative solutions. 10 CFR 835.601(e)

1. Performance goals and indicators appropriate to remedial activities and activities involving energetic materials
2. Personal protective equipment requirements and practices to accommodate other hazards on the site
3. Use of respiratory protection during normal conduct of operations due to lack of engineering controls and the temporary nature of the work
4. Use of contamination reduction corridors to accommodate the movement of personnel and heavy equipment through a variety of decontamination stations
5. Methods to obtain representative samples for the release of equipment and material from work areas
6. Surveying of materials released from Soil Contamination Areas that exhibit frequent 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 10 CFR 835.601(e)(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, snow, or ice

372 Environmental Conditions

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

1. The use of covers, wind screens, and run-off collection basins to preclude the inadvertent spread of radioactive material
2. Provisions for work-site personnel to assemble and be monitored prior to release or continuation 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. Hazards to consider include the following.

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
12. Energetic materials
13. Drilling operations

N.F. CORPORATION

Appendix 3A

Checklist for Reducing Occupational Radiation Exposure

Preliminary Planning and Scheduling

1. Plan in advance.
2. Delete unnecessary work.
3. Determine expected radiation, contamination, and airborne radioactivity levels.
4. Estimate collective dose.
5. Sequence jobs.
6. Schedule work.
7. Select a trained and experienced work force.
8. Identify and coordinate resource requirements.

Preparation of Technical Work Documents

1. Include special radiological control requirements in technical work documents (e.g., SOPs).
2. Perform ALARA pre-job review.
3. Plan access to and exit from the work area.
4. Provide for service lines (air, welding, ventilation).
5. Provide communication (sometimes includes closed-circuit television).
6. Remove or shield sources of radiation.
7. Plan for installation of temporary shielding.
8. Decontaminate or cover areas with loose contamination.
9. Work in lowest radiation, contamination, and airborne radioactivity levels.
10. Perform as much work as practicable outside radiological areas.
11. State requirements for standard tools.
12. Consider special tools, including robots.
13. State staging requirements for materials, parts, and tools.
14. Incorporate radiological control hold points.
15. Minimize discomfort of workers.
16. Revise estimates of person-rem.
17. Prepare radiological work permits.

Temporary Shielding

1. Design shielding to include stress considerations.
2. Control installation and removal by written procedure.
3. Inspect after installation.
4. Conduct periodic radiation surveys.
5. Prevent damage caused by heavy temporary shielding.
6. Balance radiation exposure received in installation against exposure saved by installation.
7. Shield travel routes.
8. Shield components with abnormally high radiation levels early in the maintenance period.
9. Shield position occupied by worker.
10. Perform directional surveys to improve design of shielding by locating source of radiation.
11. Use mock-ups to plan temporary shielding design and installation.
12. Consider use of water-filled shielding.

13. Consider worker safety and industrial hygiene issues when working with lead.

Rehearsing and Briefing

1. Rehearse
2. Use mock-ups duplicating working conditions
3. Use photographs and videotapes
4. Supervisors conduct briefings of workers

Performing Work

1. Comply with technical work documents and radiological work permits
2. Post radiation levels
3. Keep unnecessary personnel out of radiation areas
4. Minimize radiation exposure
5. Supervisors and workers keep track of radiation exposure
6. Workers assist in radiation and radioactivity measurements
7. Delegate radiological control monitoring responsibilities
8. Evaluate use of fewer workers
9. Reevaluate reducing radiation exposures and internal exposures
10. Compare actual collective dose against pre-job estimate
11. Review work practices to see if changes will reduce dose
12. 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 whole-body dose of 1000 mrem in any 1 hr. ^{10 CFR 835.501(c), 502(a)}
 - a. — A control device that prevents entry to the area when high radiation levels exist or that upon entry causes the radiation level to be reduced below that level defining a High Radiation Area ^{10 CFR 835.501(c), 502(a)}
 - b. — A device that functions automatically to prevent use or operation of the radiation source or field while personnel are in the area ^{10 CFR 835.501(c), 502(a)}
 - 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 ^{10 CFR 835.501(c), 502(a)}
 - d. — Entry ways that are locked, except during periods when access to the area is required, with positive control over each entry ^{10 CFR 835.501(c), 502(a)}
 - e. — Continuous direct or electronic surveillance that is capable of detecting and preventing unauthorized entry ^{10 CFR 835.501(c), 502(a)}
 - 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 ^{10 CFR 835.501(c), 502(a)}
2. — In addition to the above requirements, additional measures shall be implemented to ensure personnel are not able to gain access to Very High Radiation Areas when dose rates are in excess of the posting requirements for Very High Radiation Areas specified in Table 2-3. ^{10 CFR 835.501(b)(c), 502(b)}
3. — Physical access controls over High and Very High Radiation Areas shall be established in such a way that they do not prevent a person from leaving the area. ^{10 CFR 835.501(c)(e), 502(c)}

Appendix 3C

Personnel 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 the following.

Full Set of PCs

- a. Coveralls
- b. Cotton glove liners (optional)
- c. Gloves (specify type: latex, natural rubber, etc.) (if liners not worn another pair of gloves must be worn)
- d. Shoe covers
- e. Rubber overshoes
- f. Hood

Double Set of PCs

- a. Two pairs of coveralls
 - b. Cotton glove liners (optional)
 - c. Two pairs of gloves (specify type: latex, natural rubber, etc.)
 - 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. Shoe covers 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. As appropriate, it is required that leather or canvas work gloves be monitored for possible contamination build-up when handling unclad uranium items such as castings and crucibles used for melting uranium.
 5. Use of hard hats, safety shoes, and safety glasses in Contamination Areas should be controlled by the radiological work permit. Hard hats designated for use in such areas should be distinctly colored or marked.
 6. Shoe covers and gloves should be secured or taped at the coverall legs and sleeves when necessary to prevent worker contamination. Tape should be tabbed to permit easy removal. Only masking tape is acceptable.
 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 or personal underwear should not be worn under protective clothing for entry to High Contamination Areas or during work conditions requiring a double set of protective clothing.

Table 3-1 Guidelines for Selecting Protective Clothing^a

WORK ACTIVITY ^{b,c}	PROTECTIVE CLOTHING		
	LOW REMOVABLE CONTAMINATION LEVELS (1 to 10 times Table 2-2 values)	MODERATE REMOVABLE CONTAMINATION LEVELS (10 to 100 times Table 2-2 values)	HIGH REMOVABLE CONTAMINATION LEVELS (>100 times Table 2-2 values)
Routine	Full set of protective clothing	Full set of protective clothing	Full set of protective clothing, double gloves, double shoe covers ^d
Heavy work	Full set of protective clothing, work gloves	Double set of protective clothing, work gloves ^d	Double set of protective clothing, work gloves ^d
Work with pressurized or large volume liquids, closed system breach ^d	Full set of impermeable protective clothing ^d	Double set of protective clothing (outer set impermeable), rubber boots ^d	Double set of protective clothing and impermeable outer clothing, rubber boots ^d

- Tritium may require different protection.
- For hands-off tours or inspections in areas with removable contamination at levels 1 to 10 times the values in Table 2-2, lab coats, shoe covers, and gloves may be used instead of full protective clothing.
- See Article 347 for minimum protective clothing requirements for work on bench tops and in fume hoods, sample stations, open-front boxes, and glove boxes.
- Or more if specified by the radiological work permit.

Removal of Protective Clothing

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

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

Always ensure that a radiological control technician is present to provide exit monitoring and other assistance during exit from the area. The radiological control technician is stationed in the step-off pad area, wearing a level of protective clothing and respiratory protection appropriate for the contamination expected.

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

- Remove all exposed tape using tabs.
- Remove rubber overshoes or outer shoe covers.

3. Remove hood from front to rear while turning inside out. Avoid touching outer hood surfaces. Alternately, using safety scissors, cut the bottom front of the hood below the face opening and remove the hood from front to rear being careful not to touch outer hood surfaces.
4. Remove respirator, if applicable (exercise care to avoid contaminating the facial area when performing this step).
5. Remove outer pair of gloves.
6. Remove dosimeter, pass to radiological control technician who will monitor it, and place it in a clean location.
7. Remove coveralls, inside out, touching inside only.
8. Take down barrier closure, if applicable.
9. Remove tape or fastener from inner shoe cover.
10. Remove each shoe cover, placing shoe onto clean step-off pad.
11. Replace barrier closure, if applicable.
12. Remove cloth glove liners or other inner pair of gloves.
13. Commence whole-body frisking.
14. Take a nose swipe if specified by radiological work permit.

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

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

Always ensure that a radiological control technician is present to provide exit monitoring and other assistance during exit from the area. The radiological control technician is stationed in the step-off pad area, wearing a level of protective clothing and respiratory protection appropriate for the contamination expected.

Before stepping to the inner step-off pad, the worker should perform the following.

1. Remove all exposed tape using tabs.
2. Remove rubber overshoes or outer shoe covers.
3. Remove hood from front to rear while turning inside out. Avoid touching outer hood surfaces. Alternately, using safety scissors, cut the bottom front of the hood below the face opening and remove the hood from front to rear being careful not to touch outer hood surfaces.
4. Remove outer pair of gloves.
5. Remove outer coverall, inside out, touching inside only. Working across the control line, the radiological control technician may carefully assist in this step.
6. Remove tape from inner coverall and sleeves.
7. Remove inner barrier closure, if applicable.
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 perform the following.

9. Replace inner barrier closure, if applicable.
10. Have the radiological control technician monitor hands and bottom of shoe covers to ascertain degree of any contamination.
11. Have radiological control technician monitor respirator, head, neck, and shoulders. If no contamination is detected, remove respiratory protection. If contamination is detected, decontaminate or cover with tape prior to respirator removal.
12. Remove next layer of gloves.
13. Remove dosimeter, pass to radiological control technician who will monitor it, and place it in a clean location.
14. Remove inner coveralls, inside out, touching inside only.
15. Take down barrier closure, if applicable.
16. Remove tape or fastener from inner shoe cover.
17. Remove each inner shoe cover, placing shoe onto clean step-off pad.
18. Replace barrier closure, if applicable.
19. Remove cloth glove liners or other inner pair of gloves.
20. Commence whole-body frisking.
21. Take a nose swipe.

The sequence for removal of 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 exits from High 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 used 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.
 - e. Respirators are not to be removed at the inner step-off pad but at the second step-off pad or further away from the Contamination Area.

Appendix 3D**Guidelines for Monitoring Personnel with Hand-Held Survey Instruments******General Requirements***

1. Verify that the instrument is in service, response-check the instrument, set it to the proper scale, and set the audio output so it can be heard during frisking.
2. Hold probe less than 0.5 inches from surface being surveyed for beta and gamma contamination and less than 0.25 inches for alpha contamination.
3. Move probe slowly over surface, less than 1.5 to 2 inches per second, depending on the size of the probe.
4. If the count rate increases above background during frisking, pause for 5 to 10 seconds over the area to provide adequate time for instrument response.
5. If the count rate increases to a value greater than the pre-established contamination limit (minus background) or the instrument alarms, remain in the area and notify ESH-1 personnel.
6. The whole-body frisk should take at least 2 to 3 minutes for each type of contaminant.

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 sec)
 - b. Neck and shoulders
 - c. Arms (pause at each elbow)
 - d. Chest and abdomen
 - e. Back, hips, and seat of pants
 - f. Legs (pause at each knee)
 - g. Shoe tops (pause at back of leg cuff)
 - h. Shoe bottoms (pause at sole and heel)
 - i. Personnel and supplemental dosimeters
 - j. Frisk other personal items carried by worker, such as notebooks, pens, keys, etc.
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 his or her hands before handling the probe.

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

PART 1 Radioactive Material Identification, Storage, and Control

Radioactive material and radioactive sources are defined in this manual according to the use of the terms.

