Volume II
Part 20: Ionizing Radiation, Non-Ionizing Radiation

Document 20.1
Occupational Radiation Protection

Revision Type: Major

Subject Matter Expert (SME)/Author: Kathleen L. Shingleton

FAM Approval by: Quang Le
Radiation Protection Functional Area

FAM Approval date: April 10, 2017

ES&H Directorate Approval by: Frances Alston
Director, ES&H

ES&H Directorate Approval date: April 13, 2017

Last IM Review date: May 2017

Web Posting date: June 7, 2017

Implementation date: August 6, 2017

*Required when Owner/Author are the same person
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Occupational Radiation Protection*

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Occupational Radiation Protection

1.0 Basis of the LLNL Radiation Safety Program

The Department of Energy (DOE) requires LLNL to conduct its radiological activities in compliance with a documented, DOE-approved, radiation protection program (RPP). The Environment, Safety, and Health (ES&H) Manual documents in Table 1 contain the requirements of LLNL’s RPP and constitute LLNL’s ‘site-specific radiological control manual.’ Effective implementation of these documents ensures general employees, visitors, and LLNL are adequately protected and that LLNL achieves compliance with the DOE’s rule on Occupational Radiation Protection (Part 10 CFR 835, also referred to as “the Rule”) and contractually-obligated orders and standards.

Table 1. ES&H Manual Documents that Implement LLNL’s Radiation Protection Program

<table>
<thead>
<tr>
<th>ES&amp;H Manual Document</th>
<th>Title</th>
<th>Contains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document 20.1</td>
<td>“Occupational Radiation Protection”</td>
<td>Technical requirements for the overall radiological protection program, including the ALARA program</td>
</tr>
<tr>
<td>Document 20.2</td>
<td>“LLNL Radiological Safety Program for Radioactive Materials”</td>
<td>Technical requirements for the handling, storage, or transportation of radioactive materials (including radioactively contaminated items)</td>
</tr>
<tr>
<td>Document 20.3</td>
<td>“LLNL Radiological Safety Program for Radiation-Generating Devices”</td>
<td>Technical requirements for operation of RGDs</td>
</tr>
<tr>
<td>Document 22.6</td>
<td>“Exposure to Radiation in an Emergency”</td>
<td>Provisions for responding to radiological emergencies</td>
</tr>
</tbody>
</table>

1.1 Applicable Standards

1.1.1 Part 10 CFR 835, Occupational Radiation Protection

LLNL maintains one DOE-approved RPP covering Site 200 and 300 operations; the Nevada National Security Site (NNSS) RPP covers LLNL operations at NNSS. The LLNL RPP contains the text of 10 CFR 835 and LLNL’s implementation methodology.
1. Changes, additions, or updates to the RPP may become effective without prior DOE approval if the changes do not decrease the effectiveness of the RPP and the RPP, as changed, continues to meet the requirements of the Rule.

2. DOE may direct or make modifications to LLNL’s RPP and must approve (prior to their implementation) proposed changes that decrease the effectiveness of the RPP.

3. An initial RPP or an update is considered approved 180 days after its submission to DOE unless rejected by DOE at an earlier date.

4. LLNL must achieve compliance with amendments to the Rule within 180 days following DOE’s approval of the revised RPP.

The requirements of the DOE-approved RPP have been integrated as ‘shall’ statements into the applicable ES&H Manual documents shown in Table 1.

1. The DOE-approved RPP is legally binding between Lawrence Livermore National Security, LLC (LLNS) and DOE and prevails in case of ambiguity with other LLNL documents.

2. The Rule applies to LLNL management, supervisors, and individuals, including subcontractors, who handle radioactive materials, operate radiation-generating devices (RGDs), or may be exposed to ionizing radiation because of their work.

3. No one may act (or cause others to act) in a manner inconsistent with the Rule or any program, plan, schedule, or other process established by the Rule. However, nothing in the Rule shall be construed as limiting actions that may be necessary to protect health and safety.

4. Failure to comply with radiation protection program requirements could necessitate reporting to DOE under the provisions of DOE Order 232.2, “Occurrence Reporting and Processing of Operations Information;” 10 CFR 830.120, “Quality Assurance Requirements;” or the Price Anderson Amendments Act (PAAA). Significant non-compliances can result in civil and criminal enforcement actions.

1.1.2 DOE Standard 1098-2008, Radiological Control

The DOE Standard 1098-2008, Radiological Control Standard (RCS) is contractually obligated, but not federally mandated. Consistent with the DOE-approved implementation plan for the RCS, appropriate articles of the RCS have been integrated into the ES&H Manual documents shown in Table 1 as “shall,” “must,” or “should” statements, depending on the context of the RCS article.

1.1.3 DOE Standard 420.2C, Safety of Accelerator Facilities

1.1.4 DOE Order 458.1, Radiation Protection of the Public and the Environment


1.1.5 10 CFR 830, Subpart A, Quality Assurance

The provisions of 10 CFR 830 Subpart A, ‘Quality Assurance’ (i.e., the ‘QA Rule’) apply to LLNL’s nuclear and radiological facilities, activities, and operations. The QA Rule establishes quality assurance requirements for DOE contractors conducting activities, including providing items or services that affect, or may affect, the nuclear safety of DOE nuclear facilities. The QA Rule specifies criteria including, but not necessarily limited to personnel qualification and training, work processes, documents and records, design, procurement, inspection and acceptance testing, management and independent assessments, and quality improvement. For more information, contact the Directorate Assurance Manager.

1.2. Integration of Requirements into the *ES&H Manual*

Through the use of the terms “shall,” “must,” and “should,” LLNL’s radiological control program establishes a well-defined set of expectations, while providing implementation flexibility. *Appendix A* defines “shall,” “must,” “should,” and other terms used in this document.

1. The documents in *Table 1* apply to the Authorizing Organizations, support organizations, and individuals who handle radioactive materials, RGDs, or may be exposed to ionizing radiation because of their work, including:

   a. LLNL management, supervisors, and individuals.

   b. LLNL subcontractors.

   c. DOE employees.

2. Whereas only DOE may grant exceptions to “shall” statements, LLNL’s Radiological Control Manager (RCM) may grant exceptions to “must” statements. The Authorizing Organization may use their discretion in implementing “should” statements.

3. The Authorizing Organization (which may include either line program or facility staff) must ensure the documents identified in *Table 1* are effectively implemented.

   a. Consistent with LLNL’s Integrated Safety Management (ISM) process, the Authorizing Organization must ensure radiological operations are conducted within the safety envelope of the facility.

   b. For ease of reference, the terms ‘Responsible Individual’ (RI) and ‘Authorizing Individual’ (AI) are used throughout the documents in *Table 1*. At the discretion of the Authorizing Organization, tasks ascribed to the RI and AI may be completed by individuals with other titles. For example, in the Plutonium Facility, the Associate
Program Leader (APL) typically carries out RI responsibilities for programmatic operations, while the Facility Manager typically carries out RI responsibilities for support operations.

4. The appendices of the documents in Table 1 contain detailed implementing information. For example, this document contains:

   a. Appendix A  Acronyms, Terms, and Definitions.
   b. Appendix B  Conducting Internal Audits.
   c. Appendix C  Workplace Evaluations for Declared Pregnant Workers.
   d. Appendix D  Dosimeter Requirements and Results Notification Protocol.
   e. Appendix E  Environmental Boundaries for Radiation Detectors.
   f. Appendix F  Radiological Records Retention.
   g. Appendix G  Performing Radiological Design and Operational ALARA Reviews.
   i. Appendix I  Formal ALARA Job/Experiment/Task (JET) Review

1.2.1 Obtaining Exemptions from ES&H Manual “Must” Statements

1. To obtain RCM approval to not implement a “must” statement, the Authorizing Organization must submit a “must exemption” using the form provided by the ES&H Team health physicist. The form documents:

   a. The provision that is impractical to implement.
   b. Justification for the exemption.
   c. Proposed compensatory measures/technical equivalency.
   d. Concurrence signature of the ES&H Team health physicist.
   e. Approval line for the RCM.

2. The line program obtaining the exemption must retain a copy of the signed exemption form.

1.2.2 Applicability of the ES&H Manual Requirements

1. Subcontractors and subcontracted employees must be treated the same as the general staff insofar as radiological controls are concerned; i.e., they must have comparable radiation safety training (as determined by the ES&H Safety Education and Training Section), and must meet the same requirements and expectations.
2. LLNL management, supervisors, and workers (including subcontractors) shall comply with the requirements in this document and its associated documents when managing or conducting radiological work either onsite or offsite. (Subcontractors are not expected to develop their own radiological control manuals.)

3. Work conducted at another site or location where LLNL does not have overall management responsibility shall be conducted in accordance with the other site’s established regulations and policies for handling radioactive materials and operating RGDS. Usually, the site requirements are specified in the RPP, a Nuclear Regulatory Commission (NRC) license, or an NRC-agreement state license.

1.2.3 Exclusions

The documents shown in Table 1 do not apply to:

1. Background radiation [including naturally-occurring radioactive material (NORM) and consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation. Note:

   a. In some poorly ventilated buildings, particularly in underground work areas, the naturally occurring radon levels may require special evaluation for radiation protection purposes.

   b. Whereas NORM is not regulated relative to occupational radiation protection, it may be regulated for waste purposes; contact the Environmental Functional Area for more information.

2. Medical and dental exposures, including:

   a. Radiation doses received as a patient for the purposes of medical diagnosis or therapy.

   b. Radiation doses received from participation as a subject in medical research programs.

3. Activities regulated by other federal agencies, including:

   a. Activities, items, or articles regulated by the NRC or other federal agencies.

   b. Activities conducted under the Nuclear Explosives and Weapons Surety Program (relating to the prevention of accidental or unauthorized nuclear detonations).

   c. Radioactive material transportation performed under the authority of the Department of Transportation [generally, all off-site transportation including transportation between the Livermore Site (Site 200), Site 300, and NNSS].

   d. Radioactive material transportation not performed by DOE or a DOE contractor.
2.0 Potential Hazards Associated with Radiological Operations

Radiological operations could result in internal or external dose to workers; contamination of workers, work areas, equipment, or facility systems; or release of radioactive material to the environment.

1. The risk from occupational radiation dose depends on the amount of radiation dose received, the time over which the dose is received, and the parts of the body exposed.

2. Contamination of workers, areas, or equipment does not necessarily result in a measurable or recordable radiation dose, but does significantly increase the cost of conducting business.

3.0 Radiation Protection Standards

3.1 ALARA Policy and Management Commitment

As low as reasonably achievable (ALARA) is an approach to radiation protection to manage and control individual and collective doses to employees and visitors to levels that are as low as reasonable, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit, but a process for maintaining doses as far below the applicable limits as is reasonably achievable. The ALARA philosophy is based on the supposition that radiation dose increases one’s risk of cancer—the smaller the dose, the smaller the risk. Although this premise has not been proven at low doses of radiation (i.e., acute whole-body doses less than 10 rem), the Rule requires formal plans and measures for applying the ALARA process to occupational radiation exposure.

1. LLNL’s ALARA policy is as follows.

   It is the policy of LLNL to plan and conduct its radiological activities in a manner that protects the health and safety of all its employees, contractors, the general public, and the environment. In achieving this policy, LLNL shall ensure that efforts are taken to reduce radiological exposures and releases to as low as reasonably achievable (ALARA), taking into account social, technical, economic, practical and public policy considerations. The Laboratory is committed to implementing a high-quality radiological control program that reflects this policy.

2. To ensure effective implementation of LLNL’s RPP and the ALARA policy, the LLNL Deputy Director has established:

   a. A site-wide Radiation Safety/ALARA (RS/ALARA) committee as a subgroup of the Senior Management Safety Team (SMST).

      — The RS/ALARA committee functions as the Stakeholder’s Advisory Group for radiation protection and has responsibilities as described in Section 9.1.2.
— The membership should include managers and workers from the line, the technical support organization, and the radiological control organization.

b. An RCM position. The RCM heads the radiological control organization and is responsible for and should establish a high quality radiological control program. The RCM has direct access to the Deputy Director for issues related to the radiological control program.

3. In implementing this ALARA policy through the ISM process, the Authorizing Organization must:
   a. Follow LLNL’s work control process to ensure:
      — Controls are developed and implemented to reduce or eliminate unnecessary doses and keep the necessary doses low.
      — Routine area monitoring requirements are documented in the ES&H Team Health-Physics Discipline Action Plan (HP-DAP).
   b. Establish Administrative Control Levels (ACLs) for individuals or work groups with individuals who are likely to exceed 0.1 rem/y (from all operations), as specified in Section 3.2.2.
   c. Adopt the design objectives specified in Section 4.1.1 to assure occupational radiation exposures are maintained ALARA through the use of optimal facility/experimental design and physical controls.
   d. Ensure recommended ALARA dose reduction measures are evaluated, optimized, and implemented, as appropriate.

3.2 Individual Radiation Doses

3.2.1 Individual Dose Limits

To ensure the safety of the workforce, DOE has established individual radiation dose limits, as shown in Table 2.

1. LLNL shall conduct its radiological operations in such a manner that the dose limits shown in Table 2 shall not be exceeded and radiation doses are kept ALARA below these limits.
   a. Doses from background radiation, therapeutic and diagnostic medical and dental exposures, and those resulting from participation as a subject in medical research programs are not included in dose records or when assessing compliance with the occupational dose limits.
b. All occupational doses received during the current year, including that received from accidents, except the dose resulting from planned special exposures and emergency exposures, shall be included when demonstrating compliance with Table 2 limits.

c. Occupational doses received as a result of excluded activities and radioactive material transportation shall be included to the extent practicable when determining compliance with the dose limits in Table 2.

Table 2. Individual Dose Limits

<table>
<thead>
<tr>
<th>Category</th>
<th>Dose Limit (rem/y, unless otherwise noted)</th>
<th>Tissue¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>General employees</td>
<td>5</td>
<td>Whole body (internal plus external)</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>Any organ (other than eye) (internal plus external)</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Lens of the eye</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>Extremities and skin</td>
</tr>
<tr>
<td>Embryo/fetus of a declared pregnant worker</td>
<td>0.5 per gestation</td>
<td>Internal plus external (evenly distributed throughout gestation)</td>
</tr>
<tr>
<td>Occupationally exposed minors</td>
<td>0.1</td>
<td>Whole body (internal plus external)</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>Lens of the eye</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>Extremities and skin</td>
</tr>
<tr>
<td>Members of the public entering a radiologically controlled area</td>
<td>0.1</td>
<td>Whole body (internal plus external)</td>
</tr>
</tbody>
</table>

¹ The official dose terminology is provided in the LLNL RPP.

2. Efforts should be made to control each radiation worker’s lifetime occupational dose below a lifetime control level of N rem, where N is the age of the individual in years.

a. The External Dosimetry Team must

   — Make reasonable efforts to determine the lifetime occupational dose of individuals expected to receive more than 1 rem in a year.

   — Notify the RCM if a new employee has a lifetime dose greater than 20 rem.
— Provide the RCM with an annual report of all workers with a lifetime dose greater than 20 rem.

b. The RCM must inform the Authorizing Organization of any worker whose lifetime dose has exceeded their age in years.

c. The Authorizing Organization, working in conjunction with the Radiological Control Organization and the Health Services Department (HSD), must offer a special control level to each radiological worker with a lifetime occupational dose exceeding N rem, where N is the age of the individual in year. See Section 3.2.3.

3.2.2 Administrative Control Levels

An ACL is the Total Effective Dose (TED) established below the regulatory dose limits to administratively control and help minimize individual and collective radiation dose from anticipated operations. ACLs are multi-tiered with increasing levels of authority required to approve higher ACLs.

1. The RI, with support from the ES&H Team health physicist, must identify individuals and work groups containing individuals likely to exceed an annual dose of 0.1 rem (from all operations).
   a. For ongoing work, evaluate the past annual doses for workers in question (available from the ES&H Team health physicist) and consider anticipated changes in workload (e.g., “last year we processed 10 items; this year we expect to process 15 items,” “last year, 3 people shared the workload, next year, 2 people will share the same workload.”)
   b. For new work, estimate individual worker dose.
   c. Recommend challenging ACLs, recognizing that in general, reduction of individual doses should not be allowed to cause a concurrent increase in the collective dose.

2. Considering the input from the RI and the ES&H Team health physicist, the Authorizing Organization must establish numerical ACLs for individuals or work groups containing individuals likely to exceed an annual dose of 0.1 rem (from all operations).
   a. When there is wide variation in the expected doses to the various work groups at a single facility, the Authorizing Organization should develop work group-specific administrative control levels to control worker doses below the regulatory limits.
   b. ACLs must be established in writing, with a copy provided to the RCM and affected workers.
   c. Individuals must not be allowed to exceed the ACL without the prior written approval of the RCM and the Authorizing Organization. Records of authorization to exceed the ACL must be retained.
d. Names of individuals and their associated ACL must be provided to the Radiation Protection Functional Area External Dosimetry Team; contact the ES&H Team health physicist for assistance, as needed.

3. The ACL must:

a. Be based upon an evaluation of historical and projected radiation exposures, work load, and mission, and may be modified (up or down) during the year to reflect actual conditions.

b. Be periodically evaluated (relative to the worker’s individual dose and the work group’s collective dose) by the Authorizing Organization.
   — The ES&H Team health physicist must provide periodic reports (or graphs) to the Authorizing Organization for individuals or groups with ACLs.
   — If a worker exceeds their ACL of 0.5 rem or more without prior written approval, the Authorizing Organization must conduct a formal critique. The Authorizing Organization, with the concurrence of the RCM, must determine if work should be curtailed prior to the conclusion of the critique.

c. Be reevaluated annually. The choice of a low level for one year does not preclude choosing either a higher or lower level in a subsequent year.

d. Be adjusted (i.e., prorated to reflect their current work assignment) as workers move between work groups. For example, if a worker had a 1.0 rem ACL and received 0.5 rem in the first 6 months of the year and then moved to a work group with an ACL of 0.5 rem/y, their new, prorated ACL would be 
\[ (1.0 \text{ rem/y} \times 0.5 \text{ y}) + (0.5 \text{ rem/y} \times 0.5 \text{ y}) = 0.75 \text{ rem/y}. \]

4. The following individuals must approve ACLs:

a. Facility or line manager: ACLs from 0.1 rem/y up to and including 0.5 rem/y.

b. Facility or line manager, and RCM: ACLs that exceed 0.5 rem/y.

c. Facility or line manager, and RCM, and work authorization program associate director (PAD): with written justification for ACLs that exceed 1.5 rem/y.

d. The LLNL Deputy Director for ACLs that exceed 2.0 rem/y. Approval of the appropriate Secretarial Officer or designee should be sought prior to allowing an individual to exceed 2 rem/y (RCS-2008 Change 1, 211).

3.2.3 Special Control Levels

There may be individual cases where it is appropriate to establish radiation dose limits below the occupational dose limits [e.g., for a worker undergoing medical treatment, or who has a lifetime occupational radiation dose (in rem) in excess of their age (in years)]. These dose constraints are referred to as ‘special control levels.’
1. Special control levels may be requested for an individual by the Authorizing Organization, the Radiological Control Organization, or the employee, but may only be imposed with the employee’s consent.
   a. Workers or supervisors with concerns about radiation exposure should contact a Radiological Control Organization health physicist, who can provide perspective on the risk of radiation exposure.

2. Health Services, working in conjunction with the Radiological Control Organization, must determine if a special control level is appropriate, and must issue (and rescind) any special control levels.
   a. A special control level for annual occupational exposure should be offered to each radiological worker with a lifetime occupational dose exceeding N rem, where N is the age of the individual in years. The special control level should allow the individual’s lifetime occupational dose to approach and, if practicable, fall below N rem during ensuing years as additional occupational dose is received.
   b. Special control levels should not be implemented in a manner that interferes with that individual’s right to work. If reasonable efforts to implement the special control level below 1 rem per year threaten to restrict the individual’s right to work or are otherwise unsuccessful, the RCM, the affected individual, and line manager should reassess the situation and determine a path forward that is within the regulatory dose limits and otherwise acceptable to the individual.
   c. Advice from professionals in other disciplines such as human resources and legal should be obtained when establishing special control levels.

3. The Authorizing Organization must ensure special control levels are effectively implemented.

3.2.4 Minors and Pregnant Workers

1. The ES&H Team health physicist must evaluate all radiological work that is to be performed by minors. Minors must only be permitted to perform tasks that are unlikely to result in doses exceeding the relevant limits shown in Table 2. If a minor is likely to receive an occupational dose in excess of 20 percent of the relevant limit (i.e., a dose in excess of 0.02 rem), the concurrence of the RCM is required prior to the initiation of work.

2. Visitors who are minors:
   a. May enter radiologically controlled areas (RCAs) so long as an adult who ensures compliance with LLNL’s rules and policies escorts them all times.
   b. May not enter radiological areas without the approval of the RCM.
   c. Must have the written permission of the RCM to handle the following quantities of radioactive materials.
— Items with accessible contamination exceeding the thresholds in Document 20.2, Appendix D.
— Class 0 or greater quantities of dispersible radioactive material, as defined in Document 20.2, Appendix E.
— Class 1 or greater sealed radioactive sources (SRSs), as defined in Document 20.2, Appendix E.

3. LLNS employees who are pregnant, or plan or suspect a pregnancy, are strongly encouraged to contact the HSD.
   a. HSD will:
      — Provide pregnancy-related information.
      — Interview the woman to determine the potential for occupational exposure to workplace hazards.
      — Issue a medical restriction limiting radiation exposure to 0.5 rem during the gestation period if the woman formally declares her pregnancy. (Medical restrictions written to protect the embryo/fetus are issued only after the woman voluntarily signs a ‘Declaration of Pregnancy’ form and is informed of the ramifications of the restrictions.) A medical restriction may also be issued to control exposure to other workplace hazards (e.g., chemical or physical hazards, such as working at elevation or in high temperature environments). A declared pregnant worker (DPW) may ‘undeclare her pregnancy’ at any time (thus removing the medical restrictions that are in place for the protection of the embryo/fetus).
      — Maintain written Declarations of Pregnancy, including the estimated date of conception, and revocations of Declarations of Pregnancy.
      — Notify the ES&H Team and the External Dosimetry Team of the medical restriction.
   b. The appropriate members of the ES&H Team must conduct a workplace evaluation; the health physics portion of the workplace evaluation is described in Appendix C. The workplace evaluation—which can be conducted on a confidential basis if requested by the employee—helps ensure the embryo/fetus is afforded maximum protection. At any time, the employee may direct that the medical restriction (and any associated work or workplace modifications) be rescinded by providing written notification to the HSD.

3.2.5 Provisions for Conducting Planned Special Exposures

1. A planned special exposure (PSE) is appropriate only in an exceptional situation when alternatives that might prevent a radiological worker from exceeding the DOE dose limits are unavailable or impractical.
   a. Doses received as a result of a PSE shall be included in the individual’s dosimetry record and dose reports, but shall not be included when controlling the individual’s future occupational dose or when assessing compliance with the annual dose limits.
b. LLNS (and the employer, if other than LLNS) must specifically request, in writing, DOE’s authorization for the PSE.

c. The DOE Headquarters program office and the Secretarial Officer responsible for environment, safety, and health matters must jointly approve the exposure, in writing.

d. LLNL must submit a written report within 30 days after the PSE to those approving the exposure.

2. Using Table 3 and the following procedure, the ES&H Team health physicist must determine the maximum dose an individual is eligible to receive as a result of the PSE. The RCM must concur with the analysis prior to the submission of the PSE request.

a. For both the current year and for the individual’s lifetime, and for each dose type (e.g., TED, skin, organ, eye), enter in Table 3:
   — Doses from all previous PSEs (Column A).
   — Doses in excess of the occupational dose limits, excluding doses listed in Column A (Column B).

b. Perform the subtractions as indicated in Column D.

c. For each dose type, the individual is eligible to receive the SMALLER dose type value listed in Column D.

3. Prior written consent shall be obtained from each individual designated to receive the PSE. The written consent shall include:

a. The purpose of the planned operations and procedures to be used.

b. The estimated doses and associated potential risks and specific radiological conditions and other hazards that might be involved in performing the task.

c. The individual’s dose limit for the PSE.

d. Instructions on the measures to be taken to keep the dose ALARA considering other risks that may be present.

4. The Authorizing Organization, with the assistance of the ES&H Team, is responsible for:

a. Generating and maintaining records of the conduct of a PSE.

b. Submitting a written report within 30 days after the PSE to the organizations that approved the exposure.

c. Ensuring a copy of the record is placed in the individual’s personnel dosimetry file (maintained by the External Dosimetry Team), although the dose from a PSE is not to be considered in controlling the worker’s future occupational dose.
3.2.6 Provisions for Authorizing Emergency Doses

Provisions for exceeding the normal occupational dose limits in response to an emergency exposure situation are described in Document 22.6 in the ES&H Manual. Emergency doses and PSEs shall be accounted for separately and must be maintained in each person’s personnel dosimetry file.

Table 3. Determination of PSE Dose Limits

<table>
<thead>
<tr>
<th>Type of Dose*</th>
<th>(A) Doses from previous PSEs (rem)</th>
<th>(B) Doses in excess of the occupational dose limits (rem)</th>
<th>(C) PSE Dose Limit (rem)</th>
<th>(D) Dose allowed for this PSE (C)-(A)-(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Year</td>
<td>TED:</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skin:</td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Organ (specify):</td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eye:</td>
<td></td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Lifetime</td>
<td>TED:</td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skin:</td>
<td></td>
<td>250</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Organ (specify):</td>
<td></td>
<td>250</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eye:</td>
<td></td>
<td>75</td>
<td></td>
</tr>
</tbody>
</table>

* Written estimates must not be used as a basis for authorizing PSEs or emergency exposures.