1. For the purposes of this manual, radioactive material includes 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 any other materials that emit ionizing radiation.
2. For purposes of transportation in accordance with Department of Transportation (DOT) requirements, radioactive material is defined as those materials having a specific activity greater than 0.002 $\mu\text{Ci/g}$.
3. For source control purposes, a radioactive source is a radioactive material encapsulated or bonded strongly enough to prevent loss and dispersal of the radioactive material under the conditions of use and wear for which the capsule or bond was designed. The emissions of the source are typically intended for continued or repetitive use as a source of test radiation.

In accordance with DOE NS400.9, "Sealed Radioactive Source Accountability," a sealed radioactive source is radioactive material that is contained in a sealed capsule, sealed between layers of nonradioactive material, or firmly fixed to a nonradioactive surface by electroplating or other means. Controls for these types of sources are described in Article 431.

411 Requirements

1. \Rightarrow Items in Contamination, High Contamination, Airborne Radioactivity Areas, or areas with the potential for activation shall be considered contaminated until surveyed and released. ^{10 CFR 835.1101(a)(2)} 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 hr or less) activation products are present.
2. \Rightarrow Except for sealed and unsealed sources, radioactive material located within Contamination, High Contamination, or Airborne Radioactivity Areas does not require specific labeling or packaging. ^{10 CFR 835.601(a)}
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 radiation protection organization shall develop response requirements associated with a loss of radioactive material, including searches, internal investigations, and documentation. It is required that the responsible line organization must notify the radiation protection organization and Emergency Management and Response (EM&R) Group in Facilities, Security and Safeguards (FSS) Division in the event of a loss of radioactive material. Notification and reporting requirements are specified in Administrative Requirement (AR) 1-1, "Accident and Occurrence Reporting." The loss of special nuclear materials must be reported to FSS Division, as appropriate, in accordance with their requirements. The Health Physics Operations Group (ESH-1) and the Policy and Program Analysis Group (ESH-12) will evaluate risks to determine the level of effort appropriate to locate lost sources, and, commensurate with the level of risk, will search for lost sources, document the incident, and coordinate with DOE Order S000.3B responders for reporting purposes and safeguards, as appropriate.

412 Radioactive Material Labeling

1. — Radioactive material outside Contamination, High Contamination, or Airborne Radioactivity Areas shall be labeled by the responsible line organization (with assistance from the radiation protection organization if necessary) in accordance with Table 4-1. ^{10 CFR 835.401(a)}

— Table 4-1 Labeling Requirements for Radioactive Material

ITEM/MATERIAL	REQUIRED LABELING
Equipment, components, and other items that are radioactive, potentially radioactive, or have been exposed to radioactive contamination or activation sources	CAUTION: RADIOACTIVE MATERIAL and standard radiation symbol
Sealed and unsealed radioactive sources or associated storage containers	CAUTION: RADIOACTIVE MATERIAL and standard radiation symbol
Equipment, components, and other items with actual or potential internal contamination	CAUTION: INTERNAL CONTAMINATION and standard radiation symbol or CAUTION: POTENTIAL INTERNAL CONTAMINATION and standard radiation symbol
Components, equipment, or other items with fixed contamination	CAUTION: FIXED CONTAMINATION and standard radiation symbol ^{10 CFR 835.401(a)}

2. — The following are not subject to Article 412 labeling requirements.
- a. Items surveyed and determined to have contamination levels lower than Table 2-2 values if surface contamination is the only radiological hazard
 - b. Radioactive material or containers packaged and labeled for off-site shipment in accordance with DOT regulations
 - c. Personal protective equipment and clothing (laundry bags containing contaminated or potentially contaminated protective clothing must be appropriately labeled)
 - d. Radiological control samples such as air, process, and soil samples; smears; or swipes that are in the custody of radiation protection organization 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 2-3
 - h. Nuclear weapon components
 - i. ⇔ Historical items, such as uranium hexafluoride cylinders and large items used in demonstration projects, located within a location designated for the storage of radioactive material (such items shall be properly labeled when they are removed from a location designated for the storage of radioactive material) ^{10 CFR 835.1101(e)(2)}
 - j. Short-lived (half-life of 1 hour or less) radioactive material generated during an irradiation (i.e., research samples while an experiment is being conducted, etc.) that is immediately used
 - k. Beakers or other containers of radioactive material being used in such areas as hoods, glove boxes, and bench tops if the receptacles are otherwise appropriately labeled (for example, radioactive material label tape). (See Article 412.4, second sentence, for requirements regarding these items). ^{10 CFR 835.401(a)}

3. — Labels shall have a yellow background with a magenta or black standard radiation symbol. Lettering shall be magenta or black. Black is the preferred color at LANL, especially for exterior use where fading is a concern.
10 CFR 835.401(e)
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, as appropriate. Items that 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.^{10 CFR 835.401(e)}
5. — Packaged radioactive material should have the label visible through the package or affixed to the outside.
10 CFR 835.401(e)

413 Radioactive Material Packaging

1. — Items that are outside Contamination, High Contamination, or Airborne Radioactivity Areas and are confirmed or suspected of having removable radioactive contamination levels greater than Table 2-2 values shall be securely wrapped in plastic or placed in a container.^{10 CFR 835.1101(b)}
2. Items with sharp edges or projections should be taped or additionally protected to ensure package integrity.
3. Items with removable or potentially removable contamination levels in excess of 100 times Table 2-2 values should have additional packaging controls such as double-wrapping or use of plastic bags inside containers.
4. Yellow plastic wrapping material should be used for packaging radioactive material. Transparent material is preferred. Yellow plastic sheets or bags should not be used for nonradiological purposes.
5. The amount of combustible material used in packaging should be minimized.

414 Radioactive Material Storage

1. Radioactive material should be stored in a location designated for the storage of radioactive material.
2. Long-term (more than 60 days) storage of radioactive material should be in a specially designated location.
3. Decontamination or disposal of contaminated items is the preferred alternative to long-term storage.
4. Each location designated for the storage of radioactive material should be approved by the Radiation Protection Program manager or designee.
5. A custodian should be assigned responsibility for each location designated for the storage of radioactive material. A custodian may have responsibility for more than one storage area.
6. The custodian should conduct periodic walk-throughs of locations designated for the storage of radioactive material to check container integrity.
7. The custodian should conduct annual or more frequent reviews of each location designated for the storage of radioactive material, with emphasis on decontamination, movement of material to long-term storage locations, and disposal of unnecessary material.
8. Storage of nonradioactive material in a location designated for the storage of radioactive material is discouraged.
9. Outdoor storage of radioactive material is discouraged. In cases where outdoor storage is necessary, the integrity of containers shall be maintained to prevent degradation from weathering and subsequent release of radioactive material. The custodian should check container integrity monthly at outdoor locations designated for the storage of radioactive material.

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10. Radioactive material should be stored in a manner that reduces the amount of combustibles. The use of cardboard containers for storage is discouraged.
11. Flammable or combustible material should not be stored adjacent to locations designated for the storage of radioactive material.
12. Fire protection measures such as smoke detectors, water sprinklers, and fire extinguishers should be considered when establishing a location designated for the storage of radioactive material.

PART 2 Releasing Items and Transporting Radioactive Material**421 Releasing to Controlled Areas**

1. Items in Contamination, High Contamination, or Airborne Radioactivity Areas and those radiation areas with activation or activation potential shall be surveyed by trained and qualified personnel before release.
= Unpackaged radioactive material to be released to Controlled Areas shall be demonstrated to have contamination levels less than Table 2-2 values. ^{10 CFR 835.1101(a)(2)} Items to be released to uncontrolled areas shall be surveyed in accordance with Article 422.
2. = Material with fixed contamination levels that exceed the total contamination limits specified in Table 2-2 and that have removable contamination less than Table 2-2 limits may be released for use in controlled areas outside the radiological areas. ^{10 CFR 835.401(a), 1101(b), (c)(1)(2)} = These items shall be routinely monitored and controlled in accordance with administrative procedures. ^{10 CFR 835.401(a), 1101(b)} = Controls shall be established to ensure that no unmonitored individual is likely to exceed a dose equivalent that would require monitoring in accordance with Article 511 or 521. ^{10 CFR 835.401(a)}
3. = Radioactive material with removable contamination levels greater than Table 2-2 values shall be packaged before release to Controlled Areas. ^{10 CFR 835.1101(b)} = These items shall be routinely monitored and controlled in accordance with administrative procedures. ^{10 CFR 835.1101(b)} Controls shall be established to ensure that 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 being surveyed shall be controlled to prevent contamination while it awaits 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 835.703(e), 1101(d)}
6. Materials released to Controlled Areas shall be labeled in accordance with Article 412.

422 Releasing to Uncontrolled Areas

1. Material in Controlled Areas or locations designated for the storage of radioactive material, documented to have been released from Contamination, High Contamination, or Airborne Radioactivity Areas, shall be surveyed by trained and qualified personnel before it is released to uncontrolled areas. This requirement also applies to the release of items directly from radiological areas and radiological buffer areas where there exists contamination, airborne radioactivity, or activation or where there exists a reasonable potential for these conditions.
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. LANL's goal is that no items having levels of measurable contamination above natural background (using approved survey and interpretation techniques) will be knowingly released off-site, for use by the public, even at levels below those of Table 2-2. Exceptions to this goal must be as low as reasonably achievable (ALARA) and approved by the ESH-1 group leader or designee.
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.
4. Material not immediately released after survey shall be controlled to prevent contamination while it awaits release.
5. Radiological labeling shall be removed from material or defaced before the material is released for unrestricted use.

423 Transporting Radioactive Material

1. 49 CFR 170 through 180 describe requirements for inspecting and surveying packages, containers, and transport conveyances before 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 for off-site locations.
2. Table 2-2 removable contamination values as measured on packages, containers, and transport conveyances shall be used as controlling limits for on-site transport over nonpublic thoroughfares (e.g., Pajarito Road when closed to the public). 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 in a DOE conveyance from the on-site receiving location to the ultimate on-site destination.
3. On-site transfers over nonpublic thoroughfares shall be performed in accordance with written procedures using approved routes. — The procedures shall include requirements to ensure appropriate monitoring and control of the radioactive material and should be approved by the radiation protection organization. ^{10 CFR 205.2101(b)} On-site transfers must be documented with a Hazardous Materials Transfer Form, filled out by the line organization. These requirements do not apply to transfers between buildings within a technical area if the public cannot normally access the technical area because of access controls (e.g., TA-18, TA-53, and TA-55). If an empty container is transported on-site, an Empty Radioactive Materials Packaging Tag must be affixed to the container.
4. — Transfers over public thoroughfares (e.g., Pajarito Road when not closed to the public) shall be performed in accordance with this manual; DOT regulations; other federal, state, and local shipping requirements; and approved agreements. ^{10 CFR 205.2101(b)}
5. Off-site shipments of radioactive material, including subcontractors' handling of off-site shipments, shall be controlled and conducted in accordance with this manual; DOT regulations; and other federal, state, and local regulations.
6. Before shipment and upon receipt of a radioactive shipment, a visual inspection of packages should be performed by the line organization 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 by the line organization and the Business Management (BUS) Division to ensure accountability.
8. Transport conveyances should be visually inspected by the line organization before loading to ensure acceptability for the intended use.
9. Transport conveyances should be radiologically surveyed by trained and qualified personnel before loading, especially when commercial carriers specializing in radioactive transport are being used.
10. If the transport of radioactive material by non-DOE motor vehicles is to be "exclusive use," the "exclusive use" transport must be carried out in accordance with the regulations in 49 CFR, Parts 100-178 and 383-397.
11. The site emergency plan should describe appropriate responses for potential on-site radioactive material transportation accidents.
12. Drivers of 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 on-site or off-site transport.

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

The following provisions apply to sealed and unsealed radioactive sources.

1. DOE N5400.9 (extended by DOE N5400.10) describes how accountable sealed sources (i.e., not exempted) shall be controlled and maintained, and it specifies requirements for receipt, inventory, storage, transfer, disposal, and integrity testing.
 - a. An accountable sealed source is a sealed source with an activity equal to or greater than those values listed in Table 1 of DOE N5400.9.
 - b. Exempted radioactive materials are radioactive materials exempted from accountability under the requirements of DOE N5400.9 but otherwise subject to the requirements of the *LANL Radiological Control Manual* and 10 CFR 835. Exempted radioactive materials include materials in process, activated shielding materials, and liquid and gaseous sources. Materials defined as consumer products (e.g., exit signs, smoke detectors, welding rods) are not subject to the requirements of the *LANL Radiological Control Manual* and 10 CFR 835.
 - c. An exempted sealed radioactive source is a sealed source with a half-life of less than 30 days or with an activity less than the values for various radionuclides in Table 1 of DOE N5400.9.
 - d. Unsealed sources with accountable activities shall be controlled and maintained in a similar manner, except they do not require integrity testing.
2. Radioactive sources shall be procured through the Business Management (BUS) Division. Procurement of registrable radioactive sources shall be coordinated with the ESH-12 source registrar.
3. The source custodian shall perform or arrange to have performed receipt surveys of radioactive material shipments.
4. Radioactive sources, including radiography sources, shall not be brought on-site by external organizations without written approval from the ESH-12 source registrar.

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

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

Director's Policy DP105, "Hazardous and Radioactive Waste Management," and AR 10-8, "Waste Minimization," describe the program managed by the Environment, Safety, and Health (ESH) Division and the Chemical Science and Technology (CST) Division and implemented by the line organizations who are the waste generators.

4. CST Division manages the Laboratory's waste management programs as described in AR 10-1 through 10-9 and the Radioactive Material Management Area (RMMA) Program Plan. Waste generators are responsible for the proper management and disposal of their wastes according to the requirements in these documents.
5. Solid wastes are classified as commercial, radioactive, hazardous, and mixed and must be segregated, handled, and disposed of accordingly. Safe operating procedures (SOPs) that describe "knowledge of process," analytical measurements, and the rationale for proper segregation and management of these wastes shall be developed and implemented. Commercial solid wastes shall be sent to the county landfill. Radioactive, hazardous, and mixed wastes shall be sent to disposal facilities at TA-54.
6. Locations where a reasonable potential exists for the presence of radioactive contamination or activation shall be designated as RMMAs. Typically these locations coincide with areas already controlled for radiological purposes.
7. Opened radioactive waste containers should not be tamped or compacted because these actions may spread contamination or release airborne radioactivity.

442 Waste Minimization

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

1. Restrict material entering Controlled Areas established for contamination control, Radiological Buffer Areas established for contamination control, Contamination Areas, High Contamination Areas, and Airborne Radioactivity Areas to that needed for performance of work. Items should be unpackaged before they are taken into these areas, if possible.
 2. Restrict quantities of hazardous materials (such as paints, solvents, chemicals, cleaners, and fuels) entering Controlled Areas established for contamination control, Radiological Buffer Areas established for contamination control, Contamination Areas, High Contamination Areas, and Airborne Radioactivity Areas, and take measures to prevent inadvertent radioactive contamination of these materials.
 3. Substitute recyclable items for disposable ones and reuse equipment when practical. Substitute nonhazardous materials for hazardous materials whenever possible.
 4. Select consumable materials such as protective coverings and clothing that are compatible with waste-processing systems, volume reduction, and waste form acceptance criteria.
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5. Reserve an assortment of tools exclusively 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 material from contaminated materials.
7. Segregate known uncontaminated waste 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 locations designated for the storage of radioactive materials.
10. Emphasize training in waste reduction philosophies, techniques, and improved methods.

443 Mixed Waste

The requirements specified in the Resource Conservation and Recovery Act (RCRA) and the New Mexico Hazardous Waste Management Regulations apply to waste that contains both radioactive and hazardous materials. These regulations and how they apply to LANL with oversight by CST Division are discussed in detail in AR 10-3, "Chemical, Hazardous, and Mixed Waste." The following apply to mixed waste.

1. DOE 5400.3 and 5820.2A describe controls for mixed waste.
2. DOE 5400.1, "General Environmental Protection Program," DOE 5400.3, DOE 5820.2A, AR 10-8, 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 Controlling Radioactive Liquids and Airborne Radioactivity**451 Minimizing and Controlling 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.

The LANL National Pollutant Discharge Elimination System (NPDES) program in the Water Quality and Hydrology Group (ESH-18) determines the effects of effluents and supports the line organizations in managing the outfalls for compliance with the NPDES permit.

3. Activities that produce radioactive liquid waste should be suspended unless sufficient processing, collection, and storage capacity is available to accommodate the waste.
4. DOE 5400.5 specifies 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 before release and monitored during release, and the release should be terminated before exceeding predetermined limits.
7. Radioactive liquid waste that cannot be discharged shall be solidified and disposed of as solid radioactive waste.

452 Controlling 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 directly to the environment nor be used for the disposal of nonradioactive materials.
2. The Radioactive and Industrial Waste Water Science Group (CST-13) and line organizations should ensure that the following take place.
 - a. The existing radioactive drain piping configuration is documented.
 - b. Flow-indicating devices have been installed in lines intended for draining off leaks.
 - c. Plugs are in place to prevent nonradioactive input.
 - d. Alternative work controls are considered before systems are drained for maintenance.
 - e. Controls that prohibit unauthorized use of drains are in place.
3. Modifications to the design or operation of existing radioactive drain systems should be controlled by CST-13, LANL Configuration Control, and the radiation protection organization and include the following.
 - 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 and potable water supplies
 - 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 Controlling 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. Facility design is reviewed for engineering controls by ESH-12. These designs are also reviewed by the Air Quality Group (ESH-17) when 40 CFR 61 regulatory issues arise.
2. ESH-1 shall be notified when engineering controls that prevent worker exposure to airborne radioactivity, such as barriers, glove boxes, and glove bags, are compromised. An evaluation should be made of continuing operations with compromised engineering controls. Using respiratory protection to continue activities under these conditions is discouraged. Implementing engineering modifications that provide a commensurate level of worker protection is the preferred alternative.
3. Preventive maintenance and surveillance procedures shall be established in the technical work documents to ensure that equipment controls are maintained in an operable condition for containing 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 nonpersonal protective clothing shall be surveyed. Contamination levels should be below Table 2-2 total contamination values before reuse. The use of statistically representative sampling is acceptable.
5. Laundered protective clothing should not exceed the contamination limits in Table 4-2 and 4-3 before reuse.

Table 4-2 Summary of Fixed Contamination Limits for Laundered Protective Clothing

Radionuclide	Fixed Contamination Limit (dpm/100 cm ²)
Natural U, ²³⁵ U, ²³⁸ U, and associated decay products	1,000 alpha
Transuranics, ²²⁶ Ra, ²²⁸ Ra, ²³⁰ Th, ²³¹ Th, ²³¹ Pa, ²²⁷ Ac, ¹²⁵ I, ¹²⁹ I	1,000
Natural Th, ²³² Th, ⁹⁰ Sr, ²²³ Ra, ²²⁴ Ra, ²³² U, ¹²⁶ I, ¹³¹ I, ¹³³ I	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except ⁹⁰ Sr and others noted above; includes mixed fission products containing ⁹⁰ Sr	10,000 beta-gamma

Table 4-3 Summary of Removable Contamination Limits for Laundered Protective Clothing

Radionuclide	Removable Contamination Limit (dpm/100 cm ²)
Natural U, ²³⁵ U, ²³⁸ U, and associated decay products	20 alpha
Transuranics, ²²⁶ Ra, ²²⁸ Ra, ²³⁰ Th, ²³² Th, ²³¹ Pa, ²²⁷ Ac, ¹²⁵ I, ¹²⁹ I,	20
Natural Th, ²³² Th, ⁹⁰ Sr, ²²³ Ra, ²²⁴ Ra, ²³² U, ¹²⁶ I, ¹³¹ I, ¹³³ I	20
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except ⁹⁰ Sr and others noted above; includes mixed fission products containing ⁹⁰ Sr	1,000 beta-gamma

6. Sites and facilities are encouraged to do the following.
 - a. Apply the latest techniques and instrumentation to detect contamination on personal protective equipment and clothing below Table 2-2 total contamination values.
 - b. Continue efforts to reduce contamination levels on reusable personal protective equipment and clothing.

462 Laundry

1. Clothing and equipment should be laundered according to facility, color, type, and level of contamination.
2. Laundry activities should be performed using processes that minimize both potential worker exposure and the volume of waste generated.
3. Clothing and equipment should be screened before they are laundered to segregate those that are damaged, present special handling problems, or require disposal.
4. Waste streams that contain soaps, detergents, solvents, or other materials that could interfere with processing large-volume liquid waste streams should be segregated for separate processing.
5. Contracting for fully licensed laundry services is encouraged.
6. Cleaned personal protective equipment and laundered protective clothing shall be inspected before use. Clothing should be free of tears, separated seams, deterioration and damage, or repaired in a manner that provides the original level of protection.

463 Decontamination

1. Radiological work permits or technical work documents shall include provisions to control contamination at the source to minimize the amount of decontamination needed.
2. Work planning 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. Contaminated areas should be decontaminated.
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 coordinating 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.
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 before initial use, after 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 a radiological work permit,
 - c. Controlled to prevent unauthorized use,
 - d. Designed and constructed to ensure HEPA filter integrity under conditions of use, and
 - e. Designed and constructed to prevent unauthorized or accidental access to the inner surfaces of the vacuum.
4. Radiation and contamination surveys shall be performed periodically on vacuum cleaners in use, and labels on these units shall be updated after each survey. 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 review by the Criticality Safety Group (ESH-6) shall be performed and documented before the use of a vacuum cleaner for significant quantities of fissile material as defined in AR 4-1, "Nuclear Criticality Safety."
7. A review by ESH-6 is also required when it is expected that the vacuum cleaner bag could accumulate a significant quantity of fissile material over a series of operations.

CHAPTER 5 RADIOLOGICAL HEALTH SUPPORT OPERATIONS

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PART 1 External Dosimetry**511 Requirements**

1. ⇒ Personnel dosimetry shall be required for the following:
 - 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 2-1. ^{10 CFR 835.402(a)(1)(i)(ii)(iii)(iv), 1003(b)}
 - 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 835.402(a)(2)}
 - c. ⇒ Minors, students, visitors, and public expected to receive an annual external whole-body dose equivalent of 50 mrem or more in a year. ^{10 CFR 835.402(a)(3), 10 CFR 835.402(a)(1)}
2. ⇒ Neutron dosimetry shall be provided when a person is likely to exceed 100 mrem annually from neutrons. ^{10 CFR 835.402(a)(1)(i)}
3. Dosimeters shall be issued only to personnel who have been 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 to persons other than those entering Controlled Areas, Radiological Buffer Areas, Radiation Areas, or High Radiation Areas where there is a potential for external exposure is discouraged. Although issuing dosimeters to personnel who are not occupationally exposed to radiation can appear to be a conservative practice, it creates the impression that the wearers are occupationally exposed to radiation. However, this practice is acceptable at LANL until further notice.
5. Personnel shall return dosimeters to the dosimeter custodian 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, between the waist and the neck, in the manner prescribed by dosimetry personnel.
7. [Reserved]
8. The practice of taking dosimeters (TLDs or film) off-site (i.e., home or other nonwork locations) is discouraged and shall not be implemented where not already in place. However, this practice is acceptable at LANL until further notice.
9. Personnel shall not wear dosimeters issued by LANL while being monitored with a dosimeter at another off-site location (e.g., another DOE contractor site) unless approved by the Health Physics Measurements (ESH-4) Group. Temporary dosimeters for special assignments may be issued for off-site use with the prior approval of ESH-4. Personnel shall not expose their dosimeters to security x-ray devices, excessive heat, or medical sources of radiation (e.g., diagnostic x-ray procedures or diagnostic or therapeutic nuclear medicine procedures).
10. Persons whose dosimeters are lost, damaged, or contaminated while they are working should place their work in a safe condition, immediately exit the area, and report the occurrence to the Health Physics Operations (ESH-1) Group. If the dosimeter is lost or damaged off the site, the person should report the occurrence to ESH-1. The person's line manager is required to complete a Lost Dosimetry Badge Report (Form 1325). The person should not reenter the Controlled Areas until a review has been conducted, line management has approved reentry, and the dosimeter has been recovered or replaced.