3.3 Monitoring and Reporting Individual Doses

3.3.1 Internal Doses

Requirements for internal dose monitoring are contained in Document 20.2.

3.3.2 Monitoring External Doses with Dosimeters

LLNL uses several types of thermoluminescent dosimeters (TLDs) to measure external radiation doses. Appendix D contains information about the types of dosimeters used at LLNL, the requirements for their use, appropriate exchange frequencies, and the dosimeter results notification protocol.

1. The External Dosimetry Team must:
a. Maintain Department of Energy Laboratory Accreditation Program (DOELAP) accreditation for LLNL’s personnel dosimetry system.

b. Develop and maintain a technical basis document for the external dosimetry program. The technical basis document must:
   - Be consistent with DOE-STD-1095-11 (or approved revisions thereof), which specifies the requirements for accreditation of personnel external dosimetry monitoring programs by DOELAP.
   - Document that the external dosimetry program is adequate to demonstrate compliance with the dose limits shown in Table 2.
   - Address dosimeters used for monitoring radiation outside the scope of DOELAP, such as dosimetry associated with high-energy accelerators and extremity neutron dosimeters.
   - Describe the methodology used in determining the dose of record when multiple dosimeters are used and when dosimeters are relocated.

c. Provide routinely-exchanged dosimeters to LLNL staff, as required.

d. Provide dosimeters as needed for non-routine issuance to staff and visitors.

e. Determine the dose on the dosimeter and maintain dose records as specified in Section 3.3.5.

2. LLNL workers (including subcontractors) must:

a. Wear the radiation dosimeter(s) prescribed by the ES&H Team health physicist and exchange their dosimeter promptly when a new dosimeter is received (typically via Lab mail). Figure 1 shows an exploded view of a dosimeter packet. Figure 2 shows how the dosimeter packet should be configured with the security badge and other cards that may be carried.

b. Wear LLNL-issued dosimeter packets (i.e., the dosimeter in the dosimeter holder with the plastic flap bearing the LLNL logo) as follows:
   - Only by individuals knowledgeable of their proper use.
   - Facing out on the upper part of the body and not covered by other materials (including plastic cards) other than anti-contamination (anti-C) clothing.
   - Only by the person to whom it was issued.
   - Only at LLNL, or as specified in the Integration Work Sheet (IWS) or other work control document.

c. Promptly notify the ES&H Team or the External Dosimetry Team if the dosimeter is:
— Exposed to nonoccupational sources of radiation (e.g., airport X-ray machines, dental X-rays, or medical procedures), excessive heat, or moisture.

— Lost, damaged, or contaminated. In such cases, the worker must place radiological work in a safe condition, immediately exit the area, and report the occurrence to the ES&H Team. The individual must be restricted from entry into radiological areas until a review has been conducted to verify that dose limits have not been exceeded if there is a possibility of an unmonitored exposure exceeding 0.1 rem, or if the individual is within 0.1 rem of any exposure limit or level.

d. Not wear their LLNL dosimeter at other facilities that have a dosimetry program accredited under the DOELAP (e.g., Los Alamos National Laboratory, NNSS) or the National Voluntary Laboratory Accreditation Program (NVLAP) unless authorized by the LLNL RCM. If a dosimeter is needed, the host facility or the sponsoring agency is responsible for supplying the dosimeter to the individual and providing the dose of record to LLNL.

— The individual wearing the dosimeter is responsible for providing the host with the name and address of their employer (LLNS).

— If an organization outside of DOE [e.g., International Atomic Energy Agency (IAEA), NRC] provides the dose of record directly to the employee, the employee must provide a copy of the report to the External Dosimetry Team within 30 days of its receipt for inclusion in the employee’s dosimetry record.

3. Visitors:

a. Must wear an LLNL-issued dosimeter if either

— Authorized to conduct radiological work, including handling radioactive material or using radiation-generating devices.

— Entering a posted Radiation Area.

b. Must return their dosimeter at the end of their visit or six months after it was issued, whichever is shorter.

c. May wear their company-issued dosimeter in addition to their assigned LLNL-issued dosimeter if their company requires them to do so (e.g., industrial radiographers operating under a state license).

d. Are exempt from the 'TLD required' indication on the access postings to a Radioactive Materials Area (RMA), RGD Area, Contamination Area, and Buffer Area.

4. The RCM must authorize:

a. Use of alternate dosimeters at LLNL.

b. Not wearing a dosimeter (e.g., following medical administrations of radioactive material) where it is otherwise required.
c. The use of LLNL dosimeters at other U.S. sites that have a DOELAP or NVLAP accredited dosimetry program.

5. The ES&H Team health physicist must:
   a. Determine the types of dosimeters that are required and the appropriate dosimeter exchange cycle for:
      — Work to be conducted onsite at Site 200 and Site 300.
      — Off-site work within the United States where there is no ‘host facility’ or the host facility does not have a DOELAP or NVLAP accredited dosimeter program.
   b. If other than a semi-annually exchanged Panasonic 802 whole-body dosimeter is warranted, enroll workers in the appropriate monitoring protocol using the guidelines in Appendix D.
   c. Assign a ‘specially issued’ whole-body dosimeter for non-U.S. work where there is no established dosimetry program, or as discussed in Section 3.3.4, Monitoring Considerations for Non-U.S. Travel.
   d. Document the requirements for dosimeters (other than the routinely issued whole-body dosimeters) in the applicable work control documents (e.g., IWS, work permits).
   e. Conduct a dose assessment for worn and lost, damaged, or contaminated dosimeters as requested by the External Dosimetry Team and documented on the Exposure Investigation Report.
   f. Issue multiple dosimeters to individuals to assess effective dose in non-uniform radiation fields.
      — Non-uniform radiation fields exist when the dose to a portion of the whole body will exceed the dose to the primary dosimeter by more than 50 percent and the anticipated whole-body dose is greater than 0.1 rem.
      — When the radiation field is well characterized and the worker’s orientation is known, relocation of the primary dosimeter is permitted in lieu of issuance of multiple dosimeters. Under such conditions, the individual’s dosimeter must be relocated to the portion of the whole body likely to receive the highest dose.
      — Dosimeter relocation must be conducted in conformance with facility procedures or specific work control documents, such as IWSs or radiation work permits (RWPs).

6. The Authorizing Organization must ensure workers properly wear and exchange the prescribed dosimeters and adhere to the provisions of any radiological work restrictions.
3.3.3 Supplemental Dosimeters

Pocket and electronic personal dosimeters (EPDs) are supplemental dosimeters that provide real-time indication of exposure to radiation and assist in maintaining personnel doses less than the ACL. Electronic dosimeters provide an early warning of elevated exposure through the use of alarm set points at specified dose rates or integrated doses; alarming supplemental dosimeters are preferable to non-alarming supplemental dosimeters and should be used when feasible.

1. Individuals entering a high radiation area shall be monitored by a supplemental dosimeter or other means of determining the individual’s effective dose during the entry. Use of an electronic dosimeter is preferred.

2. Individuals must also wear a supplemental dosimeter when:

   a. Planned activities are likely to result in an individual dose exceeding 0.05 rem or 10 percent of the ACL from external gamma radiation in 1 work day (whichever is greater).

   b. Individual doses are expected to be greater than 100 millirem in 1 work day.

   c. Required by a work control document.
3. Supplemental dosimeters must be worn simultaneously with the primary dosimeter and located on the chest area, on or between the waist and the neck, or in the manner prescribed by radiological control procedures or work control documents.
   a. Where both TLDs and pocket or electronic dosimeters are worn simultaneously, the TLD shall provide the dose of record, unless a formal dose assessment indicates otherwise.
   b. The ES&H Team health physicist should conduct an exposure investigation if the supplemental dosimeter result differs by more than 50 percent from the primary dosimeter result, and the primary dosimeter result is greater than 0.1 rem.
   c. EPDs are self-scaling and therefore useful over a broad dose range; other pocket dosimeters should be selected with the lowest range applicable (typically 0-200 mR) for anticipated personnel exposures.

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

5. Work must be stopped and the ES&H Team must be consulted prior to continuation of work:
   a. When a supplemental dosimeter reading indicates a total dose or rate of exposure substantially greater than planned.
   b. If the supplemental dosimeter is off-scale or not functioning correctly.

6. The ES&H Team health physicist must consider the energy dependence and radiation sensitivity of supplemental dosimeters, particularly to low-energy beta and neutron radiation, when determining their applicability. EPDs may be sensitive to gamma radiation, neutron radiation, or both; other pocket dosimeters are typically only sensitive to gamma radiation. Supplemental dosimeters are not required where they are incapable of monitoring the radiation of concern.

3.3.4 Monitoring Considerations for Non-U.S. Travel

LLNL work may require individuals to work in non-U.S. facilities in a wide variety of locations, capacities, and conditions. LLNL’s goal is to assure, to the extent possible, that workers at such non-U.S. facilities are provided a standard of care similar to what they would receive if conducting similar work in the U.S. Although the host facility is responsible for providing visitors with appropriate monitoring and personal protective equipment (PPE) and for reporting any assessed doses, LLNL must ensure that LLNL workers are appropriately monitored while conducting work. Therefore, in some situations, it may be prudent for LLNL to supplement the monitoring provided by the host facility. Supplemental monitoring may include wearing an LLNL-issued dosimeter or participating in a pre- or post-trip bioassay program (which typically involves urinalysis, whole-body/lung counting, or both).
The decision to provide supplemental monitoring for an individual or group of individuals working in a non-U.S. facility involves judgment and estimates of known and projected exposures.

1. The RI should:

   a. Use the guidelines on the Foreign Travel Health & Safety web page to determine whether travelers should contact their ES&H Team health physicist regarding upcoming or just-completed non-U.S. travel.

   b. Contact the ES&H Team health physicist if there is any concern about unmonitored internal or external doses, or if the work involves being in a room or area where:

      — Gram quantities of plutonium are stored or processed.
      — kg quantities of uranium are stored or processed.
      — Curie quantities of a radioactive material are handled.
      — Radioactive material is processed in a glovebox.
      — Respirators are worn, whether required or not.
      — Dispersible (i.e., dusty or flaky) radioactive material is handled in an open area.
      — Dust, smoke, or fire involving radioactive material or contaminated equipment exists.
      — An accidental spread of surface or airborne contamination has occurred.
      — An evacuation, fire, criticality, airborne, or other alarm sounds.
      — An external dose of 0.050 rem (50 mrem) or an internal dose of 0.1 rem (100 mrem) [committed effective dose (CED)] is likely.
      — Open-beam RGD operations are occurring, or is conducted in close proximity to others who are operating X-ray or neutron-generating equipment.
      — Containers of uncontained dispersible radioactive material are opened while no respiratory protection is worn.

   c. Consider contacting the ES&H Team health physicist if the work involves:

      — Entry into areas posted with radiological warning signs.
      — Entry into areas where small to moderate quantities of radioactive materials are stored or processed (e.g., biomedical, chemistry, and radiation measurement laboratories).
      — Close proximity to others who are handling more than 1 µCi (37 kBq) of uncontained radioactive material.
      — Entry into areas where the dose rate exceeds 5 mrem/h (50 µSv/h).
      — Being in an area equipped with a radiation area monitor (RAM).
2. The ES&H Team health physicist must assist the Authorizing Organization in determining whether supplemental monitoring is needed and, if so, what type of monitoring is appropriate.

3.3.5 Dose Monitoring Records

1. The External Dosimetry Team shall maintain dose records, including records of zero doses, for each individual for whom required monitoring is performed.

   a. Individual monitoring records shall be sufficient to:
      
      — Identify each person.
      
      — Evaluate and demonstrate compliance with the dose limits in Table 2.

   b. Records shall include the following dose quantities:
      
      — Total effective dose.
      
      — Cumulative total effective dose.
      
      — Equivalent dose to the embryo/fetus of a declared pregnant worker.
      
      — Committed effective dose; committed equivalent doses to the affected organs and tissues; and identity of radionuclides and estimated intake.

   c. Records of an individual’s lifetime occupational dose should be maintained.

2. Records shall include doses received as a result of:

   a. Routine occupational exposures, including:
      
      — External doses to the extremity, skin, lens of the eye, and whole-body.
      
      — Internal doses to organs and the whole body.

      **Note:** Records of internal dose (committed effective dose or committed equivalent dose) are not required if the dose is less than 0.01 rem (10 mrem) committed effective dose; however, the bioassay or air monitoring result used to estimate the dose shall be maintained. The unrecorded internal dose estimated for any individual in a year shall not exceed the applicable monitoring threshold specified in **Document 20.2**, Section 3.2.2.

   b. Non-routine occupational exposures exceeding the Table 2 limits, including:
      
      — Unplanned exposures.
      
      — Planned special exposures.
      
      — Authorized emergency exposures.

   c. Exposure investigation reports, including (but not limited to) those resulting from:
      
      — Anomalous results (e.g., unexpected high or low doses).
      
      — Evaluations from lost or damaged dosimeters.
— Evaluations of non-uniform radiation doses.

**Note:** Records of non-uniform dose to the skin need not be retained in an individual's dose records if the dose is less than 1 rem.

— Unmonitored workers with unplanned doses exceeding the monitoring thresholds.

3. The Radiological Control Organization:

   a. Shall maintain the following records.

      — Applicable whole-body and lung counting results (including chest wall thickness measurement, where applicable).
      
      — Applicable urine, fecal, and specimen analysis results.
      
      — Results of monitoring (e.g., air monitoring) used to determine individual occupational doses from external and internal sources.
      
      — Procedures, data, and supporting information needed to reconfirm an individual's dose at a later date.

   b. Should maintain the following records.

      — Previous employment dose histories from other DOE and non-DOE facilities, as available.
      
      — Nuclear Regulatory Commission Form 4 or equivalent that documents previous occupational radiation doses.
      
      — Ongoing work history documenting work assignments and radiation doses; the facility and occupational codes defined in DOE 231.1 should be used for this process.

4. LLNS employees must provide the names and addresses of previous employers that have their occupational radiation dose records, as LLNL is required to obtain documentation of all occupational doses received during the current year when determining compliance with the dose limits.

   a. If the employee indicates that they received a positive dose during previous employment, LLNL shall make reasonable efforts (e.g., two written attempts) to obtain complete records of each individual’s prior year’s occupational dose and, upon receipt, shall enter the information into the LLNL database.

   b. If complete records cannot be obtained, a written estimate signed by the individual may be accepted to demonstrate compliance.

   c. Individuals may request their dosimetry records from the External Dosimetry Team or the ES&H Team health physicist.

5. Subcontractors are responsible for maintaining their employees’ total doses below the applicable dose limits. Therefore, LLNL does not request dose histories for subcontractor employees. LLNL does, however, report the dose of each subcontractor employee
directly to the subcontractor employee [if he or she has a mail stop (i.e., an L-code)] and to the subcontractor.

6. Dosimetry records, including detailed information, that are identified with a specific individual shall be readily available to that individual and to others (e.g., the individual’s supervisor, management, and safety personnel) on a need-to-know basis, consistent with the Privacy Act.

   a. Individuals who are monitored in accordance with the Rule shall be provided an annual dose report.

   b. Upon request, an individual shall be provided detailed information concerning his or her dose.

3.3.6 Dose Monitoring Reports

1. The External Dosimetry Team shall provide dose monitoring reports to individuals monitored in accordance with the Rule.

   a. An annual dose report shall be provided, whether or not a dose is received.

   b. A positive dose report must be provided within approximately 30 days of the dosimeter being read or the completion of an exposure investigation report, whichever is longer.

      — For non-LLNS employees, this dose report may serve as the annual report. If an individual visits a site or facility more than once in a year, then a report must be sent which sums the doses from all of the visits.

   d. Reports of individual doses shall include the site or facility name, the individual’s name and social security number, employee number, or other unique identification number, and all dose information required by Section 3.3.5.

   e. Upon request, a dose report shall be provided to an individual terminating employment.

      — The report should be provided as soon as the data are available, and shall be provided not later than 90 days after termination.

      — If requested, the ES&H Team health physicist shall provide a written estimate of the radiation dose received by that employee (based on available information) at the time of termination.

   f. Reports of radiation dose received at LLNL must be provided annually to DOE, consistent with DOE O 231.1B, Environment, Safety and Health Reporting, Annual Radiation Dose Summary. This report includes internal and external radiation dose results for monitored DOE and DOE-contractor employees, and for monitored members of the public.

2. The External Dosimetry Team must provide:

   a. Reports to the Radiological Control Organization, as follows.
— Monthly dose reports for individuals receiving a positive dose.
— Same-day dose reports for doses that exceed predetermined levels, as specified in Appendix D.

b. Reports to other monitored individuals (e.g., those monitored as a best-management practice) as directed by the RCM.

3. The ES&H Team health physicist must:
   a. Periodically (e.g., every one or two months) review individual positive dose reports and inform the RI of radiation workers who are approaching 0.1 rem for the year (e.g., have an accumulated dose exceeding 0.080 rem), if they do not have an ACL established.
   b. Periodically (e.g., every three or four months), provide the Authorizing Organization with graphs of each individual’s year-to-date dose relative to their ACL, if a positive dose has been recorded during the year. See the example in Figure 3.

Note:
— Graphs are not provided for ‘zero’ doses.
— Other mechanisms (e.g., spreadsheets) for relaying dose information may be used as agreed upon by the ES&H Team health physicist and RI.

   c. For facilities where ACLs are established, provide the Authorizing Organization with an annual report that includes a summary of:

      — Doses received, including collective and maximum individual doses.
      — Results of area monitoring.
      — Notable trends or ALARA issues.
4. Authorizing Organizations, working in conjunction with the ES&H Team health physicist, must:
   
a. Periodically evaluate the accumulated radiation dose for workers with ACLs and make necessary adjustments to ensure the individual’s ACL is not exceeded.
   
b. Periodically monitor collective dose accumulation and compare it with the pre-job dose estimate during the performance of jobs for which a pre-job dose estimate was made. Differences should be reviewed to identify causes and assess the need for corrective actions.
   
c. Evaluate and respond (as appropriate) to increasing dose, airborne, or contamination trends and other indicators that could be precursors to unnecessary dose (e.g., breaches in containment systems, personnel contamination events).

5. If LLNL is required to send a report to DOE concerning an individual’s exposure to radiation or radioactive material, that individual shall be provided a copy of the report at a time not later than the transmittal to DOE.

3.4 Posting and Labeling Requirements

An RCA is any area where access is managed to protect individuals from exposure to radiation or radioactive materials. Posting and labeling requirements specific to radioactive materials and RGDs are contained in Document 20.2 and Document 20.3.
3.4.1 General Posting Provisions

1. Posting, downposting, deposting, or altering signs containing the radiation trefoil symbol must only be done by, or under the direction of the Radiological Control Organization.
   a. Only postings approved by the RCM may be used to post RCAs. Signs may contain supplemental information. The RCM must ensure the posting requirements of 10 CFR 835 are met.
      — The radiation trefoil shall be black or magenta and imposed upon a yellow background.
   b. Postings and labels containing the radiation trefoil symbol must be defaced or destroyed prior to being disposed of in the municipal trash.
   c. Workers may dispose of contaminated items as radiological waste. Disposing of an item (e.g., a drape, photo tray) that has a ‘Contamination Area’ or a ‘Radioactive Material’ posting/label does not constitute ‘downposting.’

2. Workers shall obey posted signs.

3. Signs that contain the radiation trefoil symbol shall be used to post RCAs, as specified in this section.
   a. The affected area must be delineated with a barrier or barricade and the access posted so workers are aware of the area conditions.
   b. Posted Radiological Areas should be as small as practicable for efficiency.

4. Signs must:
   a. Properly characterize the hazard; that is, radiological postings must reflect actual or potential (expected) radiological conditions (e.g., do not post an RMA as a ‘contamination area’ just in case someone has a spill).
   b. Be posted as close to the hazard as practicable.
   c. Be mounted such that they can be easily removed or turned over in situations where the radiation environment changes frequently.
   d. Be maintained in a legible condition and updated based upon the results of the most recent surveys.
   e. Be located to enhance a worker’s ability to see the posting (e.g., at or near waist or eye level).
   f. Be clearly worded and conspicuously posted at the access point to the controlled area.
5. Postings at entrance points to areas of ongoing work activities controlled for radiological purposes should state basic entry requirements, such as dosimetry, PPE, RWP or other written authorization, and respiratory protection requirements.

   a. Work controls are typically more rigorous than access controls and are indicated in the work control document.

   b. Transient controls (e.g., ‘respirator required’) may be provided by means other than marking the routinely posted sign.

   c. 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 LIGHT IS ON.”

   d. Signs used for training should be clearly marked, such as “For Training Purposes Only.”

6. When posting access points to an area, the following apply:

   a. All access doors that can be opened from the outside shall be posted, even if the door remains locked. [This posting protects individuals such as Security Police Officers (SPOs), firefighters, and other emergency responders who may enter the area using master keys.] Individuals who allow others to access an area through such doors shall ensure those entering the area abide by the access control requirements.

   b. Doors that cannot be opened from the outside (e.g., highbay rollup doors or emergency exits out of the Plutonium Facility) are only considered access points if they are left open and unattended.

   c. Side-by-side doors do not have to be individually posted if it is obvious that both doors provide access to the same area and an appropriate sign is clearly and conspicuously posted.

   d. If more than one radiological condition (such as contamination and high radiation) exists in the same area, each condition shall be identified.

   e. Posting of doors must be such that the postings remain visible when doors are open or closed. **Note:** This provision applies to doors that are left open or closed; it does not apply to doors that are open only when someone is using it.

   f. Physical barriers must be placed so that they are clearly visible from all directions and at various elevations. Rope, tape, chain, and similar barriers used to designate the boundaries of posted areas

       — Should be distinctive (i.e., yellow and magenta or yellow and black in color).
— Must not be easily walked over or under, except at identified access points. That is, these types of barriers should be placed at a height that is between the knees and shoulders for most adults.

7. Posting requirements may be waived for periods of less than 8-continuous hours when the area is placed under the continuous observation and control of an individual knowledgeable of, and empowered to implement, required access and exposure control measures. Such individuals should be stationed to provide line of sight surveillance and verbal warnings.

8. Detailed requirements for posting areas associated with radioactive materials (i.e., Radioactive Materials Area, Radiological Buffer Area, and contaminated radiological areas) are provided in Document 20.2. Detailed requirements for posting areas and equipment associated with radiation generating devices are provided in Document 20.3.

3.4.2 Radiologically Controlled Areas

An RCA is any area where access is managed to protect individuals from exposure to radiation or radioactive materials. RCAs shall be established and posted as follows to warn individuals that they are entering areas controlled for radiation protection purposes.

1. Each access point to an RCA that is not a Radiological Area shall be clearly and conspicuously posted with one or more of the following signs:

   — CAUTION Radioactive Materials Area.
   — CAUTION Radiological Buffer Area.
   — CAUTION Radiation Generating Device Area.
   — CAUTION X-ray Area. (Historically used; ‘Radiation Generating Device Area’ is preferred.)
   — CAUTION Accelerator Area. (Historically used; ‘Radiation Generating Device Area’ is preferred.)

2. Individuals who only enter RCAs without entering a Radiological Area are not expected to receive a whole-body dose exceeding 0.1 rem in a year.

3.4.3 Radiological Areas

1. Each access point to a Radiological Area shall be clearly and conspicuously posted with one or more of the signs listed below. (Definitions for these areas can be found in Appendix A.)

   — CAUTION Radiation Area.
   — CAUTION/DANGER High Radiation Area.
   — GRAVE DANGER Very High Radiation Area.
   — CAUTION Contamination Area.
   — CAUTION/DANGER High Contamination Area.
2. The ES&H Team health physicist must determine the appropriate heading (CAUTION or DANGER) for radiological area posting.
   a. CAUTION is the default heading for radiological areas.
   b. DANGER should not be used to post
      — High Radiation Areas with dose rates less than 1 R per hour when measured at 30 cm.
      — High Contamination Areas with contamination levels less than 1,000 times the removable contamination thresholds in Appendix D.
   c. DANGER must be used to post
      — High Radiation Areas with dose rates greater than 5 R per hour when measured at 30 cm if workers are likely to access the area when the radiation is present.
      — High Contamination Areas with levels likely to be greater than 10,000 times the removable contamination thresholds in Appendix D, and which have not been sufficiently characterized.
      — Airborne radioactivity areas with concentrations of more than 1,000 Derived Air Concentrations (DAC).

3. For accessible radiological areas (excluding work enclosures) with ongoing work activities, the dose rate and contamination level or range of each should be included in conjunction with the posting at the main access point if:
   a. The area contains one or more discrete radiological areas that cannot safely be individually delineated with a barrier or a barricade (e.g., around glove boxes, where barricades might prevent emergency egress).
   b. Dose rates or contamination levels vary significantly within the posted area.

4. Dose received in an hour may be used as the criterion for posting. Very high dose rates (such as those in Very High Radiation Areas) shall be recorded in units of “rads” rather than “rem” in an hour.

3.5 Access Controls

Access controls to areas posted with the radiation symbol include training (Section 7.0) and the controls listed in this section.

3.5.1 Radiological Areas

1. The Authorizing Organization shall maintain personnel entry control for each Radiological Area; the degree of control shall be commensurate with existing and
potential radiological hazards within the area. One or more of the following control methods shall be used:

a. Signs and barricades. *(Section 3.4)*

b. Control devices on entrances.

c. Conspicuous visual and/or audible alarms.

d. Locked entrance ways.

e. Administrative controls.