512 Technical Requirements for External Dosimetry

1. ⇒ DOE 5480.15 specifies the requirements for accreditation of personnel external dosimetry monitoring programs by the DOE Laboratory Accreditation Program (DOELAP). A technical basis document shall be developed and maintained for the external dosimetry program by ESH-4. Personnel external dosimeters include

but are not limited to thermoluminescent dosimeters, track-etch dosimeters, and neutron-sensitive film. ^{10 CFR 835.402(b)}

2. — The technical basis document shall also address dosimeters that monitor radiation outside the scope of DOELAP, such as dosimetry associated with high-energy accelerators and extremity dosimeters. ^{10 CFR 835.402(b)}
3. LANL should participate in intercomparison studies for external dosimetry programs.
4. When personnel exposures to the skin, lens of the eye, and extremities are monitored, they shall be listed separately on reports.
5. Multiple dosimeters should be issued to personnel to assess whole-body exposure in nonuniform radiation fields or as required in radiological work permits. Nonuniform 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% and the anticipated whole-body dose equivalent is greater than 100 mrem. The technical basis document should describe the method used in determining the dose equivalent of record when multiple dosimeters are used.
6. A dose assessment shall be performed by Policy and Program Analysis (ESH-12) for each instance of a lost, damaged, or contaminated personnel dosimeter. The extent of the assessment is commensurate with the magnitude of the dose equivalent or potential dose equivalent being assessed.

513 Pocket and Electronic Dosimeters

Pocket and electronic dosimeters (including bubble dosimeters) are supplemental dosimeters that provide real-time indication of exposure to radiation and assist in maintaining personnel dose equivalents less than administrative control levels.

1. Supplemental dosimeters shall be issued to personnel before they enter a High Radiation Area or Very High Radiation Area (see Article 334 for entry requirements); when a person could exceed 10% of an administrative control level from external radiation in one workday; 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 ESH-1 procedures.
3. Supplemental dosimeters shall be read periodically while in use and should not be allowed to exceed 75% of full scale.
4. Work authorized by a radiological work permit shall be stopped when supplemental dosimeter readings indicate total exposure or rate of exposure that is substantially greater than planned. ESH-1 managers shall be consulted before work is continued.
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 dose equivalents greater than 100 mrem in one workday are expected. An electronic dosimeter provides an early warning of unexpected radiation fields through the use of alarm set points at specified dose equivalent rates or integrated dose equivalents.
7. When the dose equivalent results from the pocket or electronic dosimeters differ by more than 50% from the primary dosimeter result and the primary dosimeter result is greater than 100 mrem, an investigation should be initiated to explain the difference.

PART 2 Internal Dosimetry**521 Requirements**

1. ⇒ The following personnel shall participate in an internal dosimetry program:
 - a. ⇨ Personnel who have the potential to receive intakes resulting in a committed effective dose equivalent of 100 mrem or more in a year. ^{10 CFR 835.402(e)(1)}
 - b. ⇨ Declared pregnant workers who are likely to receive intakes resulting in a dose equivalent to the embryo/fetus of 50 mrem or more during the gestation period. ^{10 CFR 835.402(e)(2)}
 - c. ⇨ Minors, students, visitors, and members of the public who are likely to receive intakes resulting in a committed effective dose equivalent of 50 mrem or more in a year. ^{10 CFR 835.402(e)(3), 10 CFR 835.401(a)(1), 1043(b)}
2. ⇒ The estimation of internal dose shall be based on bioassay data rather than air concentration values unless bioassay data are unavailable or inadequate, or internal dose estimates based on representative air concentration values are demonstrated to be as or more accurate. ^{10 CFR 835.204(e)}
3. Personnel shall participate in appropriate 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 oxide, should be considered for participation in the appropriate bioassay program.
5. Personnel shall submit bioassay samples, such as urine or fecal samples, and, as appropriate, submit to bioassay procedures, such as whole-body or lung counting, at the frequency required by the bioassay program.
6. Personnel shall be notified in writing by ESH-12 of positive bioassay results above 2% of the ALI and the results of dose assessments (as promptly as they become available) and subsequent refinements. Dose assessment results shall be provided in terms of rem or mrem.

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, the DOE Radiological Control Manual and the LANL Radiological Control Manual provide the technical guidance to implement the internal dosimetry programs.

1. ⇒ A technical basis document shall be developed by ESH-12 for the internal dosimetry program. ^{10 CFR 835.402(d)}
2. Baseline bioassay monitoring of personnel who may receive intakes resulting in a committed effective dose equivalent greater than 100 mrem, as identified through the health physics checklist process, shall be conducted before they begin work that may result in intakes.
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 by ESH-12.
4. Line management shall require termination bioassay monitoring when a person who participated in the bioassay program terminates employment or concludes work involving the potential for intakes. Efforts should be made to elicit cooperation from those workers who do not submit to termination bioassay monitoring.
5. Special bioassay analyses shall also be performed when any of the following action criteria are met:
 - a. Facial or nasal contamination is detected that indicates a potential for internal contamination.

- b. Airborne monitoring indicates the potential for intakes that will result in a committed effective dose equivalent exceeding 100 mrem.
 - c. Upon direction of the radiation protection 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 by ESH-12 of any detected intakes should be conducted before a worker is permitted to return to radiological work.
 8. Bioassay measurements program personnel should use radionuclide standards from or traceable to the National Institute of Standards and Technology (NIST).
 9. Bioassay measurements program personnel should participate in the conduct of intercomparison studies and should use the "DOE Phantom Library."

523 Technical Requirements for Dose Assessment

Interpretations of bioassay results and subsequent dose assessments should include the following, when available.

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 used to estimate intake or deposition and to assess dose
6. Intradepartmental coordination between the radiation protection organization and Occupational Medicine (ESH-2) for doses that may require medical intervention

PART 3 Respiratory Protection Program

Respiratory protection equipment (hereafter referred to as respirators) 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 implementing the respiratory protection program and associated training of personnel.
3. Respirator authorization cards and respirators shall be issued by Industrial Hygiene and Safety (ESH-5) only to personnel who are medically qualified by ESH-2 and trained and quantitatively fit-tested by ESH-5 to wear the specific type of respirator. Training and qualification testing shall be performed at least annually.
4. Positive controls shall be maintained by ESH-5 for the issue, use, and return of respirators to ensure that only qualified personnel wear respirators. ESH-1 and the support services subcontractor assist with the issue and return of respirators.
5. DOE 5480.4 mandates that breathing air meet the specifications of ANSI/CGAG-7.1 Grade D breathing air as specified in 29 CFR 1910.134. Compressed air supplied to respirators shall be tested quarterly by ESH-5 or upon exchange of breathing air tube trailers. 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 by ESH-2 before being quantitatively fit-tested. The medical assessment shall determine if a worker's medical condition precludes the use of respirators and should follow the ANSI Z88.6 guidance on frequency and content of the examination. A worker's ability to accommodate the additional stress placed on the body when working in a respirator is part of this assessment.

533 Using Respiratory Protection

Personnel using respiratory protection shall meet the following provisions.

1. Be issued respirator authorization cards and respirators only upon verification of medical approval, training, and quantitative fit-testing.
2. Perform qualitative fit-tests of their respirators to ensure a proper seal before entering areas requiring respirator use.
3. Be clean shaven in the area of the respirator seal.
4. If needed, use corrective lenses that are approved by ESH-5 for use with respirators or eyeglasses (without temple bars or straps) mounted inside the respirator.
5. Be trained to leave the work area when their respirators malfunction.

6. Be trained to remove their respirators to avoid life-threatening situations when exiting an area after the respirator has failed.

Personnel using respiratory protection are required to keep respirator authorization cards current and available for inspection by supervisors, ESH-1, and ESH-5. They are also required to notify ESH-2 immediately if there is a change in health status that may affect their ability to use respirators.

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 that are less than 70° F when multiple sets of protective clothing or plastic suits were in use or strenuous work was required. The planning stages for work in high-temperature 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 before work begins on job assignments in high-temperature environments. If a person begins to feel symptoms of heat illness, the person should immediately notify the nearest coworker, 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

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 the seal 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 prohibited for routine radiological work at LANL.
3. Half-face respirators shall not be used for radiological emergency evacuation purposes at LANL.

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 or personal clothing contamination, they shall notify the ESH-1 radiological control technician and their line supervisor.
3. The extent of skin contamination should be determined before decontamination procedures are initiated.
4. Skin decontamination methods should be established for site-specific radionuclides. Skin abrasion should be avoided during the decontamination process. Situations requiring intrusive decontamination methods, such as tissue removal, require referral to ESH-2.
5. Levels of skin contamination that trigger the need for dose assessments should be established by the ESH-12 Dose Assessment Team for site-specific radionuclides. These trigger levels should not exceed 100 mrem shallow dose.
6. Personnel with skin contamination that triggers the need for dose assessment should be informed by the radiation protection organization of the initial dose estimate to their skin as soon as practical, preferably before the end of their workday.
7. Personnel with skin contamination for which a dose assessment was not performed should be informed of the nature of the contamination and an upper estimate of the dose received (such as less than 10 mrem) as soon as practicable, preferably before the end of their workday.
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 affected persons.

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 typically 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 by ESH-4 of wounds and associated bandages for contamination, including alpha emitters if applicable
 - c. Identification of the radionuclides involved by ESH-4
 - d. Medical determination by ESH-2 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 of contaminated wounds that result in internal dose equivalents greater than 2% of the Table 2-1 limits. The counseling should be performed by medical professionals from ESH-2 and ESH-12 Dose Assessment Team personnel.