2. Controls that would prevent rapid evacuation of personnel under emergency conditions shall not be installed.

3. The number, issue, and use of keys must be strictly controlled where locked entryways are used to control access to High and Very High Radiation Areas.

**3.5.2 High Radiation Areas**

1. The following measures shall be implemented for each entry into a High Radiation Area:

   a. The area shall be monitored as necessary during access to determine the exposure rates to which the individuals are exposed. Hand-held radiation detectors should be used in addition to any installed RAMs because the area dose rates may vary significantly.

   b. In addition, each individual shall be monitored by a supplemental dosimetry device or other means capable of providing an immediate estimate of the individual’s integrated equivalent dose to the whole body during the entry as specified in *(Section 3.3.3)* and *(Appendix D)*. If a supplemental dosimeter is impractical or ineffective, the RCM may authorize other means (e.g., knowledge of the area exposure rate and tracking of individual access times) to provide an immediate estimate of an individual’s dose.

2. One or more of the following controls must be used for each access point to a High Radiation Area and shall be used for each access point to a High Radiation Area if an individual’s whole-body dose could exceed 1 rem in any one hour at 30 cm from the source or from any surface that the radiation penetrates:

   a. A control device that prevents entry into the area when high-radiation levels exist or that, upon entry, causes the radiation level to be reduced below that which defines a High Radiation Area.

   b. A device that functions automatically to prevent use or operation of the radiation source or field while individuals are in the area.

   c. A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the High Radiation Area and the supervisor of the activity are made
aware of the entry. The audible signal shall be of a frequency (or be capable of producing a sound-pressure level) that can be heard over background noise.

d. Entryways that are locked. During periods when access to the area is required, positive control over each entry is maintained.

e. Continuous, direct, or electronic surveillance that is capable of preventing unauthorized entry.

f. A control device that will automatically generate audible and visual alarm signals to alert personnel in the area of the intended use or operation of the radiation source in sufficient time to either evacuate the area or activate a secondary control device that will prevent use or operation of the source.

3.5.3 Very High Radiation Areas

In addition to the requirements in Section 3.5.2, the Authorizing Organization, working in conjunction with facility staff, shall implement additional measures to ensure individuals are not able to gain unauthorized or inadvertent access to Very High Radiation Areas.

3.5.4 Members of the Public

1. Members of the public should be continuously escorted in RCAs.

2. If members of the public complete appropriate radiological worker training, they may be granted unescorted access to RCAs if the following additional criteria are met:

   a. The RCM grants prior approval.

   b. Appropriate limitations are established on the areas to be entered and the activities to be undertaken to prevent exposure in excess of 0.05 rem/y (50 mrem/y).

   c. The individual receives enhanced training providing information commensurate with the areas to be entered and activities to be undertaken while unescorted.

3. Members of the public who are minors must be prohibited from entering Radiation Areas.

4. Members of the public must be prohibited from entering high radiation, very high radiation, high contamination, and airborne radioactivity areas.

5. Members of the public who are issued radiation dosimeters should be provided with the General Employee Radiological Training (GERT) pamphlet or equivalent. (The pamphlet is available online (via HS6001).)

6. Sign-in logs or other such documents may be used as radiation safety training and orientation records.
3.6 **Internal Audits**

LLNL shall conduct internal audits of the Radiation Safety Program to identify its strengths and weaknesses, areas of vulnerability, and potential noncompliances. The audits shall be conducted no less frequently than every 36 months and shall include examination of the radiological protection program content and implementation. LLNL’s internal audit process is managed by the RCM and is described in Appendix B.

1. Upon receipt of the Internal Audit report [which is to be entered into the issues tracking system (ITS) as a required self-assessment], LLNL line managers and supervisors must ensure the corrective actions resulting from 10 CFR 835-related deficiencies are entered into ITS and actions are completed. (See DES-0048 LLNL Assessment Program for more information.)

2. Each Principal Directorate must analyze (e.g., as part of their annual ES&H performance report) their set of 10 CFR 835-related deficiencies/issues for systemic, programmatic, or repetitive deficiencies/issues, and ensure corrective items are developed and tracked in ITS.

3.7 **Timeframes for Completing Required Tasks**

The Rule requires internal audits to be completed at least every 36 months, radiation training to be completed at least every 24 months, and accountable sealed radioactive sources to be inventoried and leak tested every 6 months. These timelines may be extended for up to 30 days to accommodate scheduling needs.

### 4.0 Radiological Design Criteria

#### 4.1 New or Major Modifications to Facilities

##### 4.1.1 Design Objectives

Contact the RCM for guidance if there is uncertainty about the applicability of the design objectives in this section. See Standard STD-1189-2008, Integration of Safety into the Design Process, for information on the procedures required for design of new nuclear facilities or major modifications of other facilities.

Document 20.2 contains design criteria that apply exclusively to radioactive materials; Document 20.3 contains design criteria that apply exclusively to RGDs.

1. During the design of new facilities or major modification of existing facilities, the following objectives shall be adopted. These objectives apply to new facilities and major facility modifications involving ‘real’ property (e.g., structural shielding, physical elements such as walls and mazes, and ventilation systems used to control exposure to radiation).
a. Personnel exposure from external sources of radiation shall be limited to 20% of the applicable limit (e.g., limited to a whole-body dose of 1.0 rem/y), taking into account radiation dose rates, radiation beam ‘on’ times, and worker stay times. For areas of continuous occupancy (2000 hours per year) and continuous exposure (i.e., beam ‘on’ time), this equates to a dose rate of 0.5 millirem per hour. For RGD operations where the beam ‘on’ time may be very limited, use of an hourly dose rate may be inappropriate (i.e., for RGDs, the design criterion is usually not 0.5 mrem/h).

b. The design objective for areas routinely occupied by non-radiological workers should be to maintain radiation doses ALARA below 0.1 rem (100 millirem) per year.

2. When designing shielding for facilities containing highly intense sources of radiation (e.g., radiography facilities), the following minimum requirements apply:

a. All shielding materials must be of assured quality, uniformity, and permanency.

b. Lead shields must be protected against mechanical damage and mounted in a manner that prevents cold-flow resulting from the shields’ own weight.

c. Provisions must be made to ensure that nails, rivets, or screws that penetrate shielding are covered to provide protection equivalent to that of an unpenetrated shield. Holes in shields (e.g., for pipes, ducts, conduits, louvers) must be provided with baffles to ensure that the overall protection afforded by the shielding is not impaired.

d. The lead equivalent of doors and observation windows of exposure rooms, cubicles, and cabinets must not be less than that required for the shield in which they are located.

e. Clearances around doors (e.g., between the door jamb and lintel) must be shielded to the level required for the door itself.

f. Joints at the floor and ceiling and utility and diagnostics penetrations (and other such openings) must be evaluated to minimize radiation streaming and leakage.

3. When designing shielding for personnel radiation protection, the radiation weighting factors in Table 4 apply. A neutron radiation weighting factor of 20 for conditions of unknown spectra, for design purposes, would be consistent with the most limiting neutron radiation weighting factor.

4. Facilities currently under construction must be evaluated and the above criteria applied where practicable.

5. See Appendix H for radiological design considerations for facilities and equipment.
Table 4. Radiation Weighting Factors\(^1\), \(w_R\)

<table>
<thead>
<tr>
<th>Type and Energy Range</th>
<th>Radiation Weighting Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photons, electrons and muons, all energies</td>
<td>1</td>
</tr>
<tr>
<td>Neutrons, energy &lt; 10 keV(^2, 3)</td>
<td>5</td>
</tr>
<tr>
<td>Neutrons, energy 10 keV to 100 keV(^2, 3)</td>
<td>10</td>
</tr>
<tr>
<td>Neutrons, energy &gt; 100 keV to 2 MeV(^2, 3)</td>
<td>20</td>
</tr>
<tr>
<td>Neutrons, energy &gt; 2 MeV to 20 MeV(^2, 3)</td>
<td>10</td>
</tr>
<tr>
<td>Protons, other than recoil protons, energy &gt; 2 MeV</td>
<td>5</td>
</tr>
<tr>
<td>Alpha particles, fission fragments, heavy nuclei</td>
<td>20</td>
</tr>
</tbody>
</table>

\(^1\) All values relate to the radiation incident on the body or, for internal sources, emitted from the source.

\(^2\) When spectral data are insufficient to identify the energy of the neutrons, a radiation weighting factor of 20 shall be used.

\(^3\) When spectral data are sufficient to identify the energy of the neutrons, the following equation may be used to determine a neutron radiation weighting factor value:

\[
w_R = 5 + 17 e^{\frac{-(\ln(2E_n))^2}{6}}, \text{ Where } E_n \text{ is the neutron energy in MeV.}
\]

### 4.1.2 Optimization Analysis

1. Optimization techniques, such as 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.

   a. For review and planning of major tasks involving higher collective doses, a detailed and documented evaluation should be performed.

   b. When reduction of dose, contamination hazards, or radionuclide release raises cost-effectiveness issues, the optimization methods described in this document shall be used in developing and justifying facility design and engineered controls.

2. When conducting optimization analyses, costs in the range lower than $200–1000 per person-rem reduction in collective dose over the life of the facility are generally considered optimized.

3. These numerical guides are consistent with the National Council on Radiological Protection and Measurements (NCRP) Report 127 (1998), “Operational Radiation Safety Program,” which recognizes that there are two potential types of detriment associated
with radiation exposure. NCRP refers to these components as the ‘alpha’ and ‘beta’ components.

a. ‘Alpha’ refers to fatal and nonfatal cancers and birth defects.

b. ‘Beta’ refers to social factors and possible health detriments that reflect such factors as anxiety over individual levels of dose, uneven distribution of doses, the perceived risks of the doses, and concern on the part of management when individual doses are significant fractions of authorized limits.

4. Whereas the NCRP does not espouse a specific numerical value, it references the International Commission on Radiological Protection (ICRP) numerical values, which suggest a value of $20,000 per person-Sv (i.e., $200 per person-rem averted) for the ‘alpha’ component, and variable values for the ‘beta’ component, based on the level of dose a person receives.

5. The optimization value of $200–1000 per person-rem reduction in collective dose over the life of the facility includes both the alpha and beta components. See Table 5.

a. If individual doses are expected to be less than 0.5 rem, the optimization value should be approximately $200 per person-rem averted.

b. If individual doses are expected to be between 1.5 and 5 rem, the optimization value should be approximately $1000 per person-rem averted.

c. In all cases, the impact of other occupational hazards must also be considered when optimizing worker radiation dose.

<table>
<thead>
<tr>
<th>Dose Range</th>
<th>Alpha Component</th>
<th>Beta Component</th>
<th>Total Optimization Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.5 rem</td>
<td>$200</td>
<td>$0</td>
<td>$200</td>
</tr>
<tr>
<td>0.5 rem – 1.5 rem</td>
<td>$200</td>
<td>$400</td>
<td>$600</td>
</tr>
<tr>
<td>1.5 rem – 5 rem</td>
<td>$200</td>
<td>$800</td>
<td>$1000</td>
</tr>
</tbody>
</table>

6. For example:

a. If adding 6 inches of concrete to the walls of a facility would cost $50,000 and reduce the anticipated collective dose by 10 rem over the life of the facility, the additional cost would not be justified.

   — $50,000/10 rem = $5000/rem saved, which exceeds the guideline of $1000/rem saved.

b. If the same amount of concrete will save 100 rem, the cost would be justified:
— $50,000/100 \text{rem} = $500/\text{rem} \text{ saved}, \text{ which is within the guideline range of}$ $200–1000/\text{rem saved}.

7. The Authorizing Organization must use the guidelines in Table 5 to determine the optimized value of averted dose.

4.2 Design/Control Considerations for Existing Facilities

4.2.1 Office Spaces/Lunch Rooms in Radiological Areas

1. Existing facility designs that have office space and lunchrooms or eating areas within radiological areas require priority attention. Generally:
   
   a. Lunch rooms or eating areas, restrooms, drinking fountains, showers and similar facilities and devices must not be located within these areas.
   
   b. Office spaces must not be located within these areas; to the extent that such space is essential to support radiological work, steps should be taken to preclude unnecessary occupancy.

4.2.2 Temporary Shielding

1. Shielding with the following general characteristics must be considered ‘temporary shielding:
   
   a. Shielding that is needed for a period of 6 months or less.
   
   b. Shielding that is not physically secured to the facility or equipment (i.e., it is not affixed or otherwise an integral part of the existing shielding).

2. When using temporary shielding to minimize or prevent exposure in high radiation areas:
   
   a. The installation, use, and removal of the temporary shielding must be controlled by postings or procedure or the work control document (e.g., the IWS, Safety Plan [SP]).
   
   b. The effects of the additional weight of temporary shielding on systems and components must be evaluated and established to be within the design basis prior to installation.
   
   c. Installed temporary shielding must be periodically inspected and surveyed to verify effectiveness and integrity.
   
   d. Installed temporary shielding must be periodically evaluated to assess the need for removal or replacement with permanent shielding.
   
   e. Radiation surveys must be performed during the alteration or removal of installed temporary shielding, as appropriate.
   
   f. Removable shielding needed to prevent access to a high radiation area must be visibly marked or labeled with the following or equivalent wording: “Radiation Shielding - Do Not Remove without permission from the Radiological Control Organization.”
5.0 Work Planning

5.1 General Work Planning Provisions

1. The Authorizing Organization shall:
   
   a. Incorporate the radiological design criteria specified in Section 4.0 when designing or making major modifications to radiological and nuclear facilities.
   
   b. Develop and implement administrative control and procedural requirements as necessary to supplement facility design features, particularly when the design of existing facilities is not in accordance with current standards. Administrative control procedures include, but are not limited to, access control measures, work control documents, and technical work documents.
   
   c. Ensure that, during routine operations, anticipated occupational dose is kept ALARA and below the dose limits shown in Table 2 by implementing a combination of engineered controls; workplace monitoring; administrative controls (e.g., plans, procedures, training, and signs); and PPE (e.g., lab coats, gloves, respirators).

      — Engineered controls (e.g., confinement, ventilation, remote handling, shielding) shall be the primary method of reducing exposures in RCAs to ALARA.
      
      — For specific activities where use of engineered controls is demonstrated to be impractical, administrative controls shall be used to maintain radiation doses ALARA. Administrative controls shall be employed only as supplemental methods to control radiation exposure.
      
      — PPE provides a third tier of radiological control.
      
      — The ES&H Team must concur with the design decisions if administrative controls or PPE are to be implemented in place of engineered controls.

2. The Authorizing Organization must:

   a. Consider the guidance in Appendix G, Design Considerations for Facilities and Equipment, when designing or modifying facilities and equipment associated with radiological operations.

   b. Utilize the ES&H Team health physicist in the early planning phases to

      — Assist in the design process if designs or modifications to designs of equipment, components, instrumentation, and facilities could impact personnel radiation exposure, control of contamination, or airborne radioactivity. The health physicist’s early and ongoing participation will help ensure that radiological considerations are integrated into the design, construction, proposed operating procedures, and plans for decommissioning.
— Determine which design features in Appendix G need to be considered and incorporated, and which do not. Additional design items may need to be considered based on the design of a new or modified operation or facility.

c. Conduct and document a formal ALARA review for facilities and equipment (as specified in Appendix H) if any of the following conditions exist:

— A radiological or nuclear facility is being designed, or a major modification is being made therein, and the radiological aspects of the facility are impacted.

— Facility-supported systems (e.g., ventilation, retention) will be impacted by planned radiological operations.

— The Authorizing Organization, the RCM, or the ES&H Team indicates a formal radiological review is warranted.

d. Conduct and document a formal ALARA Job/Experiment/Task (JET) review (as specified in Appendix I) if any of the following conditions exist:

— The collective dose from an operation is likely to exceed 1 person-rem in a year.

— The predicted airborne radioactivity concentrations in areas accessible to individuals are expected during routine operations to exceed

(1) 10 times the applicable DAC value(s).

(2) 40 derived air concentration-hours (DAC-h) in a year.

— The removable contamination on accessible surfaces (outside of designated work enclosures) is greater than 1000 times the values in Document 20.2 Appendix D.

— Entry is required into areas where dose rates exceed 1 rem/h.

— Operational releases of radioactive material [other than incidental levels and permitted releases by Radiological and Hazardous Waste Management (RHWM)] to the environment are likely.

— The Authorizing Organization, the RCM, or the ES&H Team indicates a formal ALARA JET review is warranted.

e. Ensure radiological design features identified during the ALARA JET review are reflected in the job plans, procedures, or work packages.

3. With the concurrence of the Authorizing Organization, the ES&H Team Leader, and the RCM, an ALARA engineer may carry out specifically identified responsibilities that are otherwise assigned to the ES&H Team health physicist.

4. The Authorizing Organization must ensure that hazards are adequately analyzed during the planning phase and that the required safety controls and hold points/suspension points are integrated into the operation and the IWS/SP and other work control documents.
5.2. Written Authorizations and Technical Work Documents

5.2.1 General provisions

1. The Authorizing Organization shall develop and implement written plans and procedures (e.g., IWSs, SPs and operating procedures) as necessary to ensure compliance with the Rule. These plans and procedures shall be commensurate with the radiological hazards created by the activity and consistent with the education, experience, training, and skills of the individuals exposed to those hazards.

2. The Authorizing Organization must, with support from the ES&H Team, review work plans and procedures to identify and incorporate radiological control requirements, such as engineered controls and dose and contamination reduction considerations.
   a. Planning for radiological work should also include consideration of other workplace hazards (e.g., industrial hygiene, chemical safety, fire safety, electrical safety, and the like), consistent with the principles of ISM as required by 10 CFR 851, Worker Safety and Health Program.
   b. An integrated set of controls for all hazards (e.g., radiological, chemical, and physical) should be developed from this review.
   c. For routine tasks, such as surveillance, tours, and minor maintenance, performance of the above review and documentation of identified radiological protection requirements may be conducted as part of the IWS/work control process.
   d. Documents that identify radiological hazards and associated controls require the written concurrence of a Radiological Control Organization health physicist.

5.2.2 Written Authorizations

1. A written authorization shall be used:
   a. For handling or storage of radioactive material, as specified in Document 20.2.
   b. For use of RGDs, as specified in Document 20.3.
   c. To control entry into and to perform work within Radiological Areas (e.g., Contamination/High Contamination Areas, Airborne Radioactivity Areas, Radiation/High Radiation Areas).
   d. For any minor who handles class 0 or greater quantities of radioactive material, operates an RGD, or works in an area where he/she is likely to receive 20 percent of the allowable dose limit for a minor (see Table 2 and Section 3.2.3).

2. The written authorization shall specify radiation protection measures commensurate with the existing and potential hazards, which shall be documented.
   a. Written authorizations may include an IWS or an IWS/SP; an RWP; technical work documents; administrative procedures; and other work control documents.
b. If work is to be conducted in a Radiological Area, the written authorization must document that workers may be exposed to, or expected to work in, a Radiation/High Radiation Area, Contamination/High Contamination Area, or Airborne Radioactivity Area (as appropriate).

c. Hold points and suspension points must be clearly identified.
   — Hold points are specific conditions or steps in a process where a decision must be made prior to continuing work. In addition to the hold point, the work control document must specify the required response. ES&H Team involvement and documentation is required only if specified in the work control document.
   — Suspension points must be included for work in High Radiation Areas, High Contamination Areas, and Airborne Radioactivity Areas (which have no defined upper limit).

d. The written authorization should specify the following, if needed for radiological control:
   — PPE requirements.
   — Health and Safety Technologist coverage.
   — Job specific surveys [performed by the Health and Safety Technologist/Radiological Control Technician (RCT)].
   — Job specific monitoring [performed by radiological workers].
   — Contamination controls.
   — Dose minimization controls.
   — Hold points/suspension points, if needed to ensure work controls remain adequate.
   — Dosimetry requirements, other than routinely provided whole body dosimeters.

3. When radiological work is to be conducted by a subcontractor, the LLNL Radiation Work Permit for Subcontractors/Visitors must accompany the Procured Work Services document.
   a. This form does not negate the need for other work control documents (e.g., operating procedures, SPs); however, it does allow for Subcontractor-provided procedures and supplies (e.g., instrumentation, respirators).
   b. This form is not required for subcontracts specifying that LLNL will provide comprehensive radiological controls (e.g., work control documents, training, and monitoring).

4. Radiological training requirements must be clearly identified for each individual conducting radiological work.
   a. Use of the e-IWS for linking specific workers to specific courses is the preferred method of course identification.
b. Use of a training implementation matrix is acceptable if individual workers and specific courses are identified. It is not sufficient to identify a group of workers (e.g., ‘glove box users’) as needing a specific course.

c. A worker qualification program [e.g., (RCT), Radiation Zone Worker I (RZW-I)] may be used in lieu of listing specific courses for a worker if
   — The courses required for the qualification are clearly identified and meet the applicable radiation safety training requirements specified in Section 7.2.
   — Individuals with the qualification are clearly identified.
   — A mechanism is in place to ensure the worker maintains the qualification.

5.2.3 Radiological Work Evaluations

1. When developing work control documents (e.g., an IWS, SP, or other work control document), the Authorizing Organization must work with the ES&H Team health physicist and use a graded approach to:
   a. Ensure radiological hazards are adequately analyzed, taking into account lessons learned from previous or similar operations and worker errors that could result in significant amounts of unnecessary dose.
   b. Identify engineered and administrative dose reduction measures needed to ensure control of radioactive material and keep doses ALARA, taking into account normal operations and anticipated off-normal conditions. Such measures may include (but are not limited to) using tools, shielding, and PPE (including respirators); minimizing time in Radiological Areas; maximizing distance from radioactive sources; monitoring stay-times, incorporating additional ventilation controls.
   c. Determine whether individuals in the work group are likely to exceed 0.1 rem/y from the operation. If so, establish ACLs as specified in Section 3.2.2.
   d. Prior to initiating radiological work with potential high-consequences, conduct a pre-job briefing as specified in Section 6.1.
   e. Provide enhanced line and ES&H oversight during the initiation and conduct of radiological work with potential high-consequences.

2. When reviewing work control documents (e.g., an IWS, SP, or other work control document), the ES&H Team health physicist must use a graded approach to verify:
   a. Radiological hazards are appropriately characterized.
   b. Appropriate radiological controls are integrated into the document.
   c. Workers are enrolled in appropriate dosimetry/monitoring programs.
   d. An appropriate workplace is identified for the operation.
   e. Unique posting or labeling requirements are specified.
f. Area monitoring requirements are incorporated in the HP-DAP, consistent with the requirements in Documents 20.2 and 20.3.

5.2.4 Consideration of Nonradiological Hazards

1. Implementation of a radiation safety control may introduce unintended consequences that extract a cost and may negatively impact the overall safety of the operation. For example:
   a. Excessive PPE used to control dose or personnel contamination events may have deleterious consequences, such as heat stress and ergonomic impacts.
   b. Respirators used to reduce intakes of radionuclides may impair visual acuity and communications capabilities among workers.
   c. Protective clothing and equipment used to protect workers from chemical hazards may slow down work, leading to increased worker dose.

2. An integrated approach (i.e., one that considers radiological, industrial, physical, and chemical hazards) must be used during the work planning process to ensure that all occupational hazards are appropriately considered and the ALARA process is followed. Efforts to maintain radiation doses as low as reasonably achievable should not disproportionately increase the risk of personnel injury from other hazards.

3. The Work Planning Team must ensure the ES&H Team disciplines provide an integrated, balanced set of safety recommendations to the Authorizing Organization.

5.2.5 Technical Work Documents

1. Technical work documents, such as procedures, work packages, or job or research plans, must be used to control hands-on work with radioactive materials and radiation generating devices.
   a. Technical work documents must be clear and accurate.
   b. Requirements for incidental or routine work activities that involve a low potential of worker exposure or workplace contamination, such as the collection of trash or used protective clothing, should be established in generally applicable procedures.
   c. Technical work documents used to control radiological work activities should be reviewed and concurred on by the ES&H Team health physicist.
   d. The work control document (e.g., the IWS or IWS/SP, work permit) is sufficient for recurring activities and ongoing work where the hazards are well-characterized and ‘skill of the craft’ is sufficient to provide worker safety and an acceptable level of programmatic risk.

2. In addition to the work control document, the Authorizing Organization must develop detailed technical work documents if:
a. Potentially high-consequence radiological work is involved (e.g., if workers could be potentially overexposed or unacceptable equipment/facility contamination could result) and the process or operation is infrequently conducted such that competence training (i.e., skill of the craft) cannot assure adequate implementation.

b. Needed to document the approved method to implement specific processes or operations.

c. The ES&H Team indicates a more detailed technical work document is warranted. For example, if a highly contaminated glovebox is to be moved from one location to another, it is imperative that safety measures are in place and certain aspects of the operation occur before others (e.g., that temporary ventilation control is provided before the glovebox is removed from the house ventilation system). Detailed work control documents (e.g., work permits) may be used to accomplish the specific steps of the overall operation; however, an umbrella procedure must be used to tie the individual work control documents together and ensure sequence-critical portions of the overall operation occur in the correct order.

3. The Authorizing Organization must identify operations that require technical work documents other than the IWS or IWS/SP and must work with the ES&H Team to ensure that appropriate procedures are written and implemented.

5.2.6 Prestart and Readiness Reviews


6.0 Conducting Routine Radiological Work

6.1 General Information

6.1.1 Pre-Job Briefings

1. At a minimum, pre-job briefings must be held prior to the conduct of work that requires a formal ALARA JET review as specified in Section 5.1.

2. At a minimum, the pre-job briefing should include:

   a. Scope of work to be performed.

   b. Radiological conditions of the workplace.

   c. Requirements in technical work documents (e.g., the IWS/ RWP, operating procedures).

   d. Special radiological control requirements.
e. Radiologically limiting conditions, such as contamination or radiation levels that may void the IWS/RWP.

f. Radiological control hold points.

g. Stay-time restrictions.

h. Communications and coordination with other groups.

i. Provisions for housekeeping and final cleanup.


3. Attendance at the initial pre-job briefing must be documented. This documentation should be maintained with the document that authorizes the work.

   a. Pre-job briefings should be conducted by the cognizant work supervisor or other individuals familiar with the work to be performed and the required controls.

   b. Pre-job briefing topics should be documented, if different than above.

   c. Workers and supervisors directly participating in the job, cognizant radiological control personnel, and representatives from involved support organizations should attend the briefing.

6.1.2 Stop Work Authority

1. Stop work authority must be exercised in a justifiable and responsible manner.

2. Document 2.1, “General LLNL Worker ES&H Responsibilities,” in the ES&H Manual contains general 'stop work' provisions. Resumption of radiological work stopped because it is ‘imminently dangerous’ or ‘substantially dangerous’ requires the written approval of the AI and the concurrence of the RCM.

3. The Radiological Control Organization, the Authorizing Organization, and any worker through their supervisor have the authority and responsibility to informally stop 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.

4. Once radiological work has been stopped, it must not be resumed until proper radiological control has been reestablished. Resumption of work following informal work stoppages requires the concurrence of the Authorizing Organization and the ES&H Team health physicist.
6.2 Monitoring the Work Environment

6.2.1 Routine, Documented, Radiation Monitoring Programs

Workplace monitoring provides a basis for posting and labeling, development of work control documents, implementation of ALARA measures, issuance of individual monitoring devices, and verification of the efficacy of design measures and engineered controls.

1. The Radiological Control Organization must establish, document, and implement a routine radiological workplace monitoring program that is sufficient to meet the provisions in this sub-section.

   a. The routine survey/monitoring program for radiation, contamination, and airborne radioactivity must be documented in the facility-specific HP-DAP. The HP-DAP must be updated as needed to ensure the adequacy of sampling survey/monitoring programs as facility or operational changes affecting radiological control are implemented.
      
      — Surveys should include a sufficient number of survey points to characterize the area and to verify boundaries.
      
      — Survey frequencies should be established based on potential radiological conditions (i.e., considering the type and amount of material to be handled and the type of work involved [e.g., machining, wet chemistry, or dry chemistry, probability of change in conditions], and area occupancy factors). The minimum frequency for conducting radiological surveys is shown in Table 6.
      
      — Survey records must include sufficient detail to permit identification of the original survey and sampling locations and must be recorded on standard forms approved by the Radiological Control Organization.

   b. In the absence of such changes, the HP-DAP should be reviewed annually and updated as needed.

   c. The ES&H Team technologist supervisor or health physicist must review the records to ensure that the required surveys have been performed and that the documentation is accurate and complete.

   d. Survey data for each building or area should be compiled and reviewed by the ES&H Team at least quarterly. Changes or trends should be noted and corrective actions assigned, if appropriate.

2. Surveys/monitoring of work areas shall be performed to:

   a. Demonstrate compliance with the Rule.

   b. Document radiological conditions.

   c. Detect changes in radiological conditions.
d. Detect the gradual buildup of radioactive material.

e. Verify the effectiveness of engineered and process controls for containing radioactive materials and reducing radiation exposure.

f. Identify and control potential sources of individual exposure to radiation and radioactive materials.

g. Determine exposure rates during each entry to a high or very high radiation area.

3. The minimum survey frequencies in Table 6 must be implemented for routine radiological surveys, subject to the following provisions.

a. These surveys are intended to detect gradual changes in the workplace and to ensure areas are properly posted.

— The ES&H Team health physicist may specify more frequent surveys in the HP-DAP as appropriate, depending on operational issues.

— In “active” contamination and radiation areas where significant fluctuations are likely, more frequent (e.g., daily or weekly) surveys are appropriate.

b. Radiation surveys are not required if both of the following conditions are met:

— The workplace quantities of radioactive materials are not capable of producing a dose rate greater than 1 mrem/h at 30 cm.

— Other routine surveys (e.g., direct surveys for beta contamination) would be able to detect off-normal radiation levels.

c. As used in Table 6:

— “Active” means the posted area is likely to be accessed, or radioactive material is likely to be moved or handled, one or more times during the specified survey interval.

— “Inactive/Sporadic” means the area is likely to be accessed or radioactive material is likely to be handled or moved less frequently than the “Active” frequency, and the area is neither “Static” nor “No Access.”

— “Static/No Access” means any of the following:

1. The condition is engineered to be non-changing (e.g., an irradiator or a calibrator);

2. Active contamination controls (e.g., ventilation) are not needed for containment (e.g., a hood that has been disconnected and is awaiting removal or decontamination and decommissioning);

3. Engineered controls (e.g., interlocks, locked or sealed enclosures) prevent extremity or whole-body access to areas that require posting as a radiological area (e.g., an interlocked accelerator area);
(4) The facility is ‘permanently’ closed (e.g., ‘cold and dark’);

(5) The area is a posted ‘underground radioactive material area.’

d. For “Active” areas, routine surveys may be conducted at the frequency and in the locations specified for “Inactive/Sporadic” areas if either of the following conditions exist:

— There is at least one barrier between the contamination area and the worker (e.g., when the contamination is in a hood or glovebox).

— An RCT-qualified individual conducts a survey upon initial entry to the area.

e. For areas that are “Inactive/Sporadic” or “static/no access,” surveying the area boundary is sufficient (i.e., surveying containment interiors is not expected).
Table 6. Minimum Frequency of Routine Radiological Surveys Conducted by the ES&H Team in Operationally Active Facilities\(^a\)

<table>
<thead>
<tr>
<th>Area Posting</th>
<th>Area Contents (^b)</th>
<th>Contamination Surveys</th>
<th>Radiation Surveys</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Active</td>
<td>Inactive/</td>
</tr>
<tr>
<td>—</td>
<td>Type 0 or I workplace (WP)</td>
<td>Q</td>
<td>S</td>
</tr>
<tr>
<td>RMA</td>
<td>Type 0 WP</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>RMA</td>
<td>Type I WP, or Type II or III WP with Type I quantities of material</td>
<td>Q</td>
<td>S</td>
</tr>
<tr>
<td>RMA</td>
<td>Type II or III WP with Type II or III quantities of material</td>
<td>M</td>
<td>Q</td>
</tr>
<tr>
<td>RMA</td>
<td>Items with external removable contamination</td>
<td>M</td>
<td>Q</td>
</tr>
<tr>
<td>RMA</td>
<td>Items with internal removable contamination (e.g., a fume hood)</td>
<td>Q</td>
<td>S</td>
</tr>
<tr>
<td>Contamination Area; High Contamination Area</td>
<td>W</td>
<td>M</td>
<td>S or U</td>
</tr>
<tr>
<td>Fixed Contamination Area</td>
<td>M</td>
<td>Q</td>
<td>S or U</td>
</tr>
<tr>
<td>Radiation Area</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>High Radiation Area</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

\(^a\) S = Semiannual; Q = Quarterly; M = Monthly; W = Weekly; U = Upon entry.

\(^b\) Type 0, I, II, and III workplaces pertain to use of radioactive material and are defined in Document 20.2.

\(^c\) S or U, whichever is less frequent.

4. Radiation surveys must include dose rate measurements of the general area, dose rates at a distance of 30 centimeters from a source or surface of interest to evaluate potential whole-body exposures, and should include the dose rates measured on contact with potential sources of radiation where there is a potential for hands-on work or other direct contact and the extremity dose is likely to exceed 1 rem in an hour.
a. Notify the ES&H Team health physicist of any instruments whose ‘as found’ reading indicates that the instrument may have been used while out of calibration.

b. The health physicist should review surveys performed with the instrument while it was out of calibration and consider the need for additional surveys.

5. Surveys shall be performed only by individuals who have the appropriate education, training, and skills. The ES&H Team health and safety technologists must conduct and document the surveys required by the Rule unless the following provisions are met:

a. The ES&H Team leader, the work supervisor or RI, and the RCM agree, in writing, that another individual or organization will assume responsibility for conducting and documenting the surveys.

b. The person(s) taking on the responsibility must
   — Be specifically identified and trained to conduct the surveys required by the Rule.
   — Maintain and archive survey records in the same manner as similar records generated by the ES&H Team.

6. The requirements in this section may not be appropriate for all facilities (e.g., in facilities that have unique radiological conditions). If the survey frequencies in Table 6 appear inappropriate, the ES&H Team health physicist, with the concurrence of the RCM, may develop and implement a facility-specific survey program with requirements that are less stringent than those specified in Table 6.

6.2.2 Operational Radiation Monitoring

1. The routine, documented survey program conducted by the ES&H Team is designed to detect radiological changes in the workplace and gradual buildup of radioactive material. Radiological workers (i.e., programmatic personnel) must conduct operational monitoring during work activities that could affect radiological conditions.

a. The person conducting the monitoring must promptly notify the ES&H Team of changes in radiological conditions or of unplanned events.

b. Operational monitoring does not need to be documented, unless directed by the Authorizing Organization.

c. When conducting operational monitoring, dose rate measurements may be taken at any distance that provides meaningful information to the worker.

d. When conducting contamination monitoring, large area wipes are encouraged.

2. Monitoring must be performed before, during, and at the completion of work that has the potential for causing changes in levels of radiation and radioactivity.

3. Monitoring must be conducted whenever operations are being performed that might result in individuals being exposed to small intense beams of radiation, such as those generated by shielded X-ray devices or due to removal or alteration of shielding,
modification of shielding penetrations, or relocation of significant radiation sources within shielded enclosures.

4. Individuals with radiation survey instruments assigned to them must maintain the instruments by:
   a. Checking the condition of each instrument once each week, or before use (whichever is less frequent). This check is important because (1) batteries lose potency with age and meters become inaccurate with insufficient voltage; and (2) discharged batteries can leak chemicals that will ruin the instrument by corrosion. The ES&H Team Health and Safety technologist may replace alkaline batteries, if necessary.
   b. Checking each instrument for radioactive contamination. Contaminated instruments must be decontaminated before being used to monitor the workplace, further handled, or sent for maintenance or repair.
   c. Ensuring the instrument is within its calibration period. Instruments that are outside the calibration period shall not be used for health and safety purposes.

6.2.3 Portable Radiation Detectors [including Continuous Air Monitors (CAMs), Hand and Shoe Monitors]

1. Instruments and equipment used for surveys/monitoring shall be:
   a. Used only to measure the radiation for which their calibrations are valid.
   b. Periodically maintained and calibrated on an established frequency (typically, annually). Calibration frequencies must be determined in accordance with National Conference of Standards Laboratories Recommended Practice RP-1, Establishment and Adjustment of Calibration Intervals.
      — Calibrations should use National Institute of Standards and Technology (NIST) traceable sources.
      — Calibration procedures should be developed for each radiological instrument type.
      — Calibration procedures should include frequency of calibration, pre-calibration requirements, primary calibration requirements, periodic performance test requirements, calibration record requirements, and maintenance requirements type.
   c. Appropriate for the types, levels, and energies of the radiation. The types of instruments appropriate for use in a facility are identified in the HP-DAP.
   d. Appropriate for existing environmental conditions.
      — The effects of environmental conditions, including interfering radiation, on an instrument shall be known prior to use.
      — Appendix E of this document contains limiting environmental conditions.
e. Routinely tested for operability. Instrument users should perform a battery check and function test (as practicable) on instruments each time they are turned on.

2. Instruments used to perform radiation surveys/monitoring should be performance-checked (i.e., checked against a source of radiation to ensure the instrument responds) daily or, if not checked within the past 24 hours, prior to operation.

   a. If performing a quantitative performance check, the instrument should be taken out of service if it is not within ±20 percent of the expected value.

   b. If conducting documented beta-gamma surveys (e.g., those required by the HP-DAP), the instrument must be performance tested on a calibration test jig (for applicable instruments).

   c. When performance checks are not feasible, such as with instruments used to measure neutrons or tritium, compensatory actions should be established to ensure proper instrument performance.

   d. Performance checks must be documented if conducting a documented radiation survey.

3. 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 must be performed for use of instrumentation outside manufacturer's specifications. The instrument must be adjusted, calibrated, and labeled to identify the special conditions and used only under the special conditions for which it was calibrated.

4. The Radiation Calibration Laboratory (RCL) (in the ES&H Analytical Services and Instrumentation (AS&I) organization) must:

   a. Obtain, maintain, calibrate, and distribute the inventory of portable radiation-monitoring instruments used for health and safety purposes. DOE encourages standardization on the use of commercially-available radiological instrumentation. Provisions for maintenance and calibration of specialty instruments are provided below.

   b. Use NIST traceable sources for calibration. 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. ANSI N323 provides detailed technical guidance for the establishment of calibration programs.

   c. Establish a program of preventive and corrective maintenance of radiological instrumentation. Document the results of maintenance and calibration performed on instruments and equipment.

   d. Use operational tests to assess instrumentation designs that include alarms or that involve a process control used for health and safety purposes. An operational test must be developed to test components involved in an alarm or trip function and performed at least annually. This test may be performed in conjunction with the periodic calibration.
e. Use documented protocols/procedures to perform radiological monitoring instrument inspections, calibrations, performance tests, calibration equipment selection, and quality assurance.

   — Label each instrument so users can verify its calibration status.
   
   — 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.

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

5. Organizations that choose to purchase portable radiation detectors that are to be used for health and safety purposes must:

   a. Contact the RCL prior to purchasing the instrument to determine if the RCL has the capability to maintain and calibrate it.

      — The RCL can typically maintain instruments that are similar to instruments currently in their inventory; if the instrument cannot be maintained by the RCL, the Authorizing Organization must:

         (1) Arrange for a service contract with the vendor, and

         (2) Deliver the instruments to the RCL for inclusion in the radiation instrument tracking database.

   b. Ensure users of the instrument are trained.

6.2.4 Other Survey/Monitoring Requirements

1. Changes in equipment, techniques, and procedures used for surveying/monitoring the workplace shall be documented by the organization responsible for the change.

   a. The Authorizing Organization must document changes in the location or type of installed equipment such as radiation area monitors or CAMs.

   b. The Radiological Control Organization must document institutional changes such as to the personnel dosimetry or bioassay monitoring systems.

2. Monitoring requirements unique to radioactive materials and RGDs are contained in Document 20.2 and Document 20.3.

6.3 ALARA Records

1. The Authorizing Organization shall document actions taken to maintain occupational exposures ALARA and must maintain the following ALARA records, as applicable:
6.4 Evaluation of Performance

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

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

6.4.1 Conduct of Critiques

Critiques are meetings of the individuals knowledgeable about an event to obtain and document a chronological listing of pertinent facts following an unusual radiological situation or at the satisfactory conclusion of a new or unusual operation involving radiological controls. The purpose of the critique is to establish and record the facts and develop lessons learned.

1. The Authorizing Organization must utilize DES-0071, Analysis Methods, and DES-0080 Event Notification and Reporting for analyzing and reporting events.

   a. Critiques should be conducted for successes and abnormal events. Management should hold critiques for other conditions that generate concerns about radiological controls or conditions, as needed. Evaluation of complex evolutions or events may require multiple critiques.
b. The RCM must be invited to participate in critiques related to radiological operations, conditions, and controls. The RCM may choose to participate directly, send an alternate, or not participate.

c. At a minimum, critiques must be held for the following events or conditions
   — Contamination above the Document 20.2 Appendix D thresholds is detected outside of an RCA.
   — Radioactive contamination above the Document 20.2 Appendix D thresholds is tracked off-site.
   — Identification of an uncontrolled high radiation area.
   — Detection of a failed interlock associated with a radiological enclosure.
   — An unplanned external whole-body dose exceeding 1 rem occurs.
   — Planned special exposure provisions (as specified in Section 3.2.5) are used.
   — As directed by the Authorizing Organization or the RCM.

### 6.4.2 Post-job Reviews

1. The Authorizing Organization, in conjunction with the ES&H Team, should review performance after completion of non-routine radiological work. At a minimum, a post-job review must be conducted if:
   a. A stop-work order is issued for radiological purposes, as specified in Section 6.1.2.
   b. A worker unexpectedly exceeds their ACL.
   c. The pre-job dose estimate is exceeded by 1 rem.
   d. Operations result in the issuance of an Occurrence Report related to radiological operations.
   e. Significant radiological lessons learned are identified.
   f. Indicated by the Authorizing Organization or the Radiological Control Organization.

2. The post-job review must involve the workers, the ES&H Team, and other individuals that may have impacted or been affected by the situation.

3. As appropriate, the post-job review should include reviews of:
   a. The total and individual doses compared to the pre-job estimates.
   b. The efficacy of the radiological controls implemented for the work.
   c. Any adverse events occurring during the work, such as skin contaminations, unexpectedly high individual exposures, or problems resulting from unnecessarily burdensome control requirements.
   d. Conflicts between radiological safety requirements and other safety requirements.
e. Opportunities to improve performance or efficiency during repeated or similar work.

f. Significant differences between expected and actual radiological conditions or other issues affecting the work.

g. Worker input regarding possible improvements in radiological safety practices for repeated or similar work.

6.4.3 Lessons Learned

Lessons learned are available from post-job reviews and reports of past radiological events on site and at other facilities. LLNL’s Lessons Learned coordinator reviews, edits, and distributes lessons learned to a specified list of recipients.

1. Supervisors and managers of radiological work should write up and submit radiological ‘lessons learned’ to LLNL’s Lessons Learned coordinator.

2. The Radiological Control Organization and line programs (as appropriate) should incorporate lessons learned into the radiological control program, the radiological control training program, and related operations, as deemed appropriate by the RCM.

7.0 Training Requirements

7.1 General Requirements

1. Each individual shall:

   a. Complete radiation safety training, commensurate with the hazards in the area and the required controls [i.e., HS6001 General Employee Radiological Training (GERT)]:
      — Before being permitted unescorted access to RCAs (i.e., areas posted with the radiation trefoil symbol).
      — Before receiving an occupational dose during access to RCAs.

   b. Demonstrate knowledge of the radiation safety training topics identified below (as contained in HS6901 and HS6010), commensurate with the hazards in the area and required controls, by successful completion of an examination and performance demonstration.
      — Before being permitted unescorted access to radiological areas.
      — Before performing unescorted assignments as a radiological worker.

2. Radiation safety training:

   a. Shall include the following topics to the extent appropriate to each individual’s prior training, work assignments, and degree of exposure to potential radiological hazards.
— Risk of exposure to radiation and radioactive materials, including prenatal radiation exposure.
— Basic radiation fundamentals and radiation protection concepts.
— Controls for both routine and emergency actions implemented at the local level to manage and maintain doses ALARA (e.g., engineered controls, administrative controls, limits, policies, procedures, alarms, and other measures).
— The individual’s rights and responsibilities for implementing the facility’s radiological protection program.
— The individual’s responsibilities for implementing ALARA measures.
— Reports the individual may request.

b. Should address both normal and abnormal situations in radiological control.

c. Should be periodically updated to include changes to the radiological control program and applicable updates of lessons learned from operational experience and occurrence reporting from both LLNL and the DOE complex.

3. Individuals shall demonstrate satisfactory completion of Radiological Worker Training by successful completion of:

a. A performance demonstration (initial training only).

b. An examination.

— Examinations should be written; however, the RCM may approve alternatives to accommodate special needs.
— Alternative examinations should be equivalent in content to written examinations.

4. Radiation safety training shall be provided to individuals:

a. At intervals not to exceed 24 months.

b. When there is a significant change to radiation protection policies and procedures that may affect the individual.

5. If an escort is used in lieu of training, the escort shall have completed the training required for unescorted access to the area and performance of the work and shall ensure that all escorted individuals comply with the applicable safety requirements.

a. An escort does not obviate the requirement for GERT training prior to receiving occupational exposure in an RCA.

b. Working under the direct guidance of a trained and qualified worker is intended to provide a reasonable means of allowing work to continue while training is in process. It is not an approved means of bypassing training.
c. The work supervisor or RI is responsible for documenting the limitation of the person requiring direct guidance and for ensuring both the person and the worker providing guidance understand their responsibilities.

d. Radiological workers may provide direct guidance to subcontractors (e.g., a factory repair person conducting limited work at LLNL) contingent upon the approval of programmatic management and the ES&H Team. There is a radiological work permit available for use by subcontractors.

6. Records shall be maintained to demonstrate compliance with the training requirements in this section. Documentation of course completions for institutionally-provided courses is maintained in the Livermore Training Records and Information Network (LTRAIN).

7.2 Institutionally Required Training

1. Table 7 contains the Laboratory’s institutional training requirements (ITRs) for the radiation protection program (core course numbers are provided). These courses are based on DOE’s core courses to the extent practicable and are supplemented with LLNL site-specific information. Completion of the requisite ITRs meets the 10 CFR 835.901 training requirements.

   a. Successful completion of the entire core academic component of a DOE core course at one DOE site within the past two years should be recognized by other DOE sites.

      — See the ES&H Safety Education and Training Section to obtain a ‘Rad Worker’ card for use at other sites.

      — Documentation of previous training should include the individual’s name, date of training, topics covered, and name of the certifying official.

      — Under these circumstances, any additional radiological control training necessary for the individuals to perform radiological work or to enter specific areas, including site-specific aspects of the radiation safety training, shall be completed.

   b. The definitive list of institutionally required courses and their alternates is contained in LTRAIN. If discrepancies exist, the LTRAIN list supersedes the courses listed in Table 7 and in other documents [e.g., IWSs, Facility Safety Plans (FSPs), and SPs].

   c. If questions arise, the RCM has the authority to determine the applicability of the courses listed in Table 7.

   d. Except where otherwise stated, retraining for ITRs is required every 24 months.

   e. ES&H’s Safety Education and Training Section must retain instructional materials associated with institutionally required training.

2. The Authorizing Organization or the ES&H Team health physicist may require additional facility-specific radiological training for access or work in specific areas. This training is not subject to the 10 CFR 835.901 training/testing requirements, and must be conducted
in accordance with institutional requirements as specified in the applicable ES&H Manual documents or facility-specific documents, where ES&H Manual requirements do not exist.

3. Personnel training records shall be controlled and retained.
   a. LTRAIN must be used to record completion of the institutionally required training courses shown in Table 7 and should be used to record the following types of radiation safety training.
      — Instructor training.
      — Respiratory protection training.
      — Training for emergency response personnel.
   b. Formal records or summary reports of training and qualification should be readily available to first-line supervision and management of involved personnel to aid in making work assignments.

7.2.1 General Employee Radiological Training

1. All workers who are regularly assigned to work at LLNL must complete GERT.
   a. The initial GERT course is provided during New Employee Orientation (course HS0001).
   b. Retraining is done by completing HS6001.

2. Individuals (including LLNL workers and visitors) who have not completed GERT:
   a. May be escorted by a GERT-trained worker into a Radioactive Materials Area, X-ray Area, Accelerator Area, or Radiological Buffer Area.
   b. Are prohibited from entering Radiological Areas (e.g., Radiation Areas and Contamination Areas).
   c. Are prohibited from working with Class 1, 2, 3, and 4 RGDs and > Class 0 quantities of radioactive materials, even if under the escort or direct guidance of a trained and qualified radiological worker.

3. Visitors may complete GERT by reading Radiation Safety at LLNL or by completing the web version of course HS6001, available on the LTRAIN website.
   a. If a visitor is specifically included on an IWS or other work control document that requires GERT training, the visitor should take the web-based version of HS6001; otherwise, the authorizing organization (e.g., the RI) is responsible for maintaining a record of training completion.
Table 7. Radiation Safety Training Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Application</th>
</tr>
</thead>
</table>
| **HS6001**, "General Employee Radiological Training" (GERT) | Required prior to receiving an occupational dose in an area posted with the radiation trefoil symbol, and for:  
- Unescorted access into a Radioactive Materials Area, RGD Area, or Radiological Buffer Area.  
- Escorted access into a Radiation Area, High Radiation Area, Contamination Area, High Contamination Area, or Airborne Radioactivity Area.\(^1\)  
- Work with Class 0, 1, and 2 SRSs and equivalent quantities of nondispersible radioactive material. |
| **HS6901**, "Radiological Worker Core Training" or equivalent | Required for people who are neither a radioactive material handler nor RGD operator and:  
- Need unescorted access to Radiation Areas, or  
- Are likely to receive >0.1 rem/y. |
| **HS6010**, "Radiological Worker Training" or equivalent, and successful completion of a performance demonstration (i.e., **HS6010-P**, one time only). | Required for:  
- RGD Custodians and individuals who operate or work in close proximity to Class II, III, or IV RGDs (see HS6988).  
- Work with Class 3 - 4 SRSs and equivalent quantities of nondispersible radioactive material.  
- Work with Class 0 and greater quantities of uncontained dispersible radioactive material.  
- On-site transportation of up to Class 3 quantities of radioactive material.  
- Workers who neither handle radioactive material nor work with RGDs and need unescorted access into a High Radiation Area.  
- Individuals who require a DOE Radiological Worker I card for an off-site assignment. |
| An **HS6300** series course, “Contamination Control” or one of the radioactive material handling courses, or equivalent. | Required (in addition to HS6010) for:  
- Work with Class 0 or greater quantities of dispersible transuranic material.  
- Work with Class 1 or greater quantities of other dispersible radioactive material.  
- Work with uncontained items potentially contaminated above the Appendix D thresholds.  
- Unescorted access into a Contamination Area, High Contamination Area, or Airborne Radioactivity Area.  
- Individuals who require a DOE Radiological Worker II card for an off-site assignment. |
Table 7. Radiation Safety Training Courses (continued)

<table>
<thead>
<tr>
<th>Course</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS6340, &quot;Anti-Cs&quot;</td>
<td>Required for work where full anti-contamination clothing is necessary (i.e., coveralls with the openings taped, shoe covers, gloves, and a respirator).</td>
</tr>
<tr>
<td>HS6390, &quot;Introduction to Glovebox Safety&quot;</td>
<td>Required (one time only) for work conducted in gloveboxes.</td>
</tr>
<tr>
<td>HS6913, &quot;Chelation Therapy&quot;</td>
<td>Recommended for glovebox work with transuranic radioactive material. This course is available upon request by line/facility management. Retraining is not required.</td>
</tr>
<tr>
<td>HS6940, &quot;Radiation Safety for Emergency Personnel&quot;</td>
<td>Required for unescorted emergency responders (e.g., firefighters) prior to receiving a radiation dose in excess of 5 rem.</td>
</tr>
<tr>
<td>HS6988, &quot;Radiation Generating Device Safety&quot;</td>
<td>Required (in addition to HS6010) for RGD Custodians, individuals who operate Class II, III, or IV RGDs (including accelerators), and those who work in close proximity to operating Class II, III, or IV RGDs such that they need to know the potential hazards and the associated controls in order to assure their safety.</td>
</tr>
</tbody>
</table>

1 The dose limit for members of the public during access to an RCA is 0.1 rem in a year.
2 ‘In close proximity to’ is an LLNL-specific requirement intended to capture individuals who are routinely involved in RGD operations, but don’t actually operate the RGD (e.g., a radiographer assistant, a mechanical technician that reconfigures beam line components, individuals that frequently access exposure rooms in between RGD operations).