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

1. ⇒ Where appropriate, radiological monitoring of radiation exposure levels, contamination, and airborne radioactivity shall be conducted to characterize workplace conditions, detect changes in radiological conditions, and detect the gradual buildup of radioactive material in the workplace, to verify the effectiveness of physical design features and engineering and administrative controls and to identify areas requiring postings. ^{10 CFR 135.401(a)(1)(2)(3), 401(b), 403(b), 1003(b)}
2. ⇒ Monitoring shall be performed only by trained and qualified personnel using instruments that are properly calibrated and routinely tested for operability. ^{10 CFR 135.401(c)(4)}
3. Surveys for radiation, contamination, and airborne radioactivity shall be performed as specified in technical work documents and radiological work permits.
4. ⇒ ESH-1 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. ^{10 CFR 135.704(e)}
5. ⇒ Instruments used to perform radiation surveys shall be readily available and response-checked daily or before operation. ^{10 CFR 135.401(e)(4), 403(b)} When response checks are not within $\pm 20\%$ of the expected value, the instrument should be taken out of service. When response checks are not feasible, compensatory actions should be established to ensure proper instrument response.
6. Assessment of radiological conditions should include a sufficient number of survey points to characterize the radiation present and to verify boundaries.
7. ⇒ Surveys should be performed before, during, and at the completion of work that has the potential for causing significant changes in levels of radiation fields, surface contamination, and airborne radioactivity. ^{10 CFR 135.401(a)(3)}
8. ⇒ Survey frequencies should be established based on potential radiological conditions, probability of change in conditions, and area occupancy factors. ^{10 CFR 135.401(a)(3)}
9. Monitoring results should be reviewed by the cognizant radiological control technician supervisor. The review should ensure that all required surveys have been performed and that the documentation is accurate and complete.
10. Results of current surveys or facility and room survey maps should be conspicuously posted at the entrances to surveyed areas or otherwise be made readily available (e.g., posting of outdoor areas) to inform personnel of the radiological conditions.
11. Monitoring results and reports should be made available to line management (including support services subcontractor line management) and used in support of pre- and post-job evaluations, ALARA planning, contamination control, management of radiological control operations, and follow-up and correction of identified actions/deficiencies.
12. ⇒ 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. ^{10 CFR 135.401(a)(3)}

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. Daily, in office space located in Radiological Buffer Areas where the potential exists for external radiation exposure
 - b. Weekly, in routinely occupied Radiological Buffer Areas and Radiation Areas
 - c. Upon initial entry, weekly during continuing operations when the area is occupied, and when levels are expected to change in High Radiation Areas
 - d. Weekly, for operating HEPA-filtered ventilation units
 - 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 locations where radioactive materials are stored and posted as such
 - g. Monthly, for potentially contaminated ducts, piping, and hoses in use outside radiological facilities
2. — Performance of radiation surveys should include exposure rate measurements of the general area, dose equivalent rates at a distance of 30 cm from a source or surface of interest to evaluate potential whole-body exposures, and exposure rates on contact with potential sources of radiation where there is a potential for hands-on work. ¹⁰CFR 835.52.2
 3. — 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 resulting from removal or alteration of shielding. ¹⁰CFR 835.403(a)(2)
 4. — Radiation monitoring instruments shall be capable of measuring ambient radiation dose rates for the purpose of controlling radiation exposures. ¹⁰CFR 835.403(b)
 5. — Contamination buildup inside work gloves can lead to unacceptable hand doses to personnel in facilities handling uranium. Reuse of leather or cloth gloves should be reviewed carefully for such buildup and beta radiation surveys should be conducted on a periodic frequency on the interior surfaces of these gloves. ¹⁰CFR 835.401(a)(4) Protective clothing gloves shall be worn inside these work gloves to prevent contamination of the hand.

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 equivalent rates and in remote locations where there is a need for local indication of dose equivalent rates prior to personnel entering remote locations. ¹⁰CFR 835.403(b)
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, operations, systems, or equipment occur. ¹⁰CFR 835.704(e)
4. In addition to the requirements in 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. These tests shall be documented.
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 dose equivalent 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.

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. Before the transfer of equipment and material from one Radiological Buffer Area to another
 - b. Before the transfer of equipment and material from highly contaminated areas within Radiological Buffer Areas unless precautions such as bagging or wrapping are taken before 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. Weekly, in routinely occupied Radiological Buffer Areas
 - g. Weekly, or upon entry if entries are less frequent, in areas where radioactive materials are handled or stored
 - h. Weekly, or upon entry if entries are less frequent, where contamination boundaries or postings are located
 - i. During initial entry into a known or suspected Contamination Area, periodically during work, at completion of job, or as specified in a radiological work permit
 - j. After a leak or spill of radioactive materials
2. Survey requirements for the release of materials shall be met in accordance with Articles 421 and 422.
3. Contamination surveys should incorporate techniques to detect both removable and fixed contamination.
4. — Items with inaccessible surfaces that were located in known or suspected Contamination Areas, High Contamination Areas, and Airborne Radioactivity Areas and had the potential to become contaminated at levels likely to exceed Table 2-2 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. 10 CFR 835.1101(a)(2)
5. 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. Procedures for assessing these samples will be prepared by the radiation protection organization.
6. Smear surveys for removable contamination shall be reported in units of disintegrations per minute per 100 cm² (dpm/100 cm²). For smear surveys of small items covering less than 100 cm², the results shall be reported in units of dpm per area sampled.
7. Large-area swipes are encouraged and should be used to supplement standard smear techniques in areas generally assumed not to be contaminated, such as entrances to Radiological Buffer Areas. If an evaluation indicates that an area swiped is contaminated, the area may be immediately decontaminated, or a thorough contamination smear survey should be performed.
8. Areas identified as either being 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 swipes, should be used.
9. Instruments and techniques used for radioactive contamination monitoring and control shall be adequate to ensure compliance with the requirements of 10 CFR 835.404 and 404(u).

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 by the radiation protection organization 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% or more of the specified annual limit on intake (ALI) values (40 DAC-hr). An annual intake of 2% of a specified ALI generally represents a committed effective dose equivalent to a person of approximately 100 mrem. ^{10 CFR 835.209(a), 402(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. A person who is continuously exposed to a concentration of radioactivity in air of 1 DAC for one workweek would generally receive a committed effective dose equivalent of approximately 100 mrem. ^{10 CFR 835.209(a), 402(a)(2)}
4. ➤ Air-sampling equipment should be positioned to measure air concentrations at work locations. ^{10 CFR 835.403(e)(1)} If this cannot be achieved, a program of personal breathing-zone air sampling should be initiated.
5. ➤ Air-monitoring equipment shall be routinely maintained and calibrated at a frequency of at least once a year. ^{10 CFR 835.401(e)(1)} Continuous air monitors should be capable of measuring 1 DAC when averaged over 8 hr (8 DAC-hr) 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 to minimize or terminate inhalation exposures. ^{10 CFR 835.403(e)(3)}
7. The proper operation of continuous-air-monitoring equipment should be verified daily by performing an operational check. Operational checks should include positive airflow indication and internal source checks or 60-Hz electronic checks when available. Continuous-air-monitoring equipment should be verified weekly by checking for instrument response with a check source.
8. Preliminary assessments of air samples using field survey techniques should be performed promptly upon removal. In situations in which 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 on the use of 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. ESH-4 reviews and approves purchase requests for all radiation-monitoring equipment used for health and safety purposes. The requester may submit the purchase request directly to ESH-4 or to the Business Management (BUS) Division, who will route it to ESH-4 for approval. ESH-4 will maintain a list of standard radiation monitoring instruments at the Laboratory that meet American National Standards Institute/American Nuclear Society (ANSI/ANS) performance standards. This list will be available on request to expedite the review and approval process.

1. The requester must contact ESH-4 or the appropriate radiation protection group representative to request radiation monitoring instruments. User organizations must maintain physical control of pool instruments in their custody, advise the instrument pool manager of equipment location changes, respond promptly to recall notices, and immediately return defective equipment to the instrument pool manager.
2. ESH-4 determines which instruments will be used for radiation protection purposes. All such instruments become part of the ESH-4 maintenance and calibration system, where a database of their calibration/maintenance cycles is maintained. Users are notified in writing when instruments require calibration and/or maintenance. Instruments that are out of calibration shall not be used. Users should request overlapping calibration cycles for all instruments under their control so that currently calibrated instruments are always available. All calibrations performed by ESH-4 will be traceable to the NIST and will comply with the requirements of ANSI N323.
3. Radiation-monitoring instruments in the instrument pool must not be modified without the approval of ESH-4. The instrument pool supervisor assists in obtaining such approvals. User organizations must comply with the use limitations specified on the instrument's label.
4. ESH-4 will specify appropriate sources and procedures for performance-testing radiation instruments. Instrument users will ensure that instruments with the capacity for being performance-tested will be checked daily or before each use to ensure proper instrument response.

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 NIST traceable standards or their equivalents.
2. Calibration procedures shall be developed for each radiological instrument type and should 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. ^{10 CFR 835.401(c)(1)}
4. — The effects of environmental conditions and interfering radiation on an instrument shall be known before use, if the instrument is to be used in that particular adverse environment. ^{10 CFR 835.401(c)(3)}
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 should be 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

manufacturers' 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.

LANL maintains a program in ESH-4 to evaluate, repair, test, and periodically calibrate all of the radiological control survey and monitoring instruments for LANL. Each instrument is labeled with the calibration date and expiration date for the instrument's calibration. Calibration procedures are documented in the program's quality assurance procedures for each instrument.

8. Instruments whose calibration date label or performance test readings indicate that the instrument may have been used while out of calibration shall be reported to ESH-1. ESH-1 should review surveys performed with the instrument while it was out of calibration.

563 Maintenance

1. A documented program for preventive and corrective maintenance of radiological instrumentation should be provided by ESH-4.
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 before 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. The ESH-4 calibration facilities should perform inspections, calibrations, performance tests, calibration equipment selection, and quality assurance in accordance with the recommendations of ANSI N323. These facilities should be operated so as to
 - a. Locate activities in a manner that minimizes radiation exposure to operating personnel and to personnel in adjacent areas;
 - b. Minimize sources of interference, such as backscatter and nonionizing radiation, during the calibration of instrumentation and correct for interferences as necessary;
 - c. Operate in accordance with the referenced standards; and
 - d. Generate records of calibration, functional tests, and maintenance in accordance with the referenced standards.
2. If contracted calibration services are used, these services should be performed according to the referenced standards. Audits should be performed periodically on these services by LANL to confirm that the instruments are correctly calibrated.

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 controlled and radiological areas and to maintain their individual radiation exposure and the radiation exposures of others as low as reasonably achievable (ALARA). Training requirements in this chapter apply to personnel entering LANL facilities.

612 Standardization

Standardized core courses and training materials shall be used to achieve consistency DOE- and LANL-wide. In establishing local training programs, the standardized core courses shall be provided and LANL-specific information shall be added by the ES&H Training Group (ESH-13), with facility- and job-specific information provided by the appropriate line organizations (refer to Part 6 of this chapter). For example, training at accelerator facilities should be expanded to include high-energy radiation and activation products. Training at plutonium facilities should be expanded to include alpha contamination control. In all cases, the standardized core course materials shall be fully implemented.

Job-specific training is the training required for a person to perform a particular job. Facility-specific training is training required for all employees working at a particular facility. Operation-specific training is the training required for an employee to perform a particular aspect of a job or a unique operation. — Line managers must ensure that the level of training is commensurate with each worker's assignment and includes training on procedures specific to the individual's job assignment. ^{10 CFR 835.902}

Standardized core course training material developed and maintained by DOE Headquarters (EH) consists of lesson plans, designated view graphs, 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 S480.20. The standardized core course for radiological control technicians (RCTs) partially fulfills DOE training accreditation requirements of DOE S480.18B.

1. Standardized core course training material shall be used by ESH-13 for General Employee Radiological Training (GERT), Radiological Worker I and II training, and RCT training.
2. Wallet-sized training certificates that identify current training status should be provided by ESH-13.
3. — Successful completion of the standardized courses for GERT, Radiological Worker I and II training, and RCT training at one DOE site within the past two years shall be recognized by other DOE sites. ^{10 CFR 835.901(a), 902, 903}
 — Documentation of previous training shall include the individual's name, date of training, topics covered, and name of the certifying official. ^{10 CFR 835.901(a), 902, 903} However, LANL-specific aspects of the radiological training shall be completed. LANL-specific training for GERT and Radiological Worker I and II training is included with core training.
4. At LANL, 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 LANL Radiation Protection Program manager or a designee shall concur in LANL-generated radiological training material.