7.2.2 Radiological Worker Training

1. Workers shall complete the applicable radiological worker training course shown in Table 7 before performing independent work as a radiological worker and before being permitted unescorted access to Radiological Areas.

2. Workers who have completed GERT, but who have not completed radiological worker training, or whose radiological worker training has lapsed, may:
   a. Be escorted into posted Radiation Areas and Contamination Areas by a trained radiological worker if entry is not expected to result in an individual dose exceeding 0.01 rem (10 mrem) in a day or 0.1 rem (100 mrem) in a year.
   b. Work with Class 0, 1, and 2 SRSs and equivalent quantities of non-dispersible radioactive material.
c. Handle other radioactive materials (including potentially contaminated items) only under the direct guidance of a trained and qualified coworker. The following restrictions apply:

— Each trained worker may provide direct guidance to only one individual at a time, unless prior approval is obtained from the RCM.

— The person providing direct guidance must cosign (or initial) any documents generated by the untrained person.

— An ES&H Team member may not simultaneously provide ES&H oversight and ‘direct guidance’ for line operations.

3. Radiological worker training should, at a minimum, encompass the following practical factors:

a. Entering and exiting simulated radiological buffer areas and radiation areas (and high radiation areas when such training is included).

b. Performance of monitoring for personnel contamination, as applicable.

c. Verification of instrument response and source check.

d. Proper response to alarm situations or faulty radiological control equipment.

e. Donning of protective clothing, if applicable.

f. Entering a simulated radiological buffer area, contamination area, and high radiation area to perform a task, if applicable.

g. Proper response to simulated abnormal situations.

h. Removing protective clothing and equipment and subsequently exiting the simulated area, if applicable.

i. Performance of monitoring for personnel contamination, if applicable.

4. Some DOE sites use the terms “radiological worker I” (RW-I) and “radiological worker II” (RW-II) in describing levels of training. Although these terms have not traditionally been used at LLNL (because RGD training is not included in RW I or RW II training):

a. ES&H’s Safety Education and Training Section can issue RW-I and RW-II reciprocity cards for work at other sites, but the cards are not to be used to establish a worker’s training status for LLNL-required courses.

b. Workers may challenge DOE’s RW-I or RW-II core knowledge requirements by passing a comprehensive examination. If unsuccessful in one attempt, the entire standardized core RW-I or RW-II Training should be completed. Challenges should not apply to the site-specific portions.
7.3 Specialized Training

7.3.1 Specialized Radiological Worker Training

1. Specialized Radiological Worker Training should be completed for non-routine operations or work in areas with changing radiological conditions. This training is in addition to Radiological Worker Training and should be provided to personnel planning, preparing, and performing jobs that have the potential for significant radiological consequences. Such jobs may involve special containment devices, the use of mockups, and ALARA considerations.

a. Specialized Radiological Worker Training (i.e., 'just-in-time' training) should be conducted prior to conducting work that is likely to result in a dose exceeding 10% of the applicable dose limits, or that is likely to create a high contamination area outside the designated work area (e.g., changing a window on a highly contaminated glovebox).

b. In some cases, pre-job briefings provide an acceptable alternative to Specialized Radiological Worker Training.

2. Other training provided in the workplace, including mock-up training for specific jobs, trade or craft specific training, laboratory safety training, and pre-job briefings, may include specific instructions regarding radiological controls. This type of training is encouraged and documentation of these types of training is not required to satisfy the requirements of 10 CFR 835.902.

3. Radiographers should have training in accordance with the American Society for Non-Destructive Testing, ASNT-TC-1a, ‘Recommended practices.’

7.3.2 ALARA Training for Technical Support Personnel

Workers are instructed in the meaning of ALARA and management’s commitment to ALARA in GERT and Radiological Worker Training. ALARA training for technical support personnel (e.g., designers, engineers, radiological work planners) is not formally provided at LLNL; however, the goal of training (i.e., that the engineer is aware of and incorporates sound radiological controls into the design package) is accomplished via interactions with the ES&H Team health physicist during the planning and design phases of an operation or facility.

1. The Authorizing Organization must involve the ES&H Team early in the conceptual design process to ensure ALARA considerations are integrated into the design.

2. Technical support personnel should participate in selected portions of job specific and specialized training, particularly in situations using mock-ups.

3. 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.
7.3.3 Radiological Control Technician

At LLNL, RCT training is one aspect of training provided to ES&H Team health and safety technologists (i.e., ES&H Team health and safety technologists are ‘RCT qualified’ unless otherwise specified).

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

2. The minimum entry-level prerequisites for RCTs must include the following:
   a. High school education or equivalency.
   b. Fundamentals of mathematics, physics, chemistry, and science.
   c. Systems and fundamentals of process, operations, and maintenance.
   d. Reading and comprehension level sufficient to follow procedures, prepare survey maps, write reports, and prepare shipping and transfer permits.
   e. Ability to work in a support role, including communicating verbal instructions to others.
   f. Physical requirements to handle PPE and other equipment and assist others in work locations, commensurate with assignment.

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

4. The Safety Education and Training Section should develop RCT training using DOE’s standardized core course training materials, as applicable. These basic course materials must:
   a. Be expanded to include site-specific information.
   b. Include on-the-job training to provide hands-on experience directly applicable to the job.

5. Following initial qualification, the RCT should begin a 2-year cycle of continuing training required for requalification. Every requalification cycle must include completion of practical training and should include a comprehensive written examination. Continuing training should:
   a. Provide continued improvement in the knowledge and skills of the RCT.
   b. Include site-specific and DOE-wide changes in requirements and updates of lessons learned from operating experience and industry events.
c. Include written examinations as applicable, and demonstrations of proficiency controlled by qualification standards, as needed to ensure understanding of the topic.

6. Infrequently performed tasks, such as those for emergency response, may require annual training. Other tasks may require training prior to initiation.

7.3.4 RCT Supervisor Training

RCT supervisors fill ‘Key Radiation Protection Positions’; training and education standards for RCT supervisors should be consistent with DOE-STD-1107-2007, *Knowledge, Skills, and Abilities for Key Radiation Protection Positions at DOE Facilities*.

1. 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.

2. RCT supervisors' knowledge of facility radiological control hazards, programs, and procedures should exceed that expected of an RCT and should be reassessed every 2 years.

3. RCT supervisors must obtain/retain full RCT qualification.

7.4 Locally Required Training

1. The Authorizing Organization must provide a comprehensive and effective radiological control training program by supplementing institutionally-required training, as needed. At a minimum, facility or program specific training must be provided where:
   a. Individual ACLs are established.
   b. Area radiation alarms are installed.
   c. FSPs are used to control radiological operations.

2. This training shall encompass both routine and emergency conditions, engineered controls, administrative controls, limits, policies, procedures, alarms, and other measures implemented at the local level to manage and maintain doses ALARA.

3. The following activities may be used singularly or in combination to fulfill local training requirements:
   a. A review of applicable SPs.
   b. A review of operating procedures.
   c. Facility-specific orientations or safety briefings.
   d. On-the-job (hands-on) training.
4. The RI must ensure that local training requirements are identified, workers requiring local training are identified, and completed training is documented.

8.0 Records

8.1 General Provisions

1. Records shall be maintained to document compliance with the Rule and with radiation protection programs required by the LLNL RPP.
   a. A combination of media may be used for a comprehensive records system.
   b. Records of radiological control programs must be high quality, readily retrievable, and managed for the prescribed retention period.
   c. Records should be stored in a manner that ensures their integrity, retrievability, and security.
   d. Consideration should be given to cross-referencing related records to aid retrievability.
   e. Records must be handled such that personal privacy is protected.

2. Unless otherwise specified, records shall be retained until DOE authorizes final disposition.

3. The organization responsible for creation of the record is usually responsible for the long-term maintenance of the record. Appendix F specifies the responsibilities for record generation and maintenance.

8.2 Records Management Program

1. A radiological records management program should be established. This program should ensure that auditable records and reports are controlled through the stages of creation, distribution, use, arrangement, storage, retrieval, media conversion (if applicable), and disposition.

2. The records management program shall be sufficient to ensure that records are maintained as necessary to document compliance with the Rule. The records management program should include the records identified in Appendix F.

3. Detailed information concerning an individual's exposure shall be made available to that individual, upon request, and to others, as appropriate, consistent with the Privacy Act of 1974.

8.2.1 Recordkeeping Standards

1. Records shall be maintained to document:
   a. Results of surveys for radiation and radioactive materials.
b. Results of surveys and calculations used to determine individual occupational doses.

c. Results of surveys for release of materials from radiological areas.

d. Results of sealed radioactive source leak tests and inventories.

e. Results of surveys of radioactive material packages received from transportation.

f. Changes in survey/monitoring equipment, techniques, and procedures.

2. Radiological records must be accurate and legible.

3. Radiological survey records must include the following:

a. Identification of the facility and specific location (e.g., building and room) and the purpose of the record.

b. Signature or other identifying code of the preparer and date.

c. Legible entries in ink (inclusive of computer printouts).

d. Post-approval corrections identified by a single line-out, initialed, and dated, or equivalent, if provided electronically. For example, a text box containing the requisite information and added to a pdf record that is stored on a controlled-access server meets the requirement and is acceptable.

e. Review and approval of the survey by the ES&H Team health physicist or supervisor (or designee) to ensure proper completion of the survey form and evaluation of the data.

4. Radiological control records must not include:


b. Shorthand or other non-standardized terms.

5. Similar procedural standards should be established for computerized records.

6. Unless otherwise specified, radiological control records shall use the special units of curie, roentgen, rad, and rem, dpm, including multiples of these units, or other conventional units such as dpm, dpm/100 cm². Use of the international system of units (i.e., the SI units of becquerel (Bq), gray (Gy), and sievert (Sv)) should be limited to calculational, scientific, or reference purposes. The SI units may be provided parenthetically for reference with scientific standards.

7. Survey records must include the following information, as applicable:

a. Model and serial number of counting equipment or radiation detectors when direct-reading surveys are conducted.

b. Results of the measurement, including contamination (and whether the contamination was fixed or removable) and/or radiation levels (using appropriate units) with
appropriate supporting parameters (e.g., counting efficiency, counting time, correction factors, type of radiation).

c. Location of the fixed and passive air monitors and supporting parameters (e.g., flow rate, duration of sampling).

d. Location of areas found to contain hot particles, high concentrations of localized contamination, and other radiological hazards.

e. Facility conditions existing during the survey that may have affected radiological conditions.

f. Follow-up survey results for decontamination processes, (preferably cross-referenced to the original survey).

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

8.2.2 Records of Instrument Calibration and Operational Checks

1. Calibration records for fixed, portable, and laboratory radiation measuring instruments and equipment and individual monitoring devices shall be maintained. These calibration records must include frequencies, method, dates, personnel, training, and traceability of calibration sources to NIST or other acceptable standards.

a. Records of special instrument calibrations and modifications made in accordance with Section 6.2.3 shall be retained.

b. Records of additional tests and checks of instrumentation used in conjunction with a suspected overexposure, questionable indication, or unusual occurrence must be retained.

2. Calibration and maintenance records shall be maintained for instruments and equipment used for monitoring. Calibration and maintenance records should be maintained for the following equipment:

a. Portable survey instruments.

b. Bioassay measurement equipment.

c. Laboratory, counting room, and fixed radiation measuring equipment.

d. Process and effluent monitors and sampling equipment.

e. Radiation area monitors.

f. Portal monitors and other personnel contamination monitors.
g. Pocket and electronic dosimeters.

h. Air sampling equipment.

i. Tool and waste monitoring equipment.

j. Protective clothing and equipment monitors.

3. Documentation of instrument operational checks shall be maintained for documented surveys. Such records must be maintained for a period not less than the calibration period of the instrument.

4. Maintenance results for each instrument and device shall be created and retained. Maintenance histories for each instrument and device should be created and include the nature of any defects and corrective actions taken.

8.2.3 Computerization of Records

1. Records may be transferred to electronic storage media (or other data retention technology) provided certain precautions are taken to ensure that the information is maintained in a retrievable configuration.

2. Controls for the use and handling of electronic storage media (or other technology) should include the following:
   a. A master index of documents on the electronic storage medium.
   b. A program to ensure back-up and retrievability of information.
   c. Quality control during data entry and analysis.
   d. An index identifying software applications used in conjunction with the data.
   e. Software validation and verification.
   f. Periodic quality audits of software.
   g. Prevention of unauthorized manipulation of data.
   h. Assurance that previously stored information is retrievable and useable after system modifications.

8.2.4 Protection of Records

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

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

3. Records should, as a minimum, be protected from:
a. Exposure to fire, equivalent to an Underwriters Laboratories, Inc., 1.5-hour, or greater, fire resistance rating.

b. Exposure to water damage caused by a 100-year flood.

c. Exposure to windstorm velocities of 100-year recurrence.

9.0 Responsibilities

See Document 2.1, “General LLNL Worker ES&H Responsibilities,” in the ES&H Manual for a list of general responsibilities. This section describes specific responsibilities of LLNL organizations and workers who have key roles with regard to the radiation protection program. The responsibilities are specified below each title.

Responsibilities that are specific to radioactive materials or RGDs are included in Document 20.2 and Document 20.3, respectively.

9.1 Institutional Program Responsibilities

9.1.1 Radiological Control Manager

The RCM must:

1. Ensure a robust RPP.

   a. Develop and disseminate radiation safety direction for LLNL that is consistent with LLNL policies and regulatory requirements.

   b. Determine the sufficiency of the RPP internal audit program.

   c. Establish the criteria for who needs radiation safety training and concur with the radiation safety training material.

   d. Resolve conflicts between LLNL’s DOE-approved RPP and other LLNL documents.

2. Authorize:

   a. Individuals who are not a part of the ES&H Team to conduct and document surveys required by 10 CFR 835.

   b. Deviations from LLNL’s dosimeter use requirements.

   c. Deviations from ES&H Manual ‘must’ statements.

   d. Use of postings containing the radiation trefoil.

3. Approve access to radiological areas by visitors who are minors.
4. Provide a periodic report to management, summarizing the status of site-specific radiological issues, including the status of any site-wide radiological goals and performance indicators.

9.1.2 The RS/ALARA Committee

1. The RS/ALARA Committee must:
   a. Promote the optimization of radiation dose to workers and the public.
   b. Periodically review radiation-safety related occurrence reports, audits and assessments, and other data that reflects the health of LLNL’s radiation safety program. Make recommendations to management to improve progress toward controlling radiation exposure and radioactive releases.
   c. Develop and facilitate implementation of effective solutions that address radiation-safety related issues and concerns and ensure a strong, compliant radiation safety program that meets the operational needs of LLNL’s diverse line programs.
   e. Meet at least quarterly; provide minutes that reflect issues discussed, actions taken, and actions planned.
   f. Report issues and concerns to the SMST as needed, and at least annually.

2. The SMST may redirect the actions of the RS/ALARA committee, as needed.

9.1.3 Director, Environment, Safety, and Health

The ES&H Director must ensure:

1. A performance analysis is conducted for the triennial summary of 10 CFR 835 internal assessments.
2. Potential programmatic, repetitive, or systemic concerns are identified, and institutional corrective actions are developed and implemented.

9.1.4 Safety Education and Training Section

The ES&H Safety Education and Training Section must:

1. Develop, present, and document institutionally-required radiological worker training, based on course content approved by the RCM.
2. Train ES&H Team health and safety technologists (and other specifically identified individuals) to meet the ‘Radiological Control Technician’ qualification.
9.2 Authorizing Organization Responsibilities

9.2.1 Program Associate Director

1. The Authorizing Organization’s PAD or associate director (AD) must:
   a. Ensure the requirements specified in Documents 20.1 through 20.3 and Document 22.6 in the ES&H Manual are effectively implemented, and that radiological safety is not compromised to achieve production, remediation, or research objectives.
   b. Ensure reports are made to DOE, as required.
      — Keep track of incidents or occurrences and notify DOE when required.
      — Consult with the LLNL PAAA Office regarding findings or occurrences that may be reportable under the PAAA requirements.
      — Report noncompliances to the LLNL PAAA Office, in accordance with LLNL’s internal reporting procedures.
   c. When a noncompliance with the Rule occurs, ensure that corrective actions are taken to:
      — Rectify the specific event or condition and preclude it from happening again.
      — Address the weakness in the program that allowed the noncompliance to occur.
   d. Analyze (e.g., as part of their annual ES&H performance report) the directorate’s set of 10 CFR 835-related deficiencies/issues for systemic, programmatic, or repetitive concerns, and ensure corrective items are developed and tracked in ITS.

9.2.2 Authorizing Individual

The AI must:

1. Confirm that adequate resources are provided for effective implementation of the radiological controls required for the authorized activity.
   a. Confirm controls are in place for Activity Level 2, 3, and 4 operations.
   b. Conduct a pre-start review for Activity Level 4 operations involving radioactive materials.
   c. Ensure radiological training requirements are identified in the IWS or other documents that authorize radiological operations.

2. Effectively balance priorities.
   a. Be aware of potentially hazardous radiological conditions or activities and ensure that radiation safety in general and ALARA principles in particular are not compromised for the expediency of experiments or operations.
b. Encourage initiatives to identify concerns at an early stage, to prevent conditions from deteriorating, and to promote doing the right job correctly the first time.

c. Accept change that will improve radiological control performance.

d. Hold workers and their supervisors accountable for radiological control performance.

3. Ensure the ES&H Team health physicist is involved in the planning phase and design review for radiological equipment, facilities, and facility modifications.

   a. Ensure radiological design reviews are conducted and documented, as appropriate.
   
   b. Ensure facility design and physical controls are optimized.

4. Participate in internal audits required by the Rule.

5. Ensure records are maintained as specified in Appendix F of this document.

6. Ensure the ALARA process is integrated into radiological operations. That is, ensure:

   a. ACLs are established, as specified in Section 3.2.2.
   
   b. Equipment design and physical controls are optimized.
   
   c. ALARA reviews are conducted and documented, as required.
   
   d. Recommended ALARA dose reduction measures are evaluated, optimized, and implemented, as appropriate.
   
   e. Records of ALARA reviews and radiological design reviews, and other information needed to support optimization decisions, are maintained.

7. Authorize the resumption of work after a radiological stop work has been implemented, as specified in Section 6.1.2.

9.2.3 Work Supervisor or Responsible Individual

The work supervisor or RI must:

1. Define the work.

   a. Involve the ES&H Team health physicist:

      — In the planning phase and design review of facilities and equipment.
      
      — To identify individuals or work groups containing individuals who are likely to receive doses exceeding 0.1 rem/year and recommend appropriate ACLs.

   b. Ensure that hazards are adequately analyzed during the pre-start job review and that the required safety controls and hold points are integrated into the operation and the IWS/SP (or other work control documents).
c. Ensure institutionally-required and organizationally-required courses required to conduct the work are included in the IWS or accurately reflected in the individual’s LTRAIN questionnaire.
d. Conduct and document ALARA reviews, as required.

2. Plan work.

a. Identify operations that require written plans or procedures (e.g., SPs or operating procedures) and assist in the development of those plans and procedures to ensure compliance and minimize personnel exposure to radiation under normal and off-normal conditions.
b. Integrate into operations the requirements and controls specified in this document and its associated documents, along with any additional requirements identified by the ES&H Team. Technical requirements for the conduct of work should incorporate radiological criteria needed to ensure safety and maintain radiation exposures ALARA.
c. Consider work conditions when planning. Establish working conditions that enhance radiological control, including consideration of temperature, humidity, lighting, and accessibility.
d. Provide job-specific training for unique hazards associated with radiological work.
e. If a minor is hired to do radiological work, notify the RCM and the ES&H Team health physicist of the person’s work assignment.

3. Implement controls.

a. Review radiological operations with the health physicist prior to initiating work and periodically thereafter.
b. Provide workers with the appropriate tools and protective equipment and ensure their proper use.
c. Ensure operations are conducted in appropriate workplaces.
d. Implement access controls for Radiological Areas.
e. Coordinate and participate in pre-start briefings, as appropriate.
f. Ensure procedures are implemented and used effectively.

4. Conduct work.

a. Tour the workplace to review the adequacy of radiological work practices, posting, and area controls. Maintain a radiologically safe work environment and take corrective actions if potentially hazardous conditions arise.
b. Control operations so doses are kept ALARA below the dose limits.
— Encourage workers to identify radiological control deficiencies and concerns.
— Consider establishing goals to focus worker attention in specific areas (e.g., skin and personal clothing contaminations, extent of contaminated areas).
— Consider posting in the workplace selected indicators relevant to radiological control and the work group.

c. Make the workplace modifications necessary to accommodate workers’ medical restrictions (e.g., for declared pregnant workers).

d. Ensure workers:
   — Follow established SPs and procedures.
   — Wear the prescribed dosimeter and PPE.
   — Are current in all required training.

5. Respond to feedback.

   a. Periodically monitor work areas to observe personnel at work and to identify good radiological work practices and radiological deficiencies and concerns.
   b. Keep the ES&H Team health and safety technologist or health physicist informed of the status of work activities that affect radiological conditions.
   c. Take prompt appropriate action to address identified issues and prevent recurrence.
   d. Promptly notify the ES&H Team in case of changes in radiological conditions or of unplanned events.
   e. Periodically review area monitoring results provided by the ES&H Team and correct any deficiencies.
   f. Notify the worker if he or she is likely to exceed their ACL and discuss options for managing the situation.
   g. Notify management if an individual is likely to exceed their ACL and make recommendations about how to best handle the situation.

6. Respond to off-normal conditions.

   a. Conduct and document a post-job review/critique, as required.
   b. Notify the AI and the facility point of contact, facility manager, or assurance manager of any DOE-reportable events or conditions that may require an Occurrence Report (e.g., loss of control of radioactive materials, contamination outside of designated areas, inability to locate an accountable SRS). For more information, see DES-0080 Event Notification and Reporting.
c. Provide input to Occurrence Reports. (The ES&H Team can provide guidance in determining whether or not an Occurrence Report threshold has been exceeded.)

9.2.4 All Individuals

1. All individuals must:
   a. Obey posted, written, and oral radiological control instructions and procedures.
   b. Be current in the training required for unescorted access to RCAs, or be escorted by a trained worker.
   c. Wear dosimeters as prescribed and exchange the dosimeters promptly when a new one is received.
   d. Comply with this document and its associated documents when conducting radiological work.

2. All radiological workers must:
   a. Keep their dose ALARA.
      — Be generally aware of their current, annual, dose-to-date based on reports provided by the External Dosimetry Team.
      — When performing duties within radiological areas, be familiar with the area radiological conditions and be aware of the possibility that unforeseen changes may occur.
      — Control operations so that doses do not exceed the radiation protection standards and are kept ALARA.
      — Participate in ALARA reviews, as requested.
      — Implement the ALARA controls specified in plans and procedures and discontinue operations that are inconsistent with ALARA principles.
   b. Be aware:
      — Of the safety standards and requirements applicable to their work.
      — That proper radiological control is an integral part of their daily duties.
      — Of their year-to-date accumulated dose and the radiation levels associated with the work to be done.
      — Of potential radiation-related hazards in their work area; the area radiological conditions and the possibility that unforeseen changes may occur; and the applicable safety controls.
      — Of the recommendation to contact the HSD if planning a pregnancy, or upon positive diagnosis of pregnancy, and decide whether or not to submit a Declaration
of Pregnancy form. (This is separate and distinct from contacting the HSD and is available from the HSD.)

c. Work safely and compliantly.
   — Implement the controls specified in this document, its associated documents, and other plans and procedures associated with radiological work (e.g., SPs and operating procedures).
   — If during the use of procedures a written requirement cannot be responsibly followed, discontinue work and obtain guidance.
   — Conduct ongoing operational and programmatically required monitoring (e.g., of hands and work areas during radioactive material-handling operations, around RGDs during routine and non-routine operations).
   — Use the appropriate tools and protective equipment.
   — Routinely clean up after operations.

d. Be qualified to conduct the work.
   — Wear radiation dosimetry as prescribed and exchange it on the specified frequency.
   — Provide bioassay samples on the frequency specified.
   — Be current in all required radiological training before beginning work, or work under the direct guidance of a trained worker.

e. Report to the line supervisor, facility point of contact, or the ES&H Team any workplace situations that require attention (e.g., unsafe conditions, spills, accidents, or injuries) and any event or condition that might be reportable under the DOE Occurrence Reporting System (see PRO-0082, Reporting Occurrences to DOE.)

9.3 Radiological Control Organization

9.3.1 ES&H Teams

1. The ES&H Team leader must:
   a. Ensure facility-specific HP-DAPs are developed, maintained, and implemented. (The ES&H Team health physicist creates a facility-specific HP-DAP from the template HP-DAP by selecting the instructions that are appropriate for a given facility, based on facility operations. The ES&H Team health and safety technologist carries out the facility-specific instructions specified by the health physicist.)
      — Ensure HP-DAP compliance is documented and associated radiological monitoring records generated in the facility are maintained.
      — Ensure corrective actions are implemented for noncompliances that apply to the HP-DAP.
b. Negotiate with line/facility management the appropriate levels of funding and staffing support so that the necessary resources are available to implement the ES&H Team requirements and controls specified in this document and its associated documents.

c. Inform line/facility management of potential vulnerabilities if adequate resources are not provided to meet compliance requirements.

d. Ensure records are maintained, as specified in Appendix F of this document.

2. The ES&H Team health physicist must:

a. Provide to the Authorizing Organization:

   — Technical support that is consistent with the ALARA process.

   — Radiological safety oversight, including monitoring adherence to 10 CFR 835 and the ES&H Manual documents listed in Table 1.

   — Assistance in the development and delivery of additional radiological training, if needed.

b. Establish the facility-specific radiation-monitoring program.

   — Identify and document area survey requirements in the HP-DAP.

   — Review and update (as necessary) the HP-DAP annually, or more frequently if needed.

c. Periodically review surveys and air sampling data and ensure the controls are effective.

   — Update the controls in the work control document, as appropriate.

   — Respond to unexpected results.

d. Tour the workplace to review the adequacy of radiological work practices, posting, and area controls. Ensure SPs adequately describe:

   — The magnitude of radiological hazards.

   — The physical and administrative controls required for maintaining personnel doses, effluent discharges, and contamination levels ALARA.

e. Prepare for and respond to off-normal conditions.

   — Provide input for the development of emergency plans and procedures, as requested.

   — Respond to radiological spills, accidents, and emergencies.

   — Notify the Authorizing Organization of workplace survey/monitoring results that may be indicative of barrier failures.

f. Conduct workplace evaluations for minors and workers with pregnancy-related medical restrictions, including:
— Recommending work or workplace modifications.
— Documenting the review using the forms and guidance provided by the RCM or
designee.

g. Determine radiation monitoring requirements for individuals, including the type of
dosimeter required and the appropriate exchange frequency.
— Review radiation dosimetry and survey data.
— Provide RIs with periodic dose reports for individuals with ACLs.
— Inform management of radiation workers who are approaching an annual dose of
0.1 rem (e.g., have an accumulated dose exceeding 0.08 rem) and do not have an
ACL.
— Provide the Authorizing Organization with an annual summary of the radiation
protection program (e.g., individual and collective doses, area survey results, and
notable trends or ALARA issues) in facilities where ACLs are established.

h. Provide recommendations to reduce occupational doses and the spread of radioactive
contamination when:
— Evaluating radiological operations.
— Evaluating designs and modifications to designs of equipment, components,
instrumentation, and facilities that could impact personnel radiation exposure,
control of contamination, and airborne radioactivity.
— Participating in Prestart or Readiness Reviews.

i. Support the Authorizing Organization’s implementation of the ALARA program.
— Assist with conducting and documenting ALARA reviews.
— Identify individuals or work groups with individuals who are likely to receive
>0.1 rem/y and assist in determining appropriate ACLs.
— Provide individual names and employee numbers and the respective ACLs to the
External Dosimetry Team.

3. The ES&H Team health and safety technologist must:

a. Assist program, facility, and service workers with implementing the requirements
specified in this document and its associated documents.

b. Fulfill the posting and monitoring requirements of the Rule, including:
— Conducting and documenting the routine radiation and contamination surveys
prescribed in the HP-DAP.
— Maintaining documentation of field surveys (e.g., swipes counted on field-swipe
counters, radiation surveys, and equipment release surveys).
— Ensuring areas are properly posted.
c. When observing work in progress, informing the worker, the work supervisor, or the ES&H Team health physicist of actions or operations that are inconsistent with procedures or best management practices.

   — During continuous or extended daily operations, maintain logs to document radiological occurrences, status of work activities, and other relevant information. The oncoming health and safety technologist should review the log and receive a turnover briefing from the worker they are relieving.

   d. Respond to radiological alarms, spills, accidents, and emergencies.

   e. Notify the facility point of contact (or the facility manager) and the ES&H Team leader and health physicist of incidents or conditions that may warrant their attention.

9.3.2 Radiation Protection Functional Area/Analytical Services and Instrumentation

The Radiation Protection Functional Area (RPFA) and Analytical Services and Instrumentation (AS&I) organization must:

1. Provide institutional radiological services to LLNL (RPFA).
   
a. Develop policies and practices for site-wide implementation of the RPP.
      
      — Upon request, determine whether work activities comply with the requirements in this document, its associated documents, and the RPP.
      
      — Provide technical support to the ES&H Team health physicists.

b. Develop and maintain manuals, procedures, and other documents used to implement institutional elements of the RPP, including (but not limited to):

      — The DOE-approved Radiation Protection Program.
      
      — ES&H Manual documents specified in Table 1.
      
      — Institutional procedures used to implement the RPP.
      
      — Health Physics Field Operations Procedures.
      
      — The master (template) HP-DAP.

c. Coordinate internal audits required by the Rule.

      — At the end of each 3-year internal audit cycle, compile the issues raised in the individual audits and present a comprehensive report to LLNL management.
      
      — Maintain associated documentation.
      
      — Assist programs in determining if deficiencies warrant a PAAA report to DOE.

d. Develop and authorize the use of radiological area postings.

      — Determine whether specialty posting and labeling comply with the Rule.
      
      — Provide radiological postings, signs, and labels.
e. Approve purchases of radiologically controlled items (e.g., radiation detection instruments, radioactive materials, RGDs).

f. Periodically provide the Radiation Safety/ALARA Committee with summaries of survey results required by the HP-DAP.

2. Provide radiological services to the Authorizing Organizations, via the ES&H Teams (RPFA and AS&I).

a. Analyze samples for radioactivity (e.g., air samples, swipes, bulk samples, biological samples).

b. Maintain a DOELAP-accredited in vivo and in vitro measurement capability (e.g., lung counting, whole-body counting, thyroid counting, wound counting, urine/fecal sampling).

c. Maintain documentation of analytical results evaluated by the respective laboratories.

d. Maintain a DOELAP-accredited dosimetry system.

   — Issue personnel dosimeters for routine use and maintain documentation of the dosimeter results.
   — Provide termination dose reports for individuals with external doses.
   — Provide the annual dose report to DOE and to individuals.

e. Maintain the capability to analyze nuclear accident dosimeters and biological materials following a criticality accident.

f. Calibrate and maintain hand-held radiation detectors and installed contamination monitors, including CAMs, Hand and Shoe Monitors, and portal-type contamination monitors.

g. Provide technical oversight to other organizations performing calibration functions for installed instruments used for radiation safety purposes.

9.4. Other Laboratory Organizations

9.4.1 Payroll Supervisor

The payroll supervisor must ensure that:

1. The LTRAIN questionnaire for radiological workers is updated at least annually.

2. Work restrictions that result from lapsed radiological training are documented.

9.4.2 Strategic Human Resources Management Department

Strategic Human Resources Management must notify the assurance manager, work supervisor, or RI about any minors who are to perform work at LLNL.
9.4.3 Contractor Assurance Office
The Contractor Assurance Office must assist programs in determining whether deficiencies warrant issuance of a PAAA report to DOE.

9.4.4 ES&H Assurances Division
The ES&H Assurances Division, Office of Audits and Oversight, must verify that corrective actions identified in the internal audits required by the Rule have been addressed by the responsible organization and closed out in ITS.

10.0 Requirement Source Documents


11.0 Resources for More Information

11.1 Contacts
For additional information about the Radiation Protection Program at LLNL, workers should contact the following:

1. Work supervisor or RI.
2. Authorizing Individual (a designated manager in the facility, program, or service line).
3. ES&H Team health and safety technologist.
4. ES&H Team health physicist.
5. ES&H Team leader.
6. The LLNL RCM.

11.2 Applicable Lessons Learned
The “Radiation Protection” category of the Lessons Learned Program contains information pertinent to occupational radiation protection.

11.3 Other Sources
1. For additional information about topics discussed in this document, refer to the ES&H Manual documents listed below. The official version is available on the ES&H web page.
2. Guidance from the following document(s) has been incorporated into this document wherever feasible:

3. The following DOE directives pertain to radiological safety design and are provided for the convenience of the reader:
   b. DOE O 458.1, “Radiation Protection of the Public and the Environment.”
   c. 10 CFR 830, “Nuclear Safety Management.”
   d. DOE O 231.1B. Admin Change 1, “Environment, Safety and Health Reporting.”
# 12.0 Revision History

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<th>Revision Type</th>
<th>Revision Number</th>
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<td>04/06/17</td>
<td>Major</td>
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<td>06/04/99</td>
<td>Major</td>
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</tbody>
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Appendix A
Acronyms, Terms, and Definitions

The terms and definitions provided in this appendix are specific to their use in this document.

Absorbed dose (D)  The average energy imparted by ionizing radiation to the matter in a volume element per unit mass of irradiated material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).

Accessible area  An area is considered to be accessible to individuals when it contains entrance or access points of sufficient size to permit human entry, such that any portion of the whole body (excluding the forearms and legs below the knees) could be exposed to the radiological hazard. The following types of areas are considered accessible:

1. Areas with entrance or access points consisting of unlocked doors or doorways.
2. Areas with entrance or access points consisting of locked doors or other controls and interlocks.
3. Areas enclosed by cattle fencing or cyclone fencing that is not topped with barbed wire or razor wire or other such material.
4. Work areas such as chemical fume hoods.

The following types of areas are NOT considered accessible:

1. Areas with entrance or access points consisting of doors or portals, such as man-hole covers, that are bolted or otherwise more permanently sealed, unless such doors or portals are opened on a routine basis.
2. Areas in which the radiological hazard is located underground, such that significant soil excavation, drilling, natural forces, or other forms of intrusion would be required to gain access.
3. Areas with entrance or access points that require the use of tools, lifting equipment, or excavation equipment to gain access.
4. Areas enclosed by fencing topped with barbed wire, razor wire, or other such material.

Note: Contaminated items or equipment with orifices large enough for extremity access (but not whole body access) should be labeled as ‘Radioactive Material,’ not a ‘Contamination Area.’

Administrative Control Level (ACLs)  A numerical occupational dose constraint established at a level below the occupational dose limits to administratively control and helps reduce individual and collective dose.
| **Airborne radioactivity area** | Any area, accessible to individuals, where the concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed the derived air concentration (DAC) values listed in 10 CFR 835, Appendix A or C, or where an individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-hours in a week. |
| **As low as reasonably achievable (ALARA)** | An approach to radiation protection to manage and control individual and collective doses to the workforce and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit but a process that has the objective of attaining doses as far below the applicable limits as is reasonably achievable. |
| **ALARA Engineer** | An engineer/scientist specifically trained in radiation dose control methods. ALARA engineers typically have a technical background in physics, health physics, engineering, or nuclear engineering, with experience in dose modeling (including time/motion modeling), shielding design, ventilation design, and containment methods. |
| **Area** | A location with defined boundaries that workers can occupy. Areas have ‘access points’ through which people enter and exit. Type I and II workplaces are typically managed as ‘areas.’ |

- Radiologically controlled areas must be posted with the signs specified in Section 3.1
- Downposting must be done under the direction of the ES&H Team.

Items exist within areas. ‘Items’ include things that people can move or handle, as well as non-movable things such as walls, equipment, and piping. Items that are radioactive or contaminated must be labeled.
<table>
<thead>
<tr>
<th>Definition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Background radiation</strong></td>
<td>Radiation from:</td>
</tr>
<tr>
<td></td>
<td>• Naturally occurring radioactive materials that have not been technologically enhanced.</td>
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<tr>
<td></td>
<td>• Cosmic sources.</td>
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<td></td>
<td>• Global fallout as it exists in the environment (such as from the testing of nuclear explosive devices).</td>
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<tr>
<td></td>
<td>• Radon and its progeny in concentrations or levels existing in buildings or the environment that have not been elevated as a result of current or prior activities.</td>
</tr>
<tr>
<td></td>
<td>• Consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation.</td>
</tr>
<tr>
<td><strong>Calibration</strong></td>
<td>To adjust or determine either:</td>
</tr>
<tr>
<td></td>
<td>• 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.</td>
</tr>
<tr>
<td></td>
<td>• The strength of a radiation source relative to a standard (e.g., primary, secondary, or tertiary) or conventionally true value.</td>
</tr>
<tr>
<td><strong>Collective dose (person–rem)</strong></td>
<td>The sum of individual whole-body doses (Total Effective Dose) within a specified group of people.</td>
</tr>
<tr>
<td><strong>Committed effective dose (CED)</strong></td>
<td>The sum of the committed equivalent doses to various tissues or organs in the body ($H_{T,50}$), each multiplied by the appropriate tissue weighting factor ($w_T$)—that is, $E_{50} = \Sigma w_T H_{T,50} + w_{\text{Remainder}} H_{\text{Remainder},50}$. Where $w_{\text{Remainder}}$ is the tissue weighting factor assigned to the remainder organs and tissues and $H_{\text{Remainder},50}$ is the committed equivalent dose to the remainder organs and tissues. Committed equivalent dose is expressed in units of rems (or Sv).</td>
</tr>
<tr>
<td><strong>Committed equivalent dose ($H_{T,50}$)</strong></td>
<td>The equivalent dose calculated to be received by a tissue or organ over a 50-year period after intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed equivalent dose is expressed in units of rem (or Sv).</td>
</tr>
<tr>
<td><strong>Contaminated Radiological Area</strong></td>
<td>A general term that is inclusive of any area defined as a Contamination Area, High Contamination Area, or Airborne Radioactivity Area.</td>
</tr>
</tbody>
</table>
Contamination Area

Any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed (but do not exceed 100 times) the removable surface contamination values specified in Appendix D of Document 20.2, "LLNL Radiological Safety Program for Radioactive Materials," in the ES&H Manual.

Controlled area

See “Radiologically Controlled Area.”

Cumulative total effective dose

The sum of all total effective dose values recorded for an individual plus, for occupational exposures received before the implementation date of this amendment, the cumulative total effective dose equivalent (as defined in the November 4, 1998 amendment to this rule) values recorded for an individual, where available, for each year occupational dose was received, beginning January 1, 1989.

DAC

Derived air concentration.

Declared pregnant worker (DPW)

A woman who has voluntarily declared to her employer, in writing, her pregnancy for the purpose of being subject to the occupational dose limits to the embryo/fetus as provided in 10 CFR 835.206. The declared pregnant worker may revoke this declaration, in writing, at any time.

Direct guidance

For the purpose of the Rule, direct guidance requires a fully trained co-worker or supervisor to be in audible or visual contact with the worker who is not fully trained so that guidance and assistance can be readily provided if necessary. The level of supervision shall be commensurate with the hazards of the operation and the level of training completed by the worker.

DOELAP

Department of Energy Laboratory Accreditation Program

Dose

A general term for absorbed dose, equivalent dose, effective dose, committed equivalent dose, committed effective dose, or total effective dose.

Effective dose ($H_E$)

The summation of the products of the equivalent dose received by specified tissues or organs of the body ($H_T$) and the appropriate tissue weighting factor ($w_T$)—that is, $E = \sum w_T H_T$. It includes the dose from radiation sources internal and/or external to the body. For purposes of compliance with the Rule, equivalent dose to the whole body may be used as effective dose for external exposures. The effective dose equivalent is expressed in units of rems (or Sv).
Equivalent dose ($H_T$) The product of average absorbed dose ($D_{T,R}$) in rad (or gray) in a tissue or organ ($T$) and a radiation ($R$) weighting factor ($w_R$). For external dose, the equivalent dose to the whole body is assessed at a depth of 1 cm in tissue; the equivalent dose to the lens of the eye is assessed at a depth of 0.3 cm in tissue, and the equivalent dose to the extremity and skin is assessed at a depth of 0.007 cm in tissue. Equivalent dose is expressed in units of rems.

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

Extremity Hands and arms (below the elbow) or feet and legs (below the knee).

General employee An individual who is either a DOE employee, a DOE contractor employee, an employee of a subcontractor to a DOE contractor, or an individual who performs work for or in conjunction with DOE or utilizes DOE facilities.

At LLNL, this definition means an individual who is either a LLNS or a LLNS contractor employee, an employee of a subcontractor to LLNL, or an individual who performs work for or in conjunction with LLNL operations.

GERT General Employee Radiological Training.

HP-DAP Heath Physics Discipline Action Plan.

High Contamination Area Any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed 100 times the removable surface contamination values specified in Appendix D of Document 20.2.

High Radiation Area Any area, accessible to individuals, where radiation levels could result in an individual receiving an equivalent dose to the whole body in excess of 0.1 rems in one hour at 30 cm from the radiation source or from any surface that the radiation penetrates.

Hold point Specific conditions that require work to stop and a decision to be made in order for work to continue.

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

ITR Institutional training requirement.
ITS
Issue tracking system.

IWS
Integration Work Sheet.

Lifetime occupational dose
Lifetime occupational dose is determined by summing all occupational internal and external doses received during the individual's lifetime. The internal contribution to lifetime occupational dose from intakes prior to January 1, 1989, may be calculated in terms of either cumulative annual effective dose or committed effective dose equivalent. The committed effective dose equivalent should be used to the extent that adequate data are available to calculate doses in these terms.

Member of the public
An individual who is not a general employee. An individual is not a member of the public during any period in which he/she receives an occupational dose.

Minor
An individual less than 18 years of age.

Monitoring
The measurement of radiation levels, airborne radioactivity concentrations, radioactive contamination levels, quantities of radioactive material, or individual doses and the use of the results of these measurements to evaluate radiological hazards or potential and actual doses resulting from exposures to ionizing radiation. 'Monitoring' does not require formal documentation unless specifically stated. (Also see ‘survey.’)

Must
A requirement that shall be implemented, unless the RCM authorizes otherwise, in writing.

NIST
National Institute of Standards and Technology.

NORM
Naturally-occurring radioactive material.

NRC
Nuclear Regulatory Commission.

Occupational dose
An individual's ionizing radiation dose (external and internal) as a result of his/her work assignment. Occupational dose does not include doses received as a medical patient or doses resulting from background radiation or participation as a subject in medical research programs.

Operational ALARA review
An ALARA review associated with an activity or operation.
PAAA  Price Anderson Amendment Act.

Planned special exposure (PSE)  A planned exposure received by a radiological worker only in an exceptional situation (e.g., when alternatives that might prevent a radiological worker from exceeding the routine dose limits are unavailable or impractical). Doses from planned special exposures are accounted for separately from doses received from routine occupational exposure.

PPE  Personal protection equipment

Radiation  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 the Rule, does not include nonionizing radiation (e.g., radio waves, microwaves, or visible, infrared, or ultraviolet light).

Radiation Area  Any area, accessible to individuals, where radiation levels could result in an individual receiving an equivalent dose to the whole body in excess of 0.005 rem (5 mrem) in one hour at 30 centimeters from the source or from any surface that the radiation penetrates.

Radiation Protection Program (RPP)  The term, ‘Radiation Protection Program’ may refer either to the DOE-approved document required by Part 10 CFR 835, or more generally to LLNL’s radiation safety program, as promulgated through the ES&H Manual documents specified in Table 1.

Radioactive material transportation  The movement of radioactive material by aircraft, rail, vessel, or highway vehicle. Radioactive material transportation does not include preparation or packaging of material for transportation, storage of material awaiting transportation, or application of markings, and labels required for transportation.

Radiological Area  Any area within a controlled area defined as a Radiation Area, High Radiation Area, Very High Radiation Area, Contamination Area, High Contamination Area, or Airborne Radioactivity Area.

Radiological Buffer Area  An intermediate area established to prevent the spread of radioactive contamination and to limit doses to general employees who have not been trained as radiological workers.

Radiologically controlled area (RCA)  Any area where access is managed to protect individuals from exposure to radiation or radioactive material. At LLNL, RCAs are posted with a radiation trefoil symbol.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Radiological Control Technician (RCT)</td>
<td>An individual trained in accordance with the DOE definition of a 'Radiological Control Technician' and qualified by the RCM to perform the duties of an RCT. At LLNL, ES&amp;H Team health and safety technologists are typically RCT-qualified.</td>
</tr>
<tr>
<td>Radiological Control Organization</td>
<td>A general term inclusive of the Radiation Protection Functional Area and the ES&amp;H Team health physicists, RCT-qualified Health and Safety Technologists, as applicable.</td>
</tr>
<tr>
<td>Radiation weighting factor (w$_R$)</td>
<td>The modifying factor used to calculate the equivalent dose from the average tissue or organ absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate radiation weighting factor. The radiation weighting factors to be used for determining equivalent dose in rems are shown in LLNL’s DOE-approved RPP document.</td>
</tr>
<tr>
<td>Radiological work</td>
<td>Work with any form (i.e., dispersible, nondispersible, or waste) of radioactive material in excess of the Class 0 thresholds specified in Document 20.2, Appendix D, any type of work in a Contamination Area or Radiation Area, or work with radiation-generating devices (RGDs). Document 20.3, “LLNL Radiological Safety Program for Radiation-Generating Devices,” in the ES&amp;H Manual defines RGDs and the associated safety program. Observation of an activity does not constitute radiological work if the observer is at a sufficient distance from that activity to protect him/her from potential hazards.</td>
</tr>
<tr>
<td>Radiological worker</td>
<td>A general employee whose job assignment involves operating RGDs or working with radioactive material in excess of the Class 0 thresholds specified in Appendix D, or who is likely to be routinely occupationally exposed above 0.1 rem per year total effective dose.</td>
</tr>
<tr>
<td>RAM</td>
<td>Radiation area monitor.</td>
</tr>
<tr>
<td>RCL</td>
<td>Radiation Calibration Laboratory.</td>
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<tr>
<td>RCM</td>
<td>Radiological Control Manager.</td>
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<tr>
<td>RCS</td>
<td>Radiological Control Standard, DOE S1098-2008.</td>
</tr>
<tr>
<td>Rem</td>
<td>A general unit used to quantify equivalent dose, total effective dose, committed equivalent dose, committed effective dose, or total effective dose. ('Rem' is an acronym for 'Roentgen Equivalent Man'.)</td>
</tr>
<tr>
<td>RGD</td>
<td>Radiation-generating device.</td>
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</tbody>
</table>
RS  Radiation safety.
RWP  Radiation Work Permit.
Safety plan (SP)  A document identifying the hazards and requisite controls associated with an operation or facility. Safety plans are approved by the Authorizing Organization and include Integration Work Sheets (IWS), IWS with a safety plan, facility safety plans (formerly known as facility safety procedures), and operational safety plans (formerly known as operational safety procedures).
SRS  Sealed radioactive source.
Shall  A mandatory requirement from the Rule.
Should  A recommended practice. Can also indicate a desirable or best management practice. Written justification for declining to implement a 'should' statement is not required.
SMST  Senior Management Safety Team.
Special Control Level  Control levels applied to consenting individuals whose lifetime dose totals are in excess of N rem where N is defined as their age in years.
Survey  Radiological monitoring that requires formal documentation.
Suspension point  A newly encountered radiological condition for which the controls in the Work Control Document are clearly not adequate. Reaching a suspension point requires work to stop and the condition to be formally addressed in a change to the work control document, or the use of an alternate work control document that adequately addresses the hazards and controls. In this context, 'suspension point,' 'suspension guide,' and 'limiting condition' are generally synonymous.
TLD  Thermoluminescent dosimeter.
Total effective dose (TED)  The sum of the effective dose (for external exposures) and the committed effective dose (for internal exposures).
Very High Radiation Area  Any area accessible to individuals where radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads in one hour at 1 m from a radiation source or from any surface that the radiation penetrates.
Volumetrically contaminated

Material with radioactivity distributed throughout the material. Volumetric contamination may result from radioactivation, or from mixing radioactive material with nonradioactive material (e.g., as in contaminated soil).

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 tissue ($H_T$) is multiplied by the appropriate weighting factor to obtain the effective dose equivalent contribution from that tissue. The weighting factors are provided in the LLNL Radiation Protection Program (RPP).

Whole body

For the purposes of external exposure, any exposure to the head, trunk (including male gonads), arms above and including the elbow, or legs above and including the knee.
Appendix B
Conducting Internal Audits

1. Internal audits of the radiation protection program (RPP) shall be conducted and documented no less frequently than every 36 months. Records should include:
   a. Assessment checklists.
   b. Assessment methods.
   c. Assessment results.
   d. Assignment of corrective actions.
   e. Completion and verification of corrective actions.