613 Requirements

1. — Written examinations for General Employee Radiological Training, Radiological Worker I and II training, and RCT qualification shall be used to demonstrate satisfactory completion of theoretical and classroom material. ^{10 CFR 835.901(a), 902, 903} Examinations should be written; however, the Radiation Protection Program manager may approve alternatives to accommodate special needs. Alternative examinations should be

equivalent in content to written examinations. The test items shall be based on training objectives. These examinations will be reviewed and maintained by the LANL Testing Office (Training and Development/Evaluation Section). The examination process should meet the following requirements:

- a. Establishment of a minimum passing score
 - b. Exclusion of true/false questions
 - c. Use of questions randomly selected from a question bank
 - d. Acknowledgment by the student's signature that the student participated in a post-examination review
 - e. Measurement of competence in required skills using performance-based examinations
 - f. Remedial actions for failure to meet the minimum score
 - g. Questions that test what the student is expected to remember months after the training rather than testing short-term memory of theoretical material
2. Training should address both normal and abnormal situations in radiological control.
 3. GERT shall be completed every 2 years. ⇒ Changes to the program as identified by the radiation protection organization and line organizations shall be incorporated by ESH-13 as they are identified and a decision made by the radiation protection organization if retraining before the 2-year period is needed. ^{10 CFR 835.902(b)} In the alternate year when full retraining is not completed, the latest GERT handbook (student guide) should be distributed by ESH-13 for self-study.
 4. ⇒ Radiological Worker I and II retraining shall be completed every 2 years. ^{10 CFR 835.902} In the alternate year when retraining is not performed, refresher training provided by ESH-13 shall be completed.
 5. ⇒ LANL-specific and refresher training provided by ESH-13 and job-, facility-, and operation-specific training provided by the operating organization shall include changes in requirements and updates of lessons learned from operations and maintenance experience and occurrence-reporting for LANL and across the DOE complex. ^{10 CFR 835.901(b)}
 6. The effectiveness of radiological control training should be verified by surveying a limited subset of former students in the workplace. This verification is in addition to performance evaluations routinely performed by ESH-13. This evaluation should include observation of practical applications and discussion of the course material and may include written examinations. The survey should be performed by radiation protection organization managers and supervisors, quality assurance personnel, or senior instructors and coordinated with the appropriate line organization after the former student has had the opportunity to perform work for several months. The results should be documented by ESH-13.
 7. Requirements for respiratory protection training are outlined 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 necessary for GERT. Visitor orientation and the use of trained escorts may be used as an alternative to training with the concurrence of the Radiation Protection Program manager.
 10. Reserved
 11. Training records and course documentation shall meet the requirements of Article 725.
- 614 Qualification Standards for Radiological Control Technicians (RCTs)**
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 by Health Physics Operations (ESH-1) to include LANL-specific elements. The LANL-specific elements may include input from the appropriate line organizations. This input may also include information related to operations of the line organization and the hazards associated with these operations. ^{10 CFR 835.943}
4. = Qualification standards for the RCT position shall include on-the-job training by ESH-1 to provide hands-on experience directly applicable to the job. ^{10 CFR 835.943}
5. On-the-job trainees shall be under the control of qualified personnel. = Before performing a job function without direct supervision, a trainee with partially completed qualifications shall have completed the qualifications for that task. ^{10 CFR 835.943}

615 Oral Examination Board

1. The oral examination board(s) shall determine the qualification of candidates for RCT and supervisor positions. The oral examination board provides an opportunity to identify areas of weakness related to performance of RCT 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 Radiation Protection Program manager shall designate the board members and appoint chairpersons.
3. The board constituted to evaluate RCT qualification should be composed of at least three persons to include an RCT supervisor, radiation protection organization staff, and line management operations department supervisors and staff personnel, as applicable. RCT 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. It is recommended that these questions be based on training objectives and reviewed by the LANL Testing Office. (Training and Development/Evaluation Section)
5. The board constituted to evaluate RCT 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 LANL instructor qualification program or possess equivalent qualifications.
2. Instructors should have the technical knowledge, experience, and instructional skills required to fulfill their assigned duties.
3. Instructors-in-training shall be monitored by a qualified instructor.
4. Subject-matter experts without instructor qualification may provide training in their areas of expertise. However, these subject-matter experts should be trained as instructors when this occurs routinely.

PART 2 General Employee Radiological Training**621 Site Personnel**

Personnel who may routinely enter a Controlled Area unescorted (excluding radiological buffer areas and radiological areas) and encounter radiological barriers, postings, or radioactive materials shall receive GERT provided by ESH-13. — This training shall be successfully completed before potential occupational radiation exposure. GERT is recommended for all employees. ^{10 CFR 835.941(a)} GERT is the minimum training requirement for unescorted access to Controlled Areas. Additional facility- or operation-specific training requirements may exist at individual facilities.

1. GERT shall include the standardized core course training materials and a written examination. For unescorted access to Controlled Areas, workers must pass the General Employee Training (GET) examination.
2. Standardized DOE core GERT shall be expanded to include LANL-specific information, such as site-specific radiation types, alarm responses, and policies. These two training components constitute GERT.
3. Workers may challenge GERT 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 GERT is approximately 1 hour.
5. Additional training beyond GERT 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. Escorted visitors who enter a Controlled Area shall receive a radiological safety orientation from the operating organization responsible for the area. Unescorted visitors require GERT as a minimum. This orientation 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 requirements
 - 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 by the operating organization. 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 by the operating organization.
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. — As a minimum, Radiological Worker I training shall be completed before entering Radiological Buffer Areas and Radiation Areas without a qualified escort. ^{10 CFR 835.902} The frequency of this training is specified in Article 613.4.
2. — As a minimum, Radiological Worker II training is required for unescorted entry into areas as stated in Table 6-1. ^{10 CFR 835.902} The frequency of this training is specified in Article 613.4. Additional training is required for special job functions with radiological consequences per Article 634.1.
3. Workers may challenge Radiological Worker I or II standardized core by passing a comprehensive examination. If unsuccessful in one attempt, the entire standardized core Radiological Worker I or II training shall be completed. Challenges do not apply to the site-specific portions.
4. Radiological Worker I training is not a prerequisite for Radiological Worker II training.
5. Radiological Worker I and Radiological Worker II training are self-contained courses; the core training is provided by ESH-13, and the job-, facility-, and operation-specific training is provided by the operating organization. Radiological Worker II training includes all of the requirements of Radiological Worker I training and expands on the topic of hands-on work with radioactive materials. Radiological Worker II training prepares the worker to deal with higher levels of radiation and/or radioactive contamination than those addressed in Radiological Worker I training.

632 Radiological Worker I

1. — Workers whose job assignments require access to Radiological Buffer Areas, Radiation Areas, and locations posted for the storage of radioactive materials (as specified in Article 333.1) shall complete Radiological Worker I training as a minimum before being permitted to enter these areas without a qualified escort (see Article 658). ^{10 CFR 835.902}
2. — Radiological Worker I training shall use the DOE standardized core course training materials and, in addition, shall emphasize LANL-specific information. ^{10 CFR 835.902}
3. — Radiological Worker I training should encompass at a minimum the following LANL-specific practical factors:
 - a. Entering and exiting simulated Radiological Buffer Areas and Radiation Areas
 - b. Frisking for personnel contamination, as applicable
 - c. Verifying instrument response and performing source checks
 - d. Responding to alarm situations ^{10 CFR 835.902}
4. Expected time to complete the standardized core course and LANL-specific Radiological Worker I training is approximately 8 hours.
5. Reserved

633 Radiological Worker II

Workers whose job assignments involve unescorted access to High and Very High Radiation Areas, Contamination Areas, High Contamination Areas, and Airborne Radioactivity Areas and/or workers who have potential contact with hot particles or perform operations on bench tops, in fume hoods, at sample stations, in open-front boxes, or in glove boxes shall complete Radiological Worker II training.

1. - Radiological Worker II training shall use the standardized core course training materials and, in addition, shall emphasize LANL-specific information. ^{10 CFR 103.902}
2. - Radiological Worker II training shall encompass the following LANL-specific practical factors.
 - a. Donning protective clothing
 - b. Entering a simulated Radiological Buffer Area, Contamination Area, and High Radiation Area to perform a task
 - c. Responding to simulated abnormal situations
 - d. Responding to simulated alarms or faulty radiological control equipment
 - e. Removing protective clothing and equipment and subsequently exiting the simulated area
 - f. Frisking for personnel contamination
 - g. Verifying instrument response and performing source checks ^{10 CFR 103.902}
3. Expected time to complete the standardized core and LANL-specific Radiological Worker II training is approximately 16 hours.

634. Specialized Radiological Worker Training

1. Specialized radiological worker training shall be completed for nonroutine operations or work in areas with changing radiological conditions. This training is in addition to Radiological Worker II training and is required for personnel planning, preparing, and performing jobs that have the potential for high radiological consequences. Such jobs may involve special containment devices, the use of mockups, and ALARA considerations. This training is provided by the operating organization, the radiation protection organization, and ESH-13, if requested.
2. Additional training for employees in specialized facilities, such as accelerators and laboratories, will be developed. See Part 6, Training for Special Applications.

Table 6-1 Radiological Worker Entry Training Requirements

Area	Training Requirements ^a
Radiological Buffer Areas	Radiological Worker I or II
Storage of radioactive material	Radiological Worker I or II
Radiation Areas	Radiological Worker I or II
High or Very High Radiation Areas ^b	Radiological Worker II
Contamination Areas or High Contamination Areas	Radiological Worker II
Soil	Radiological Worker II
Airborne Radioactivity Areas	Radiological Worker II ^c
Bench tops, fume hoods, sample stations, open-front boxes, or glove boxes	Radiological Worker II

- a. Includes core and LANL-specific information.
- b. Entry requirements further restricted by Article 334.
- c. Requires respiratory protection qualification (Article 531).

PART 4 RCT Qualification**641 Requirements**

Training and qualification of RCTs 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. Core training for RCTs is provided by ESH-13. The comprehensive written examination for qualification and requalification is administered by ESH-13.

642 RCT

1. → RCT 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. ^{10 CFR 203.940}
2. RCT training shall use the standardized core course training materials and in addition should emphasize LANL-specific information.
3. RCT 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 RCTs meet standards for physical condition and education. At a minimum, these standards should include the following.
 - a. High school education or equivalent
 - 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 and to communicate verbal instructions to others
 - f. Physical requirements to handle personal protective equipment and other equipment and to assist others in work locations, commensurate with assignment.
5. RCTs are encouraged to pursue registration by the National Registry of Radiation Protection Technologists (NRRPT).
6. LANL gives 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 (on-the-job) training, the RCT shall pass both a comprehensive written examination and an oral examination board for final qualification.
2. → Following oral examination board qualification, the RCT should begin a 2-year cycle of continuing training required for requalification. Every requalification requires completion of on-the-job training, a comprehensive written examination, and a final session before the oral examination board. ^{10 CFR 203.940}
3. Continuing training should provide continued improvement in the knowledge and skills of the RCT. Continuing training is provided by the radiation protection organization and ESH-13. Continuing training course content input from the line organizations is encouraged.

4. Continuing training should include LANL-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. ^{10 CFR 835.1502(e)} Other tasks may require retraining before initiation of a task.
7. Personnel who maintain qualifications as RCTs satisfy the requirements of Radiological Worker II training.

644 RCT Supervisors

1. RCT supervisors shall be qualified as RCTs and should participate in continuing radiological training programs.
2. RCT 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. RCT 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 RCT supervisor's depth of knowledge should exceed that expected of an RCT.

645 Subcontracted RCTs

1. Subcontracted RCTs (to include RCTs brought in by contractor organizations, e.g., environmental restoration contractors) should have the same knowledge and qualifications required of LANL RCTs 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 in which they will be employed
 - b. Written examination and oral evaluation to verify appropriate knowledge level in accordance with Articles 614 and 615
 - 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 RCT supervisor
2. Subcontracted technicians who work at the facility for extended time periods (more than 6 months) are identified by the radiation protection organization and should receive continuing training commensurate with their assigned duties. This should include successful completion of an oral examination.

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PART 5 Other Radiological Training

The following articles list training requirements that are in addition to other required training.