2. To ensure a comprehensive evaluation, both an institutional program audit and facility-specific implementation audits must be conducted.
   a. The institutional program audit should evaluate the institutional aspects of:
      — Management and administration of the RPP.
      — Adequacy of RPP-related documents and procedures.
      — The ALARA Program.
      — Radiological training.
      — Internal dosimetry.
      — External dosimetry (including the Declared Pregnant Worker Program).
      — Instrument calibration and maintenance.
      — Radiation-generating devices.
      — Sealed source accountability.
   b. ES&H Team audits include a review of records generated by the health physicist and the health and safety technologist as a result of ES&H Manual and Heath Physics Discipline Action Plan (HP-DAP) requirements. These audits focus on the:
      — Timeliness of HP-DAP reviews, revisions, and approvals.
      — Timeliness of HP-DAP implementation.
      — Quality of records produced, including (but not limited to) radiation and contamination surveys, air monitoring, equipment release, and RGD safety surveys.
      — Record availability.
   c. Facility implementation audits focus on how the RPP is implemented by the facility, line program, and the ES&H Team. Facility implementation audits may be either ‘topical’ or
‘comprehensive’ in scope and may include work observations. Topical audits evaluate the hazards and controls associated with one or more of the following:

— Radioactive materials.
— Sealed radioactive sources (SRS) (i.e., implementation of the local SRS control program).
— RGDs
d. As it relates to the topical area being audited, the assessment includes the:

— Adequacy and adherence to institutional policies and procedures (e.g., ES&H Manual, institutional procedures).
— Adequacy and adherence to facility-specific procedures (e.g., IWSs, SPs, operating procedures).
— Area controls (e.g., adequacy of the workplace relative to the type of work being conducted, access controls, contamination controls, postings, instrumentation).
— Process controls (e.g., safety surveys, transfer controls).
— Worker qualification (e.g., training, dosimetry).
e. In addition to the above, comprehensive facility audits also evaluate:

— Implementation of radiological aspects of the Facility Safety Plan (FSP).
— Implementation of the ALARA Program.
— Compliance with dose limits.
— Radiological aspects of facility/equipment design reviews.

3. To ensure effective implementation of the audit program, the RCM must determine the following:

a. The sufficiency of the internal audit program.

b. The audit schedule (including modifying the schedule within the triennial audit requirement, as needed).

c. The audit criteria/lines of inquiry.

d. The type of audit (i.e., focused or comprehensive) conducted in each facility. In general, certain facilities should be reviewed each audit cycle (e.g., nuclear facilities and other facilities of management interest); other facilities may be audited in alternate audit cycles (i.e., at least once every six years).

e. Whether or not a condition represents a noncompliance with the Rule or the ES&H Manual. The RCM may contact the Contractor Assurance Office for additional perspectives when evaluating potentially non-compliant conditions.
4. The Radiation Protection Functional Area must:
   a. Coordinate, conduct, and document the facility-specific audits, including identifying nonconformances with the Rule and the ES&H Manual.
   b. Ensure the institutional audit is conducted each triennial cycle. Individuals that are not a part of the Radiation Protection Functional Area should lead the institutional audit.
   c. Periodically summarize the audit results for management.
   d. Maintain records to document the results of internal audits and other formal reviews of the RPP content and implementation.

5. As appropriate, the Director of ES&H shall ensure a causal analysis is conducted, potential programmatic or systemic concerns are identified, and institutional corrective actions are developed and implemented.

6. The Authorizing Organization must:
   a. Participate in the facility’s internal audits, including supplying an account number, as requested.
   b. Provide a Point of Contact (POC) for the audit. The POC is responsible for actively facilitating the conduct of the audit, ensuring the auditor receives information in a timely manner, and that the appropriate individuals are involved in the audit.
   c. Respond to findings and concerns and, in conjunction with the Contractor Assurance Office, determine whether deficiencies warrant submission of a PAAA Nonconformance Tracking System (NTS) report.
   d. Ensure the corrective actions resulting from the internal audit are entered into ITS, actions are completed, and the actions are effective.
   e. Record completion of the assessment in the ITS database in the case where no deficiencies are noted during the internal audit.

7. The guidelines in PRO-0042, Issues and Corrective Action Management shall be used to document the audit.
Appendix C

Workplace Evaluations for Declared Pregnant Workers

1. The health physics portion of the workplace evaluation includes the following elements:
   
a. Discussing with the worker her current dose, work assignment, and the likelihood of receiving occupational exposure during pregnancy as a result of normal and off-normal operations.

b. Recommending work or workplace modifications that ensure the:
   
   — Dose received during the gestation period is maintained as low as reasonably achievable below 0.5 rem (500 mrem).
   
   — Rate of dose accrual is limited to approximately 0.05 rem (50 mrem) per month once the pregnancy is declared.
   
   — Monthly dose rate is limited and managed to assure the 0.5 rem embryo/fetus dose limit is not exceeded during the entire gestation period from the estimated date of conception.
   
   — Worker is enrolled in a monthly dosimeter exchange cycle and an appropriate bioassay program if there is the likelihood for internal dose in excess of 0.01 rem (10 mrem) during the gestation.

   c. Documenting the interview and workplace evaluation and sending a copy of the documentation to the HSD Provider, or as directed on the applicable form.

2. Program, facility, and service management must make reasonable modifications to ensure the DPW's dose is as low as reasonably achievable.

   a. If these modifications do not adequately reduce the risk, the DPW must be assigned to a different job while the medical restriction is in effect.

   b. If the dose to the embryo/fetus has already exceeded 0.5 rem by the time a worker declares her pregnancy, the worker shall not be assigned to tasks where additional occupational exposure is likely during the remaining gestation period.

   c. Any changes made as a result of the medical restriction must have the concurrence of DPW. Such changes shall not affect her benefits, seniority, or potential for promotion.
Appendix D
Dosimeter Monitoring Guidelines and Results Notification Protocol

D.1. Dosimeter Types and Exchange Cycles

1. The following four types of whole-body dosimeters are used at LLNL:

   a. The **Panasonic 802 dosimeter** (identified by a dosimeter holder with a blue front) is the default dosimeter at LLNL and is typically exchanged quarterly or semi-annually.

   b. The **Panasonic 810 dosimeters** (identified by a dosimeter holder with a black front) should be issued to workers who have the potential to receive an occupational radiation dose in excess of 10 mrem/monitoring period. These dosimeters are typically exchanged monthly or quarterly.

   c. **Panasonic 810/CR-39 dosimeters** (identified by a dosimeter holder with a black front and white plastic on the back) must be worn by individuals who have the potential to receive an occupational neutron dose in excess of 0.05 rem (50 mrem) in a year. The CR-39 dosimeter normally provides the dose of record for neutron dose.

   d. **Nuclear Accident Dosimeters** (NADs) (identified by a dosimeter holder with filled cavities bordering the hole provided for the Panasonic dosimeter). These dosimeters shall be worn in combination with one of the dosimeters described above by individuals entering areas where a criticality accident is possible. NADs are only read in case of a nuclear accident.

      The Radiological Control Organization shall maintain methods and equipment for analyzing NADs and biological materials.

2. Workers should be enrolled in the following cycle exchanges. The exchange frequency may be increased at the discretion of the health physicist.

   a. **Monthly**—For workers who are likely to receive an external occupational radiation dose >0.1 rem/y under normal conditions (e.g., plutonium handlers), or who could receive a radiation dose >0.1 rem under off-normal conditions and might not otherwise be aware of it (e.g., RGD operators). For workers whose dose is typically monitored with a supplemental electronic personal dosimeter, the exchange frequency may be extended to quarterly.

   b. **Quarterly**—For workers who handle radioactive material or operate RGDs who are likely to receive more than 0.01 rem during the monitoring period, but are *not* likely to receive an external radiation dose >0.1 rem/y under normal conditions (e.g., RHWM workers and Class II RGD operators), or who would otherwise be unaware of off-normal conditions that may result in radiation exposure.
c. **Semiannually**—For workers, including radiological workers, who are *not* likely to receive an occupational external radiation dose >0.015 rem/monitoring period under normal conditions.

3. Table D-1 shows the Rule’s requirements and additional LLNL requirements for wearing various types of dosimeters.

**Table D-1. Monitoring Requirements**

<table>
<thead>
<tr>
<th>Dosimeter Type</th>
<th>Must be Worn By</th>
<th>10 CFR 835 Requirements</th>
<th>Additional LLNL Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole-body dosimeter</td>
<td>• Radiological workers who, under typical conditions, are likely(^1) to receive any of the following:</td>
<td>• An effective dose of 0.1 rem or more in a year.</td>
<td>• All on-site LLNS employees, supplemental labor employees, and visitors who:</td>
</tr>
<tr>
<td></td>
<td>— An equivalent dose to the skin of 5 rem or more in a year.</td>
<td>• An equivalent dose to the eye of 1.5 rem or more in a year.</td>
<td>— Work with Class II, III, or IV RGDs.</td>
</tr>
<tr>
<td></td>
<td>• Individuals entering a High or Very High Radiation Area.</td>
<td>• Individuals entering a High or Very High Radiation Area.</td>
<td>— Work with Class 3 - 4 SRSs or equivalent quantities of radioactive material.</td>
</tr>
<tr>
<td></td>
<td>• DPWs who are likely to receive an equivalent dose 0.05 rem or more to the embryo/fetus during the gestation period.</td>
<td>• Minors and members of the public who are likely to receive from external sources an effective dose of 0.05 rem or more in a year.</td>
<td>— Enter a posted Radiation Area.</td>
</tr>
<tr>
<td>Extremity dosimeters</td>
<td>Radiological workers who are likely to receive an equivalent dose to extremity of 5 rem or more in a year.</td>
<td>Radiological workers who are likely to receive an extremity dose of 1 rem or more in a year.</td>
<td></td>
</tr>
<tr>
<td>Supplemental dosimeter(^2)</td>
<td>Individuals entering a High Radiation Area.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear Accident Dosimeters (NADs)</td>
<td>Individuals entering areas where a criticality accident is possible.</td>
<td></td>
<td>Individuals entering the Plutonium Facility Radioactive Materials Area.</td>
</tr>
</tbody>
</table>

\(^1\) "Likely" is determined by the ES&H Team health physicist and may be determined by reviewing historical dosimetry records or by calculation.

\(^2\) The dosimeter shall be capable of providing an immediate estimate of the individual’s integrated equivalent dose during the entry. Where a supplemental dosimeter is impractical or ineffective (e.g., when monitoring doses from neutron radiation), other means (e.g., knowledge of the area exposure rate and tracking of individual access times) may be used to provide immediate indication of an individual’s dose.
D-2. Dosimeter Type and Exchange Cycle

1. Table D-2 shows the appropriate type of dosimeter and exchange cycle, based on an individual’s work or work situation.

2. The Radiological Control Manager may authorize alternate dosimeter types or exchange frequencies.

3. Contact the ES&H Team health physicist if changes in dosimeter type or exchange cycle are needed for an individual or group of individuals.

Table D-2. Acceptable Dosimeter Exchange Cycles for LLNS Employees (not Visitors)

<table>
<thead>
<tr>
<th>Individuals that:</th>
<th>Whole Body Dosimeters</th>
<th>Extremity Dosimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Panasonic Dosimeter</td>
<td>CR-39 NAD</td>
</tr>
<tr>
<td></td>
<td>Model</td>
<td>Ctrl Q S</td>
</tr>
<tr>
<td>Work with or around radioactive material of sufficient activity and energy that an external dose &gt;0.1 rem/y is likely</td>
<td>x x</td>
<td></td>
</tr>
<tr>
<td>Work with or around radioactive material of sufficient activity and energy that an external dose &gt;0.040 and &lt;0.1 rem/y is likely</td>
<td>x x</td>
<td>(x)</td>
</tr>
<tr>
<td>Are likely to receive a neutron dose in excess of 0.050 rem/y</td>
<td>x x</td>
<td>x x</td>
</tr>
<tr>
<td>Work with or around low energy photon emitters</td>
<td>(x) x</td>
<td>x x</td>
</tr>
<tr>
<td>Work with Class II or III RGDs</td>
<td>x x</td>
<td>(x)</td>
</tr>
<tr>
<td>Work with or in close proximity to Class IV RGDs (See Table 7)</td>
<td>x x</td>
<td></td>
</tr>
<tr>
<td>Spend more than 20% time in the RMA of a facility where a nuclear criticality is possible (currently, only B332)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are assigned to an office in B332 or B335</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are Declared Pregnant Workers</td>
<td>x x</td>
<td>x</td>
</tr>
<tr>
<td>Are Minors</td>
<td>x x</td>
<td>(x)</td>
</tr>
<tr>
<td>Are likely to receive an extremity dose of 1 rem in a year from normal or off-normal operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do not handle rad material or work with RGDs, and are not likely to receive an external whole body dose &gt; 0.030 rem/y</td>
<td>(x) x</td>
<td></td>
</tr>
</tbody>
</table>

Note: “(x)” means it is acceptable, but not generally preferable.
D-3. Dose Investigations

1. The External Dosimetry Team must promptly notify the RCM of elevated dosimeter readings as shown in Table D-3.

Table D-3. Timeframes for Notification of Elevated Dosimetry Readings

<table>
<thead>
<tr>
<th>Dose Type</th>
<th>Dosimeter Reading</th>
<th>Timeframe for EDT to Notify the RCM</th>
<th>Timeframe for RCM to Notify the Individual and the Supervisor¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole body dose</td>
<td>&gt;5 rem</td>
<td>Immediately</td>
<td>Within 2 hours (to allow for verification of dose)</td>
</tr>
<tr>
<td>Shallow dose</td>
<td>&gt;50 rem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extremity dose</td>
<td>&gt;50 rem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole body dose</td>
<td>&gt;1 rem</td>
<td>Within 2 hours</td>
<td>Day of notification (preferably) or next working day</td>
</tr>
<tr>
<td>Shallow dose</td>
<td>&gt;5 rem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extremity dose</td>
<td>&gt;5 rem</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Notification may be made via the ES&H Team.

2. The ES&H Team health physicist must investigate anomalous dosimeter readings or results that exceed the thresholds identified in Table D-4. The results shall be documented, at a minimum, on an Exposure Investigation Request form, and shall be included in the affected individual’s personnel dosimetry file.

3. A formal dose investigation must be conducted for any dose that exceeds the limits specified in 10 CFR 835.202. The investigation report shall be included in the affected individual’s personnel dosimetry file.

Table D-4. Dosimeter Thresholds That Trigger an Investigation

<table>
<thead>
<tr>
<th>Dose¹</th>
<th>Panasonic 802</th>
<th>Panasonic 810</th>
<th>Panasonic 810/CR-39</th>
<th>Extremity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photon</td>
<td>0.1</td>
<td>0.1</td>
<td>0.3</td>
<td>—</td>
</tr>
<tr>
<td>Neutron</td>
<td>0.02</td>
<td>0.03</td>
<td>0.1</td>
<td>—</td>
</tr>
<tr>
<td>Whole-body dose to a DPW or minor worker</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>—</td>
</tr>
<tr>
<td>Skin</td>
<td>0.1</td>
<td>0.3</td>
<td>0.3</td>
<td>—</td>
</tr>
<tr>
<td>Extremity</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
</tbody>
</table>

¹ Any positive dose on a dosimeter worn by a visitor is investigated.
Appendix E
Environmental Boundaries for Radiation Detectors

1. Instruments used for radiation monitoring and contamination control shall be appropriate for the existing environmental conditions. Instruments must respond accurately when used in the pressure, temperature, and relative humidity ranges presented in Table E-1. Prior to use in conditions outside these ranges or in any radio frequency (RF)/magnetic field, instruments shall be source checked to determine if their response is accurate.

2. Following is the source check procedure:
   a. Contact the ES&H Team health and safety technologist for an appropriate check source and instructions for its use.
   b. Source-check the instrument in the environment it is to be used daily, or before the radiation survey, whichever is less frequent.
   c. Contact the ES&H Team health physicist if the instrument does not measure the check source accurately. Correction factors (e.g., air density for ion chambers), special adjustments (e.g., high-voltage reduction), or selection of a different instrument may be necessary.
### Table E-1. Environmental Boundaries for Radiation Detectors

<table>
<thead>
<tr>
<th>Detector Type</th>
<th>Temp (°F)</th>
<th>Relative Humidity (%)</th>
<th>RF/Magnetic Field</th>
<th>Pressure</th>
<th>Comments/Cautions</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-M</td>
<td>50 to 110</td>
<td>10 to 80</td>
<td>Test required</td>
<td>Sea level to 10,000 ft.</td>
<td>Not suitable for pulsed fields; may indicate ‘zero’ in high intensity fields. May be affected by magnetic and electrostatic fields.</td>
</tr>
<tr>
<td>Scintillation</td>
<td>50 to 90</td>
<td>10 to 80</td>
<td>Test required</td>
<td>Sea level to 5,000 ft.</td>
<td>May not be suitable for pulsed fields. May be affected by magnetic and electrostatic fields.</td>
</tr>
<tr>
<td>Ionization chamber</td>
<td>50 to 90</td>
<td>10 to 80</td>
<td>Test required</td>
<td>Sea level to 10,000 ft.</td>
<td>(Air density corrections are likely needed at &gt;2,000 ft.) Eberline models RO-2, RO-2A, and RSO-5 may read zero in strong magnetic fields.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Certain instruments (e.g., Victoreen 471RF) have some protection against RF fields, but they should also be source checked.</td>
</tr>
<tr>
<td>Air or gas flow proportional</td>
<td>50 to 90</td>
<td>10 to 80</td>
<td>Test required</td>
<td>Sea level to 1,500 ft.</td>
<td>Failures have been noted above 90% relative humidity; high voltage shall be reduced to operate at high elevations.</td>
</tr>
</tbody>
</table>
Appendix F
Radiological Records Retention

Records of the radiological control program consist of policy statements, procedures, work control documents, and supporting data. This appendix identifies the individuals and organizations responsible for various records. It also provides guidance for the long-term retention of these records.

1. Records generated as a result of the Rule’s requirements shall be retained until DOE authorizes their disposition. Upon cessation of activities that could result in the occupational exposure of individuals, all required records related to individual exposure monitoring shall be transferred to DOE.

2. Table F-1 lists the types of records that must be retained and the individual or organization responsible for doing so. Responsibility typically lies with the individual or organization that produced the record. However, where there is a distributed responsibility for a record, the involved organizations (e.g., the Authorizing Organization or service organization) should jointly determine who will be responsible for the record and clearly document the decision. Note: The records in Table F-1 may not be generated in all facilities.

3. The Responsible Individual or Authorizing Organization shall:
   a. Maintain custody of the identified records or send them to long-term storage in accordance with the Storage Retrieval Disposition Guidelines available from Records Storage.
   b. Ensure one-of-a-kind documents (e.g., ALARA records, field-swipe records, ES&H Team health and safety technologist logbooks) can be located. It is important to document the location of infrequently collected records to ensure they are not lost in the event of personnel or program changes.
   c. Produce records when requested (e.g., for audits and inspections).
   d. Protect records from damage.
   e. After accumulating a sufficient quantity of frequently generated records (e.g., surveys, Equipment Release Forms, swipe surveys), sort them by record type and arrange them in chronological order.
<table>
<thead>
<tr>
<th>Type of Record</th>
<th>Responsible Individual or Organization¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Policy Statements (and revisions)</strong></td>
<td></td>
</tr>
<tr>
<td>RPP-related <em>ES&amp;H Manual</em> documents (e.g., Document 20.1, 20.2, 20.3, and 22.6)</td>
<td>ES&amp;H Directorate</td>
</tr>
<tr>
<td>RPP-related site wide procedures</td>
<td>ES&amp;H Directorate</td>
</tr>
<tr>
<td>Policies</td>
<td>RPFA</td>
</tr>
<tr>
<td>RPP records and Implementing procedures (and revisions)</td>
<td></td>
</tr>
<tr>
<td>Master Health Physics Discipline Action Plan (HP-DAP)</td>
<td>RPFA</td>
</tr>
<tr>
<td>Health Physics Field Operations (HP-FO) Procedures</td>
<td>RPFA</td>
</tr>
<tr>
<td>SRS accountability records</td>
<td>Nuclear Material Control and Accountability (MC&amp;A) Group</td>
</tr>
<tr>
<td>Reports of loss of radioactive material</td>
<td>Authorizing Organization</td>
</tr>
<tr>
<td>SRS leak test records</td>
<td>RPFA</td>
</tr>
<tr>
<td>Radiation Safety / ALARA Committee meeting minutes</td>
<td>RS/ALARA Committee</td>
</tr>
<tr>
<td>Radiological training course documentation</td>
<td>ES&amp;H - Safety Education and Training Section</td>
</tr>
<tr>
<td>Radiological training course completions</td>
<td>ES&amp;H - Safety Education and Training Section</td>
</tr>
<tr>
<td>Radiological Work Control Documents</td>
<td></td>
</tr>
<tr>
<td>Integration Work Sheets (RCS 741)</td>
<td>Authorizing Organization or ES&amp;H Team</td>
</tr>
<tr>
<td>Facility safety plans (and revisions)</td>
<td>Authorizing Organization or ES&amp;H Team</td>
</tr>
<tr>
<td>Safety plans (and revisions)</td>
<td>Authorizing Organization or ES&amp;H Team</td>
</tr>
<tr>
<td>Radiation Work Permits</td>
<td>Authorizing Organization or ES&amp;H Team</td>
</tr>
<tr>
<td>Hazard Assessments (Radiological)</td>
<td>Authorizing Organization or ES&amp;H Team</td>
</tr>
<tr>
<td>Procedures/instructions for radiological work</td>
<td>Authorizing Organization or ES&amp;H Team</td>
</tr>
</tbody>
</table>
Table F-1. Radiological Records Retention List (continued)

<table>
<thead>
<tr>
<th>Type of Record</th>
<th>Responsible Individual or Organization¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual Records</strong></td>
<td></td>
</tr>
<tr>
<td>Dosimetry records for individuals monitored with an LLNL dosimeter</td>
<td>RPFA</td>
</tr>
<tr>
<td>Records of doses received during emergency conditions, accidents, and planned special exposures</td>
<td>RPFA</td>
</tr>
<tr>
<td>Medical evaluations and treatment performed in support of the radiological protection program</td>
<td>Health Services Department</td>
</tr>
<tr>
<td>Records of declarations of pregnancy and rejections</td>
<td>Health Services Department</td>
</tr>
<tr>
<td>Medical restrictions (for radiological work)</td>
<td>Health Services Department</td>
</tr>
<tr>
<td>Records of medical approvals and fit-test results for respirator use</td>
<td>Health Services Department, Worker Safety and Health Functional Area</td>
</tr>
<tr>
<td>Individual course completion records</td>
<td>LTRAIN</td>
</tr>
<tr>
<td><strong>Internal Dosimetry Program</strong></td>
<td></td>
</tr>
<tr>
<td>Technical basis document</td>
<td>RPFA</td>
</tr>
<tr>
<td>Internal Dosimetry Program Manual</td>
<td>RPFA</td>
</tr>
<tr>
<td>Procedures (bioassay, calibration, and counting laboratory)</td>
<td>AS&amp;I</td>
</tr>
<tr>
<td>Results of in vivo measurements (e.g., whole-body counts and lung counts)</td>
<td>AS&amp;I</td>
</tr>
<tr>
<td>Results of in vitro measurements (urine, fecal, and specimen analysis)</td>
<td>AS&amp;I</td>
</tr>
<tr>
<td>Records of dose assessments, if required</td>
<td>RPFA</td>
</tr>
<tr>
<td>Records of bioassay programs (participants)</td>
<td>RPFA</td>
</tr>
<tr>
<td>QA records</td>
<td>AS&amp;I</td>
</tr>
<tr>
<td><strong>External Dosimetry Program</strong></td>
<td></td>
</tr>
<tr>
<td>Technical basis document</td>
<td>RPFA</td>
</tr>
<tr>
<td>Policies</td>
<td>RPFA</td>
</tr>
<tr>
<td>Procedures</td>
<td>RPFA</td>
</tr>
<tr>
<td>Dosimetry results and dose reconstructions</td>
<td>RPFA</td>
</tr>
<tr>
<td>QA records (DOELAP audits)</td>
<td>RPFA</td>
</tr>
<tr>
<td>Results of maintenance and calibration performed on devices used for individual monitoring (dosimeters and personal alarming dosimeters)</td>
<td>RPFA and AS&amp;I</td>
</tr>
<tr>
<td>Type of Record</td>
<td>Responsible Individual or Organization¹</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>ALARA Records</td>
<td></td>
</tr>
<tr>
<td>Administrative Control Levels/(historically, ALARA goals) (as applicable)</td>
<td>Authorizing Organization</td>
</tr>
<tr>
<td>Formal ALARA reviews</td>
<td>Authorizing Organization</td>
</tr>
<tr>
<td>Facility design reviews affecting radiological operations</td>
<td>Authorizing Organization</td>
</tr>
<tr>
<td>Radiological safety analysis and evaluation reports</td>
<td>Authorizing Organization</td>
</tr>
<tr>
<td>Internal Audits</td>
<td>RPFA/Authorizing Organization</td>
</tr>
<tr>
<td>Internal audits and inspections and other reviews of radiological protection</td>
<td></td>
</tr>
<tr>
<td>program content and implementations</td>
<td></td>
</tr>
<tr>
<td>Radiological Instrumentation</td>
<td></td>
</tr>
<tr>
<td>Testing</td>
<td>AS&amp;I</td>
</tr>
<tr>
<td>Maintenance</td>
<td>AS&amp;I</td>
</tr>
<tr>
<td>Calibration records</td>
<td>AS&amp;I</td>
</tr>
<tr>
<td>Operational logs (e.g., CAM logbooks)</td>
<td>ES&amp;H Team</td>
</tr>
<tr>
<td>Field Monitoring Records</td>
<td></td>
</tr>
<tr>
<td>Facility-Specific Health Physics Discipline Action Plans (and revisions)</td>
<td>ES&amp;H Team</td>
</tr>
<tr>
<td>Exposure (radiation area) surveys</td>
<td>ES&amp;H Team/ RPFA</td>
</tr>
<tr>
<td>Radiological surveys (if not in ES&amp;H’s Sample Tracking and Results (STAR)</td>
<td>ES&amp;H Team/ RPFA</td>
</tr>
<tr>
<td>database)</td>
<td></td>
</tr>
<tr>
<td>Swipe Log records</td>
<td>ES&amp;H Team</td>
</tr>
<tr>
<td>RGD survey records</td>
<td>RGD safety officer</td>
</tr>
<tr>
<td>Contamination surveys</td>
<td>ES&amp;H Team/ RPFA</td>
</tr>
<tr>
<td>Air sampling/monitoring results</td>
<td>ES&amp;H Team/ RPFA</td>
</tr>
<tr>
<td>Equipment Release Forms</td>
<td>ES&amp;H Team or Authorizing Organization</td>
</tr>
<tr>
<td>CAM alarm worksheets (for filters counted in the field)</td>
<td>ES&amp;H Team</td>
</tr>
<tr>
<td>ES&amp;H Team health and safety technologist logbooks</td>
<td>ES&amp;H Team</td>
</tr>
<tr>
<td>Radiological incident and occurrence reports (and critique reports, if applicable)</td>
<td>Program or facility</td>
</tr>
</tbody>
</table>

¹ RPFA = Radiation Protection Functional Area; ES&H = Environment Safety and Health
Appendix G
Design Considerations for Facilities and Equipment

The design considerations and features in this appendix are provided to assist the Authorizing Organization and the ES&H Team in ensuring the radiological design objectives and requirements of Document 20.1 are effectively implemented.