651 Management Training

LANL line managers who manage, supervise, or oversee radiological control programs shall be trained in the principles of the *LANL Radiological Control Manual*. Such training, provided by ESH-13, should be based on DOE standardized core course training materials supplemented by LANL-specific procedures and be completed by new personnel before they formally assume line supervision and management responsibilities. Incumbents should participate in continuing training provided by ESH-13. 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, and procedure writers) should be trained by ESH-13 with support from the radiation protection organization in the principles of ALARA, basic ALARA techniques, and dose reduction techniques. They should also participate in selected portions of LANL-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. It is desirable that planners have Radiological Worker II training.

654 Radiological Control Personnel

1. Radiological control technical staff and management should have the following.
 - 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 the following.
 - a. Applicable training on standardized core course topics from Radiological Worker I and II and RCT training and additional job-, facility-, and operation-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 provided by ESH-13.
5. Certification and involvement with professional industry organizations should be encouraged.

655 Radiographers and Radiation-Generating-Device Operators

Sealed source radiographers who are not working under a USNRC license shall be trained by the Policy and Program Analysis Group (ESH-12) and ESH-13 in accordance with 10 CFR 34.31. Sealed source radiographers who are working under a USNRC license are expected to have the required training before they arrive on the site.

Operators of radiation-generating devices (for example, sealed source irradiators and neutron generators) that are used for nonradiographic purposes and are capable of generating an unshielded radiation intensity of at least 100 mrem in 1 hour when measured at 30 centimeters from the source should have training that is appropriate for the radiation source involved and commensurate with the level described in 10 CFR 34.31. Operators of intentional and incidental x-ray-generating devices (including x-ray radiography) shall be trained in accordance with LS107-03.0. Accelerator training is addressed in Article 664.

656 Emergency Response Personnel

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

1. Emergency response personnel, from both on-site and off-site, may be required to work in radiological areas.
2. = Emergency response personnel should receive special radiological worker training, provided by ESH-13 in cooperation with Emergency Management and Response (EM&R) in Facilities, Security and Safeguards (FSS) Division, commensurate with the situations they are likely to encounter. ^{10 CFR 835.1302(e)}
3. = Such training should be based on the Radiological Worker standardized core course and LANL-specific training materials. ^{10 CFR 835.1302(e)}
4. If such workers are not trained, trained escorts should be assigned.
5. Training should make it clear that saving lives has priority over radiological controls.
6. Records of this training should be maintained by ESH-13.

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

Tour groups and visiting dignitaries, scientists, and specialists who require unescorted access to posted areas other than Controlled Areas should complete the following training.

1. Operating organizations should establish, in coordination with ESH-13 and the radiation protection organization, radiological control training for tour groups and visiting dignitaries, scientists, and specialists that is 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, with the written concurrence of the Radiation Protection Program manager, provide an alternative to training.
3. Training for tour groups, visiting dignitaries, scientists, and specialists should be based on the Radiological Worker standardized core course and LANL-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 I or II training. In any event, training should be commensurate with the work to be performed. If limited training is provided for limited tasks, methods should be established to limit the approved work and to make other staff members aware of the limitation, such as posting a signed-off training card.
5. Records of this training should be maintained by the operating organization or, through special arrangement, by ESH-13.

658 Escort Training

1. Operating organizations are expected to provide escort training for personnel who will escort individuals in Controlled Areas, Radiological Buffer Areas, or Radiological Areas. Training includes the following topics:
 - a. Escort's ES&H responsibilities for the visitor
 - b. Visitor and management responsibilities for radiation safety
 - c. Dosimetry requirements for the visitor
 - d. Personal clothing and protective equipment requirements for the visitor
 - e. Emergency response for the visitor
 - f. Work restrictions, if any, imposed on the visitor
2. Escorts are required to have the same level of training required of workers in the area.
3. Examination is not required for specific escort training. However, the escort must be examined on the training provided as a result of the Article 658.2 requirement.
4. Records of the training shall be maintained by the operating organization.

PART 6 Training For Special Applications**661 Plutonium Facilities**

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 glove box operations and procedures
- Special instruments and measurement techniques
- Personnel protection
- Inventory control and accountability
- Criticality safety
- Biological effects
- Bioassay program

662 Uranium Facilities

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

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

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
Bioassay program

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 occupational records. ^{10 CFR 835.401(a)(2), 701(a)} 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, stored appropriately, and managed for the prescribed retention period. Consideration should be given to cross-referencing related records to aid retrievability. Records should be handled in such a way that personal privacy is protected.

Information and data generated by LANL's radiation protection program shall be maintained in accordance with the requirements of DOE 1324.2A, "Records Disposition." The documentation standards contained in ANSI N13.6, "Practice for Occupational Radiation Exposure Records System," and DOE Order 5484.1, "Environmental Protection Safety and Health Protection Information Reporting Requirements," shall be followed. Records that differ from the recommendations of ANSI N13.6 in such areas as applicability, information content, and formulation must be justified and documented.

712 Records Management Program

1. — An occupational radiological records management program shall be established by the Policy and Program Analysis Group (ESH-12). ^{10 CFR 835.701(a)} — 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. ^{10 CFR 835.702(c)(2), 1301(e)} — The records management program should ensure that the following records are maintained. ^{10 CFR 835.702(a)}
 - a. Occupational radiological policy statements
 - b. Occupational radiological control procedures
 - c. — Individual monitoring records ^{10 CFR 835.702(a)}
 - d. Internal and external dosimetry policies and procedures (including basis documents)
 - e. Personnel training (course records and individual records)
 - f. ALARA records
 - g. Occupational radiological instrumentation maintenance, repair, performance test, and calibration records
 - h. Occupational radiological surveys
 - i. Area-monitoring dosimetry results
 - j. Radiological work permits
 - k. Occupational radiological performance indicators and assessments
 - l. Radiological safety analysis and evaluation reports
 - m. Quality assurance records
 - n. — Occupational radiological incident and occurrence reports (and critique reports, if applicable) ^{10 CFR 835.1301(e)}
 - o. Accountability records for sealed radioactive sources
 - p. Records for release of equipment and materials to Controlled Areas and uncontrolled areas, as appropriate
 - q. Reports of loss of radioactive material
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 LANL.
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 and consistent with the Privacy Act of 1974, which contains requirements to protect the privacy of individual records. ^{10 CFR 835.792(f), 801(d)}

713 Record-Keeping Standards

1. Radiological records shall be accurate and legible. The records should include the following information.
 - 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 radiation protection organization and the line organization responsible for radiological records specific to their operation maintain a file of names, signatures, and initials for future identification of the person who signed or initialed a record.
3. Radiological records should not include the following.
 - a. Opaque substances for corrections
 - b. Shorthand or other nonstandard terms
4. Similar procedural standards should be established for computerized records.
5. — Unless otherwise specified, the quantities used in the records required in this chapter shall be clearly indicated in special units of curie, rad, or rem, including multiples and subdivisions of these units. SI units are not authorized for use in the records required in this chapter, except parenthetically. ^{10 CFR 835.4}

PART 2 Employee Records**721 Employment Exposure History**

— Records detailing an employee's preemployment and employment history and the associated dose equivalent quantity shall be maintained by ESH-12, ¹⁰ CFR 835.702(e). Where practical, the association between the appropriate dose equivalent quantity and job function should be preserved to establish trends and for future worker health studies. The following information should be maintained.

1. Previous work history detailing radiological work assignments, to the extent practical, and yearly assigned dose equivalent quantities at other DOE and non-DOE facilities
2. Nuclear Regulatory Commission Form 4 or equivalent that documents previous occupational dose equivalent quantities
3. Ongoing work history documenting work assignments and dose equivalent quantities (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 dose equivalent quantities

722 Personnel Radiological Records

1. — Records of doses received by all individuals for whom individual monitoring was performed 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. ¹⁰ CFR 835.702(b)(1)(i)(ii)(iii)(iv), 702(d), 1301(b) Individual occupational internal and external dose records and records of the programs used to assess individual doses shall be generated and maintained by ESH-12 at a level sufficient to provide appropriate reports to the employee, management, and others required by applicable regulations. Current employee records should be readily available to those authorized to have access to them. Data necessary to support or recalculate doses at a later date shall be maintained pursuant to Section 4 of ANSI N13.6. Specific data that shall be recorded and retained for individuals for whom monitoring is required are listed in Articles 721 through 731.
2. Radiation dosimetry records shall contain enough information to identify each person, including social security or employee number (e.g., Z number).
3. — Radiation dosimetry records of routine and special exposures shall be retained for each person monitored. ¹⁰ CFR 835.702(a)(b) — This shall include records of all numerically positive and zero dosimetry results and, where possible, the lower limit of detection. ¹⁰ CFR 835.702(b)(2) Procedures, data, and supporting information needed to reconfirm a person's dose at a later date should be maintained.
4. — External dose records shall include the following.
 - a. Applicable extremity, skin, eye, and whole-body dose results measured with personnel dosimeters, including all multiple dosimeter badging results ¹⁰ CFR 835.702(c)(1)(ii)(iii)(iv)
 - b. Evaluations related to anomalous dosimetry results such as unexpected high or low dose equivalents
 - c. — Dose reconstructions from lost or damaged dosimeters or for unbadged workers ¹⁰ CFR 835.703(b)
 - d. Evaluations of nonuniform radiation doses.
5. — Internal dose records shall include the following.
 - a. Applicable whole-body and lung-counting results (including chest wall thickness measurements and other measured physical parameters where applicable)
 - b. — Applicable urine, fecal, and specimen analysis results, including estimated intake and identity of radionuclides ¹⁰ CFR 835.702(c)(4)(iii)
 - c. Dose assessment, as required ¹⁰ CFR 835.702(c)(4)(i)(ii), 703(b)

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 occupational exposure records for that worker. ^{10 CFR 835.702(c)(6)}
9. — Records of lifetime occupational dose, including cumulative total effective dose equivalent since January 1, 1989, should be maintained with the individual's occupational exposure records. ^{10 CFR 835.702(c)(5)(iii)}
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 by the requesting organization.
12. — Emergency doses and planned special exposure shall be accounted for separately, but maintained with the individual's occupational exposure records. ^{10 CFR 835.204(e)(7), 702(e), 1301(b)}
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 2-1 (see Article 723 for requirements for records of radiological incidents and occurrences). ^{10 CFR 835.702(b)}

723 Other Personnel Radiological Records

1. — Radiation dosimetry records of radiological incidents and occurrences and the circumstances surrounding those exposures, including the incident reports, shall be retained by ESH-12. ^{10 CFR 835.702(a), (c)(2)}
2. Records of employee radiological safety concerns that have been formally investigated and documented should be maintained by ESH-12.
3. — Records of the formal written declaration of pregnancy shall be maintained. ^{10 CFR 835.704(d)} Records of revocations of such declaration, 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 by the Occupational Medicine Group (ESH-2).
2. For respirator users, physical examination reports should be maintained by ESH-2 and quantitative fit-test results should be maintained by the Industrial Hygiene and Safety Group (ESH-5).
3. Medical evaluations, pregnancy evaluations, and treatment performed in support of the radiological program should be documented by ESH-2.
4. Maintenance of records by ESH-2 related to nonoccupational exposure to radiation or radioactive material, such as medical therapeutic or diagnostic radiation, is encouraged. Where practical, maintenance of records of preemployment nonoccupational exposure to radiation is encouraged.

725 Radiological Training and Qualification Records

1. Records of training and qualification in radiological control shall be maintained in accordance with Chapter 6 in the *LANL Radiological Control Manual* 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 (e.g., donning and doffing protective clothing) training as well as for formal classroom training.
2. Formal records of training and qualification (listed in paragraph 3 below) shall be readily available to first-line supervisors and managers of involved personnel to aid in making work assignments.
3. Personnel training records shall be controlled and retained by the organization (e.g., ESH-13, line organization) sponsoring the training. The sponsoring organization is responsible for entering the training information into the Employee Development System (EDS). The EDS is maintained by the Training and Development Group.
—At a minimum, these records shall include the following. ^{10 CFR 835.903}
 - a. — Course title
 - b. Attendance sheets with instructor's name
 - c. Employee's name, Z number, and signature
 - d. Date of training ^{10 CFR 835.903}
 - 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. Tests, quizzes, responses, and acknowledgments of training, with the date and signature of the person trained
 - i. Special instructions to females and their supervisors concerning prenatal exposure to radiation, acknowledged by the worker's signature
4. — Records shall be retained for the following types of training by the organization specified in Chapter 6 in the *LANL Radiological Control Manual*.
 - a. General Employee Radiological Training (GERT)
 - b. Radiological Worker I and II Training
 - c. Periodic retraining
 - d. Respiratory protection training
 - e. Training of radiological control personnel
 - f. Instructor training
 - g. Qualifications for special tests or operations
 - h. Orientation and training of visitors
 - i. Training of emergency response personnel ^{10 CFR 835.704(a)}
5. The following instructional materials shall be maintained by the ES&H Training Group (ESH-13) or the line organization, as specified in Administrative Requirement 1-4 in the *LANL Environment, Safety, and Health Manual*.
 - 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 given to ESH-13 for retention.

PART 3 Visitors**731 Record Requirements**

— For visitors entering an area where radiation monitoring is required, the following records shall be maintained. 10 CFR 835.702(a)

1. Documentation of completion of radiological orientation
2. — Radiation dose records, including zero dose. 10 CFR 835.702(a) These records shall be sufficient for compliance with all applicable dose limits and monitoring and reporting requirements to be evaluated.

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. Dose reports should be provided to each employer of a visitor who is sent a dose report. If the visitor is a DOE headquarters employee, the dosimetry report will be sent to the Systems Safety Development Center, EG&G Idaho, as required by DOE Order 5484.1. If the exposure exceeds the radiation protection exposure standards in Chapter 2 of this manual, the radiation dose equivalent shall be reported to the visitor and the visitor's employer within 24 hours after the exposure or within 24 hours after the exposure has been confirmed. Reports may be made by telephone, FAX, or Teletype. If the report is made by telephone, a printed copy must follow within 30 days.

PART 4 Radiation Protection Program Records**741 Policies, Procedures, and Radiological Work Permits**

Records of the LANL Radiation Protection Program should consist of policy statements, procedures, standards, radiological work permits, and supporting data. The records should be maintained by the radiation protection organization 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 radiological work permits should be maintained by the Health Physics Operations Group (ESH-1) for archiving at a later date. Records of facility-specific radiological control activities (e.g., safe operating procedures and ALARA committee meeting minutes) are maintained by the line organization.

Safe Operating Procedures (SOPs) shall be prepared and maintained by responsible line organizations.

742 ALARA Records

— Records of as low as reasonably achievable (ALARA) plans and goals shall be maintained by ESH-12 and by operating organizations to demonstrate the adequacy of ALARA programs. ^{10 CFR 835.704(b)} 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 by ESH-12 to ensure that sufficient records are specified, prepared, reviewed, approved, and maintained to accurately reflect completed work. ^{10 CFR 835.704(c)} DOE 5700.6C provides additional information regarding quality assurance records.

PART 5 Radiological Surveys**751 Requirements**

Occupational radiation protection programs require the performance of radiation, airborne radioactivity, and contamination surveys to determine existing conditions in a given location. Records shall be kept to document the suitability, quality, and accuracy of monitoring methods, techniques, and procedures used during any given period pursuant to Section 6 of ANSI N13.6. — Workplace changes in monitoring equipment, techniques, and procedures are to be documented and the documents maintained by the radiation protection organization. ^{10 CFR 835.704(e)}

— Records that establish the conditions under which individuals were exposed, such as facility radiological conditions (as generated by the monitoring programs) and surveys for releasing personal property and workplace surfaces from more stringent requirements, shall be kept by the radiation protection organization to provide a chronological historical record. ^{10 CFR 835.703(a)} These records shall be maintained pursuant to Section 5 of ANSI N13.6. Facility and room survey maps with sufficient detail to permit identification of original survey and sampling locations should be maintained by ESH-1. 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.

1. Date, time, and purpose of the survey
2. General and specific location of the survey
3. Name and signature of the surveyor and radiological control technician supervisor
4. Pertinent information needed to interpret the survey results
5. Reference to a specific radiological work permit or SOP if the survey is performed to support the permit or SOP

752 Radiation Surveys

—In addition to the elements provided in Article 751, records of radiation surveys shall include, at a minimum, the following information. ^{10 CFR 835.703(a)}

1. Instrument model and serial number
2. — Results of the measurements of area dose equivalent rates ^{10 CFR 835.703(a)(b)}

753 Airborne Radioactivity

—In addition to the elements provided in Article 751, records of airborne radioactivity shall include, at a minimum, the following information. ^{10 CFR 835.703(a)}

1. Model and serial numbers of the sampler and laboratory counting instrument when available or unique identifiers of each sampler and instrument
2. Location of fixed-air samplers
3. Location of portable air samplers used for a survey
4. — Air concentrations in general airborne areas and breathing zones ^{10 CFR 835.703(a)(b)}
5. Supporting parameters, including collection efficiency, flow rate, duration of sampling, correction factors, and filter medium.

754 Contamination Surveys

→ In addition to the elements required by Article 751, records of contamination surveys shall include, at a minimum, the following information. ^{10 CFR 835.703(a)}

1. Model and serial number of counting equipment
2. → Contamination levels (using appropriate units) and appropriate supporting parameters including counting efficiency, counting time, correction factors, type of radiation, and whether the contamination was fixed or removable ^{10 CFR 835.703(a)}
3. Location of areas found to contain hot particles or high concentrations of localized contamination
4. Follow-up survey results for decontamination processes cross-referenced to the original survey

PART 6 Instrumentation and Calibration Records**761 Calibration and Performance Tests**

1. — Calibration records for fixed, portable, and laboratory radiation-measuring equipment and individual monitoring devices shall be maintained by the Health Physics Measurements Group (ESH-4) and include frequencies, method, dates, personnel, training, and traceability of calibration sources to National Institute of Science and Technology (NIST) or other acceptable standards. ^{10 CFR 835.703(d)(1)}
2. — Calibration records shall be maintained for the following equipment.
 - a. Portable survey instruments
 - b. — Bioassay measurement equipment ^{10 CFR 835.703(d)(2)}
 - c. Laboratory, counting room, and fixed radiation-measuring equipment
 - d. Process and effluent monitors and sampling equipment
 - e. Radiation area monitors
 - f. Portal monitors and other personnel contamination monitors
 - g. — Pocket and electronic dosimeters ^{10 CFR 835.703(d)(2)}
 - h. Air-sampling equipment for workplace monitoring and stack effluent monitoring
 - i. Tool- and waste-monitoring equipment
 - j. — Protective clothing and equipment monitors ^{10 CFR 835.703(d)(1)}
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, corrective actions taken, and calibration results for each instrument that is part of the occupational radiation protection program, shall be generated and retained by ESH-4. ^{10 CFR 835.703(d)(1)}

762 Special Calibration Records

Records of additional tests and checks of instrumentation used in conjunction with a suspected overexposure, questionable indication, or unusual occurrence shall be retained by ESH-4. In addition, records of special instrument calibrations and modifications made in accordance with Article 562.6 shall be retained by ESH-4.

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 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 that the resulting film copy is capable of producing a clear, legible copy after being stored for the specified period. The following controls shall be administered by the organization responsible for the records.

1. Verification that the resultant copy is legible
2. Confirmation that all 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 that certain precautions are taken by the organization responsible for the records 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 as specified in DOE 1330.1C, "Computer Software Management"
 - f. Periodic quality audits of software
 - g. Prevention of unauthorized manipulation of data
 - h. Assurance that previously stored information is retrievable and usable after system modifications by moving the data to contemporary media/systems, if necessary
3. Optical disks may be used to archive records if the optical disks satisfy the following.
 - a. They provide a reliable system to prevent overwriting or erasure of records.
 - b. Software and user controls are consistent with Article 773.2.
 - c. Manufacturer recommendations relating to software control, disk life expectancy, environmental storage conditions, and maintenance are incorporated into policies and procedures.
 - d. Quality controls on the copying and imaging processes are consistent with Article 772.
 - e. Previously stored information is retrievable and usable after system modifications by moving the data to contemporary media/systems, if necessary.

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 835.701(b), 702(b)}
2. Once a record has been created, reviewed, and signed by the appropriate supervisors, 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 the following.
 - a. Exposure to fire, equivalent to an Underwriters Laboratories 1.5-hr, or greater, fire resistance rating
 - b. Exposure to water damage caused by a 100-year flood
 - c. Exposure to windstorm velocities of 100-year recurrences

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(e)} = Upon request, an individual shall receive a current radiation dose record. ^{10 CFR 835.702(f)}
2. = Upon the request from an individual terminating employment, records of exposure shall be given to that individual as soon as the data are available, but not later than 90 days after termination. ^{10 CFR 835.801(b)} = If requested, a written estimate based upon available information shall be provided upon termination. ^{10 CFR 835.801(b)}
3. = Reports of individual doses shall include the name of the laboratory, the individual's name and social security or employee number, and all dose information required by Article 722. ^{10 CFR 835.801(e)}
4. = Reports of individual exposure to radiation or radioactive materials required under DOE 5000.3B 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. ^{10 CFR 835.204(e)(1), 702(e)(2), 801(e), 1201(b)(6)} = 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 equivalent results for monitored DOE and LANL employees, subcontract employees, and visitors. ESH-12 prepares the Radiation Exposure Information Reporting System (REIRS) report in accordance with the directions provided in DOE Order 5484.1 and sends it to the Systems Safety Development Center, EG&G Idaho, by March 31 of each year.

783 Reports to Line Organizations and Radiation Protection Groups

ESH-12 shall provide records of monthly radiation exposures of individuals to all operating groups and line organizations for the individuals in their organizations, and to the radiation protection groups assigned to support those organizations. Line managers should use these monthly exposure reports in their individual exposure control and ALARA programs.

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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: Any area where the 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.

As Low As Reasonably Achievable (ALARA): An approach to radiological control to manage and control exposures (individual and collective) to the work force and to the general public at levels as low as is reasonable, taking into account social, technical, economic, practical and public policy considerations. As used in this Manual, ALARA is not a dose limit but a process that has the objective of attaining doses as far below the applicable controlling limits as is reasonably achievable.

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

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

background radiation: Radiation from

- (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

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

contamination reduction corridor: A defined pathway through a hazardous waste site contamination reduction 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 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.

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.

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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 2400m^3). 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 record-keeping 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) ($1 \text{ rad} = 0.01 \text{ gray}$).

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 $H_{E,50} = \sum w_T H_{T,50}$. Committed effective dose equivalent is expressed in units of rem (or sievert).

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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 rem = 0.01 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 = ΣW_TH_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 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).

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.

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.

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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. Example 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 monodisperse 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: Any area where contamination levels are greater than 100 times the values specified in Chapter 2, Table 2-2, of this Manual.

high radiation area: Any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.1 rem (0.001 Sv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

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

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

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

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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.

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

monitoring: Actions intended to detect and quantify radiological conditions.

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.

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.

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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: Any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.005 rem (0.05 mSv) in one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

radioactive material: For the purposes of this Manual, radioactive material includes any material, equipment or system component determined to be contaminated or suspected of being contaminated. Radioactive material also includes activated material, sealed and unsealed sources, and material that emits radiation.

radioactive material area: An area or structure where radioactive material is used, handled or stored.

radioactive 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 required by Chapter 2, Part 3 of this Manual.

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 label: Label on an item which indicates the presence of radiation or radioactive materials.

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 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 I or II 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."

Glossary

Individuals who complete either Radiological Worker I or Radiological Worker II 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.

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.

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.

Glossary

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: Any area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in one hour 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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