The items listed in this appendix are derived from numerous DOE standards and 'Good Practices' manuals (but are not inclusive) and must be tailored to LLNL facilities, equipment, and operations. Radiological design features depend on the radiological operations, type of facility, and risk factors; therefore, the applicability of design features identified in this appendix will vary from project to project. Implementation of applicable design features shall be performed using ALARA principles described in Document 20.1 (i.e., optimization analysis).

1. Facility/Operation Layout

1.1. Ensure the design incorporates (as appropriate):

a. Measures for protection for radiation workers, adjacent radiation workers, non-radiation workers, co-located workers, the public, and the environment from hazards associated with
   - The use of radioactive material and RGDs during normal operation and anticipated operational occurrences.
   - Co-located or adjacent non-radiological hazards that could change radiological conditions under off-normal conditions.

b. Specific engineered features and controls for reducing occupational radiation exposure (e.g., shielding, hoods, glove boxes, confinement/containment structures or containers, interlocks, barricades, decontamination features, and remote operations).

c. Design features and controls for each access point to high and very high radiation areas as specified in Section 5, 'Access Controls'.

d. An appropriate number and location of fixed radiation survey or monitoring equipment.

1.2. Ensure the design optimizes:

a. Layout of radiological operations and movement of radioactive materials to keep radiation doses ALARA.

b. Traffic flow to minimize radiation exposure to radiation workers and non-radiation workers.
1.3. Ensure the design controls, or eliminates hazardous areas.
   a. Include personnel entry control for each radiological area, commensurate with existing or potential radiation hazards.
   b. Eliminate confined space zones that require maintenance or operational activities unless determined to be essential.
   c. Adequately protect high occupancy areas and existing uncontrolled areas from new or increased radiation sources.
   d. Properly shield or locate control rooms and non-radiological work areas away from radiological areas.

1.4. Provide sufficient operational space, including:
   a. Adequate operational, maintenance, production, research, and additional shielding space.
   b. Locating equipment and controls for ease of accessibility and to minimize radiation exposure to personnel during normal operation, including inspection, removal or replacement of equipment, shutdown, maintenance, and postulated off-normal conditions.
   c. Adequate space, features, and controls for managing waste during collection, storage, and transfer/transport.
   d. Hallways, doorways, and labyrinths wide enough to permit safe movement of equipment, items, and workers in PPE.
   e. An appropriate distance between serviceable components and substantial radiation sources in the area.

1.5. Consider in the design:
   a. Use of audible or visual alarms to alert personnel to operational or off-normal conditions.
   b. Inclusion of appropriate design features to drain and store fire protection sprinkler water as potentially radioactive liquid waste.

2. Maintenance and Operations

2.1. Consider provisions for dose control, including:
   a. Modification or assembly of items in a non-radiological area prior to installation in radiological area.
   b. Systems or components that permit rapid installation or setup to minimize radiation dose during installation in a radiological area.
c. The ability to perform surveillance from outside high radiation areas, very high radiation areas or high hazard radiological areas through the use of camera monitors, viewing ports or remote instrumentation.

d. Easy access, adequate workspace, adequate lay down areas and adequate lighting to service components in lower radiation areas.

e. Systems that prevent personnel from inadvertently entering radiation areas, high radiation areas or high hazard radiological areas.

f. Adequate shielding or distance between the workers and the radiological operation.

g. Systems or shielded transport carts for movement of high-dose rate radioactive material within the facility.

2.2. Consider provisions for contamination control, including:

a. Systems and components that allow for ease of operations, maintenance and decontamination in radiological areas; for long service life, ease of removal, and low frequency of maintenance.

b. Designated equipment staging, filter bagging, and temporary waste storage areas for HEPA filter replacement and maintenance operations associated with large filtration systems.

c. Remote replacement of filter plenum components (e.g., lighting) that require routine maintenance so personnel do not have to enter the filter plenum to conduct the maintenance.

2.3. Consider provisions for efficient operations, including:

a. Adequate space to perform maintenance or service in a radiological area.

b. Remote handling, robotics, and automation, where appropriate.

c. Local and remote readouts for radiological monitors.

d. Proper access to perform technical surveillance requirement activities.

e. Equipment that functions in a radiological environment under normal and off-normal conditions.

f. Adequate space for the placement of permanent or temporary shielding needed to reduce radiation levels. If temporary shielding is anticipated, consider the need for a storage area for the temporary shielding.

g. Use of utility corridors and/or interstitial spaces to minimize or eliminate routine maintenance in radiological areas.
2.4. Consider provisions for worker safety, including:

a. Permanent platforms, walkways, stairs, or ladders to permit safe access into or around radiological areas. Design platforms and work surfaces instead of ladders or other temporary structures, whenever possible.

b. Rigging or cranes as permanent systems in the facility to provide ease of installation, operations, maintenance, and decommissioning.

3. Shielding

3.1. Determine the source term:

a. Determine radiation dose rates with radiation source terms that are representative of the radiological condition.

b. Consider material flow and time-motion studies to determine source-worker geometry and stay times for routine operations and maintenance.

c. Select resuspension factors that are based on the physical and chemical forms of radioactive material during routine operations and maintenance.

3.2. Design the operation:

a. Determine appropriate shielding or separation distance.

b. Plan the radiation shielding type and location with respect to ergonomic issues and time to perform tasks or operations.

c. Consider the design of shielding as permanent or temporary. Temporary shielding requires administrative controls and configuration control.

d. Include adequate space to install temporary shielding if required for higher radiation levels – such as a possible change in design criteria and mission.

e. Design hot cells, shielded rooms, shielded storage rooms, shielded vaults, and other structures with appropriate room size, usability, shielding, storage location for radioactive sources and other features, as applicable.

3.3. Design the shield and layout:

a. Use a radiation transport code with appropriate assumptions and operational/radiological criteria to ensure design incorporates the appropriate level of conservatism.
b. Use the appropriate material composition and fluence-to-dose conversion factors to
determine shielding or dose rate values.

c. Minimize the number of penetrations through shield structures or properly design
penetration to minimize radiation streaming. Design penetration with proper shielding
or configuration.

d. Ensure uniform shielding across the structure when different materials are used. The
different material might be due to a door, viewing window, penetration, etc. Viewing
windows and doors should be properly shielded, so they are equivalent to adjacent
shielding structures.

e. Design glovebox window shielding glass so it is attached to the outside of the glovebox
structure for easy replacement and will not interfere with the integrity of the glovebox
containment window.

f. Ensure shielding design is integrated with facility structure with respect to floor loading,
seismic loading, and other structural design considerations.

g. If shielding activation is likely, consider using materials that will reduce personnel
radiation exposure.

3.4. Include the following information in the shielding documentation:

a. Source term dose rate calculations.

b. Shielding calculations.

c. Assumptions.

d. Material composition and densities.

e. Fluence-to-dose conversion factors.

f. Methodology, model, and other appropriate information.

g. Activation analysis, if applicable.

4. Contamination Control

4.1. Determine if a change room or decontamination room is required:

a. Design appropriate size and location for
   — The male and female uncontrolled and controlled sides of change rooms.
   — The decontamination room, as applicable.

b. Optimize change room size, layout, and flow pattern to minimize or eliminate co-
mingling of potentially contaminated and clean articles/people.
c. Determine appropriate decontamination systems, and whether showers and drains should be connected to the radioactive liquid waste line.

4.2. Include structural features that help control contamination, such as:

a. Floor-wall interfaces with a rounded surface.

b. A minimal number of wall, floor, and ceiling penetrations.

c. Curbs or containment devices to control the spread and accumulation of contaminants.

d. Floor drains, vacuum system, or other processes that remove contaminants from the work environment.
   — Design floors or surfaces with proper slope to drains.
   — Design double-walled transfer pipelines or ensure multi-pipe encasements are used when penetrating walls, external to the building, and where deemed necessary for the control of contamination spread.

4.3. Minimize future decontamination efforts:

a. Choose surfaces that can easily be decontaminated via the use of commonly-available materials, coatings, or finishes for walls, floors, equipment, items, counter tops, etc.

b. Minimize crevices, holes, notches, recesses, socket-head cap screws, and knurled finishes.

c. Seal penetrations, seams, curved corners and gaps in walls, floors, ceilings, equipment, and structures where contamination might ‘hide.’

f. Provide sufficient space to decontaminate items that have a potential of becoming contaminated (e.g., drains, pumps, vacuums).

g. Design light fixtures and other items used in contaminated environments so they are enclosed to decrease chance of collecting contamination.

4.4. Provide appropriate ventilation control:

a. Design ventilation (filtration, room airflow patterns, and air exchanges) to control airborne radioactive material and inhalation by workers during normal and off-normal operations.

b. Design ventilation systems so adjacent rooms or areas do not affect each other.

c. Design filtration for ventilation system to meet radiological and safety bases.

d. Include ‘housekeeping filters’ on gloveboxes to minimize contamination of facility ducting and downstream HEPA filters.
4.5. Control of radioactive liquids:

a. Design radioactive liquid drain lines with appropriate slope for length of pipe run, with no collection areas and minimal bends and back-flow devices.

b. Incorporate continuous monitoring and recording of radioactivity, flow, volume, pH, and other parameters required for material control and proper waste treatment operations, as needed.

c. Design and construct waste storage or holding tanks and transfer lines so that leakage is detected and contained before it reaches the environment.

d. Eliminate potential cross-connection of radioactive drains with non-radioactive or sanitary drains that might be an unmonitored release pathway.

e. Minimize the distance from the point of generation to storage and shipping areas, eliminate potential for cross-contamination, and prevent generation of mixed waste.

f. Review nuclear criticality issues for liquid radioactive waste system, when appropriate.

5. Access Controls


5.2. Ensure personnel entry control for each radiological area is commensurate with existing or potential radiological hazards within the area, by using one or more of the entry control methods listed in Document 20.1 Section 3.5.

5.3. Ensure each entrance or access point to High and Very High Radiation Areas has the entry control features required in Document 20.1 Section 3.5., including provisions for emergency egress. Ensure measures are in place to prevent inadvertent entry into these areas.


6.1. Siting considerations:

a. Locate pumps and other liquid handling systems apart from the storage or holding tanks to reduce radiation exposure during maintenance.

b. Design sampling ports apart from the storage or holding tanks to reduce radiation exposure.

c. Provide adequate space to allow service on pumps or to take samples.

d. If a holding tank is designed, provide a drainage system beneath radiological tanks and ensure it is connected to the radioactive waste liquid system or a holding tank.
(Note: Justify use of holding tank versus the direct connection to the radioactive waste liquid line.) Ensure the floor is properly sloped toward the drain.

6.2. Containment considerations:

a. Design containment (i.e., drip pan or catch basin) under the pumps and sample ports to contain potential spread of contamination.

b. Design tank vents or relief pipes so they are directed to an appropriate drain. Ensure system vents are not pressurized, under normal and off-normal situations, creating a condition that could spread contamination.

c. Provide a drain in the pump casing when appropriate.

d. Cover pump seals to prevent contaminated liquids from being ejected from the pump.

6.3. Valve design considerations:

a. Design valve stems upright, unless otherwise stated and justified.

b. Design or install valves for radiological use to minimize cavities and crevices.

c. Design valves for installation or removal without cutting or welding, unless justified.

d. Design valves requiring frequent use in a radiation or high radiation area to be operated remotely, unless justified.

e. Segregate the piping system for radioactive and non-radioactive materials, when possible (e.g., not co-located in same pipe chase). This will reduce the radiation exposure during maintenance and repair of the pipes.

6.4. Piping/drainage considerations:

a. Design unique, radioactive liquid waste double-walled pipes when penetrating through walls, outside building structures and underground.

b. Ensure rooms connected to a common drain line are kept at sufficiently negative pressure.

c. Design pipes containing radioactive materials with appropriate slope, and minimal length and horizontal runs.
   — Design large bends, avoid sharp bends in slurry system piping (minimum of five times the diameter or greater should be considered).
   — Design lengths of pipe without traps, dead legs, low points or stagnant areas, unless justified.
   — Incorporate drains at unavoidable low points or dead legs to flush out radioactive residues.
   — Design drip pans for low point pipe connections or other potential leaking pipe locations.
d. Minimize overhead pipes containing radioactive materials, unless justified. If overhead piping is installed, design a drip shield for overhead piping, or double-walled piping, or other engineering features, as appropriate.

e. Design pipes containing alpha-emitting radioactive materials without Teflon washers, compression fittings, Teflon seals, or other material susceptible to radiation damage.

6.5. Maintenance/sampling considerations:

a. Design or install dependable pumps to minimize the frequency of maintenance. Pumps requiring frequent maintenance should be equipped with flanged connections for easy removal when in a radiation, high radiation area or other high-hazard radiological areas.

b. Design tanks, sumps, pumps, valves, pipes, traps and other items with mechanisms for flushing and decontamination and to ensure waste fluids are not held up long after operation.

c. Design tanks with an agitator or mixer mechanism for homogenous sampling and to minimize localized radioactive material buildup.

d. Design back-flush connections and/or other approved systems or structures, when appropriate.

e. Design components intended for use in a radiological area to facilitate draining, flushing and cleaning by chemical or mechanical methods.

f. Design sampling ports in as low as possible radiation areas apart from the tanks. Ensure sampling ports have drip pans where needed.

g. Design the location of valves away from radiological operations, tanks, filters, demineralizers, etc., where appropriate and depending on radiation levels.

6.6. Slurry systems:

a. Design slurry systems with check valves or strainers at the interface with liquid systems, when appropriate.

b. Design spent resin or slurry piping with full-ported valves and without screwed connections or orifices, unless justified.

c. Design spent resin or slurry piping with a downward slope and design to maintain turbulent flow, unless justified.

d. Design slurry systems with minimal pipe connections and fittings.

e. Design resin and slurry piping tees to ensure flow through the straight portions and the branch line is located above the run.

6.7. Miscellaneous considerations:
a. Design appropriate shielding or other radiation exposure reduction techniques around tanks, pumps, filtration systems, or sumps.

b. Provide criticality monitors for tanks and filters, where appropriate. Contact the Nuclear Operations Criticality Safety Group for assistance in design.

c. Evaluate the amount of nickel, manganese, and cobalt in the design of tanks and other metal items, when neutron sources and potential (α,n) reactions are involved as they present activation issues.

d. If fissile material is involved, ensure the Nuclear Operations Criticality Safety Engineer is involved in the design process.

7. Instrumentation

7.1. Instrumentation selection and design:

a. Ensure the proper radiation instruments are selected for the type and intensity of radiation. Ensure sufficient redundancy and capability (e.g., range, rugged construction, and will not fail in high radiation fields, etc.) for normal operation and emergency conditions.

b. Design radiation monitoring as fixed systems, whenever possible.

c. Select instruments for long service life and low maintenance requirements, especially in radiological areas.

d. Design appropriate redundancy in instrumentation based on Safety Analysis or operational needs.

e. Design instrumentation to minimize contamination of the system and provide ease of decontamination.

f. Design instrument taps or connections above the piping mid-plane, unless justified.

g. Design instrumentation with flushing capability to reduce accumulation of deposits, where appropriate.

7.2. Location of instrumentation:

a. Locate instrument readouts in the lowest radiation level area or low-hazard radiological areas, unless justified.

b. Functionally group the location of instruments, readout, and controls to minimize time spent in a radiological area.

c. Design into the facility the appropriate number of and location for the fixed air samplers and continuous air monitors (CAM).

d. Design remote calibration into instrumentation permitting this capability, especially for instrumentation in a radiation, high radiation, or high-hazard radiological areas.

7.3. Maintenance considerations:
a. Provide specialty gases required for instrumentation (i.e., P-10 gas for PCMs) via a house gas system or ganged gas bottles to prevent the loss of gas pressure when changing gas bottles.

b. Locate an instrument repair shop within the controlled area, where appropriate and practical, to minimize the movement of potentially contaminated instruments outside of the controlled area or facility.

c. Provide uninterrupted power supply (UPS) for appropriate radiological and non-radiological instruments and monitors.

8. Ventilation

8.1. Siting considerations:

a. Ensure the exhaust stack from facility and adjacent facilities is located away from the supply air building intake system.

b. Evaluate the location of the facility’s supply air intake with respect to facility and surrounding facility exhausts.

8.2. Determination of requirements:

a. Evaluate the radiological activities and determine and verify ventilation requirements.

b. Determine the filtration requirements (type of filter, and the number of stages) for the ventilation system and workplace area, which is usually directed by safety basis requirements.

c. Design confinement and ventilation systems adequately for the required level of protection from airborne contamination with respect to air flow patterns, location of air supply, penetrations, exhaust, and other relative items.

d. To the extent practicable and applicable, utilize the ventilation sampling and monitoring guidance provided in ANSI N13.1, “Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities.”


8.3. Facility design considerations:

a. Ensure the flow of air is from the lesser to the potentially greater airborne contamination area.

b. Ensure appropriate pressure gradients between a specific area and adjacent areas. Evaluate impact of pressure gradient changes with adjacent areas to design appropriate ventilation system, proper location of air monitoring instruments, etc.

c. Include an interlock system between the supply and exhaust air to ensure that when the exhaust shuts down the supply shuts down. This will prevent the over-
pressurization of certain areas and the potential of spreading contamination from airborne radioactive materials.

d. Design the ventilation system with an exhaust gate after the filter plenum to prevent back draft from outside wind into the plenum and through the facility during filter replacement work, where appropriate.

e. Segregate room airflow and volumes from the uncontrolled and controlled areas, including the change room, where appropriate.

8.4. Ventilation system design considerations:

a. Design ventilation systems (ducts and plenums) to minimize radioactive material buildup, excluding filters.

b. Design confinement and ventilation system to prevent the release of radioactive materials to the workplace atmosphere including the change room.

c. Do not pass supply air ducts through radiological areas and exhaust air from a controlled area through an uncontrolled area.

d. Ensure that supply air ducts are under sufficient positive pressure with respect to adjacent areas, if the air ducts passes through a potentially radioactive airborne area.

e. Design systems to ensure that the exhaust air duct is under negative pressure until air ducts reaches environmental release ports or exhaust fans.

f. Design systems to ensure that process fittings, valves, and equipment for tritium processes are installed inside a ventilated hood or glove box, where appropriate.

g. Design minimal number of bends and minimal length of tubing in the radioactive air sampling or monitoring system. Include non-reactive materials in the design for ductwork and monitoring systems.

h. Design ventilation system to reduce moisture/humidity prior to HEPA filters.

8.5. Filters and demineralizers:

a. Design filtration systems with smaller filter sizes for ease of handling during replacement or provide a mechanical system to move larger filters, where appropriate.

b. Ensure filters are designed to minimize servicing frequency.

c. Ensure filter plenum containment is designed to allow efficient removal of filters.

d. Ensure that filter containment is located in low occupancy and low traffic areas, and in a location away from high hazard and radiological areas, whenever possible.

e. Include an appropriate amount of space to remove filters, especially if filters require shielding or remote handling is required.

f. Provide appropriate level of filtration (roughing, HEPAs, or both) for the inlet air system.
g. Evaluate the need for roughing filters prior to HEPAs in the exhaust ventilation system and incorporate in design, if justified.

h. Ensure the Nuclear Operations Criticality Safety Group assesses any criticality issues associated with the filtration system.

8.6. Maintenance considerations:

a. Include a magnehelic gauge at HEPA filtration assembly central location or facility monitoring location so proper function of the filter can be evaluated such as material loading or leaks in gaskets to damaged HEPA filters.

b. Provide an appropriate amount of shielding for filter banks or separate filter banks from each other to permit working on one with the other filter bank operational. Ensure there is an appropriate amount of space to perform testing and balancing, maintenance, and filter change out.

c. Include appropriate ports and openings to decontaminate ductwork.

d. Evaluate the potential of filters and demineralizers becoming radiation sources and shield appropriately.

9. Waste Minimization

9.1. Design operations, processes and facilities to minimize waste generation with respect to filters, seals, consumables, etc.

9.2. Design operations, processes, and facilities to avoid generation of mixed waste and to minimize generation of radioactive waste.

9.3. Design operations, processes, and facilities to segregate the non-radioactive waste stream from the radioactive waste stream with appropriate space to accommodate waste containers.

9.4. Evaluate material selection for minimization of hazardous, radioactive, and mixed waste generation. Material selection considers environmental concerns, such as those that promote energy efficiency, resource conservation, and indoor air quality.

9.5. Ensure radioactive waste generated by exhaust ventilation systems during operation and maintenance activities (such as filters) is included in the overall waste management strategy.

9.6. Use bio-based fluids for hydraulic equipment and bio-based lubricants for mechanical equipment, where possible. Use oil-less vacuum pumps, where possible.
Appendix H
Formal ALARA Design Review for Facilities and Equipment

Use this form to document a Formal ALARA Review for Facilities and Equipment.

Facility or equipment:

Review conducted by:

ES&H Team health physicist concurrence:

Responsible Individual concurrence:

Authorizing Individual concurrence:

Design review date:

1. Scope of the Design Review

Specify the scope of radiological design review, including support equipment and systems, and associated hazardous materials, as appropriate.

2. Radiological Source Term

Specify the radiological source term in terms of dose rate at a given distance for radiation-generating devices, and in terms of grams or activity for radioactive materials. Include the physical and chemical form of the material.

3. Engineered Controls

Specify the engineered controls based on the ‘design considerations for facilities and equipment’ specified in Appendix G and any radiological controls required by the Safety Basis document. Address the following topics (as applicable), using the detailed guidance provided in Appendix G. Write ‘NA’ for non-applicable elements.

<table>
<thead>
<tr>
<th>Required Controls</th>
<th>Best Management Practice Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility/Operation</td>
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<tr>
<td>Layout</td>
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<tr>
<td>Maintenance and</td>
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<tr>
<td>Operations</td>
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### Required Controls

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<tr>
<th>Required Controls</th>
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<tbody>
<tr>
<td>Shielding</td>
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<tr>
<td>Contamination Control</td>
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<tr>
<td>Access Controls</td>
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<tr>
<td>Liquid Systems</td>
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<tr>
<td>Instrumentation</td>
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<tr>
<td>Ventilation</td>
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<tr>
<td>Waste Minimization</td>
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</tbody>
</table>

### Best Management Practice Controls

<table>
<thead>
<tr>
<th>Best Management Practice Controls</th>
</tr>
</thead>
</table>

### a. Identify any conditions that are inconsistent with the Appendix G guidelines.

### b. For previously uncontaminated areas/equipment, specify the extent of anticipated ‘new’ facility/equipment contamination.

### 4 Optimization Analysis

*If 'optimization analysis' was used to justify NOT implementing an engineered control, attach the analysis.*

### 5 Design Dose Criteria

*Indicate the expected annual whole body dose to the maximally exposed worker under normal operations, presuming controls are in place.*

<table>
<thead>
<tr>
<th>Dose Level</th>
<th>Approval Requirements</th>
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<tbody>
<tr>
<td>&lt; 0.1 rem</td>
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<tr>
<td>0.1 rem to 0.5 rem</td>
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<tr>
<td>0.5 rem to 1 rem</td>
<td>Requires Facility or Line Manager, and RCM approval</td>
</tr>
<tr>
<td>1 rem to 1.5 rem</td>
<td>Requires Facility or Line Manager, RCM, and PAD approval</td>
</tr>
<tr>
<td>1.5 rem to 2 rem</td>
<td>Requires Facility or Line Manager, RCM, and work authorization program associate director (PAD) approval</td>
</tr>
<tr>
<td>&gt; 2 rem</td>
<td>Requires Facility or Line Manager, RCM, work authorization program associate director (PAD), and Deputy Director approval</td>
</tr>
</tbody>
</table>
Appendix I

Formal ALARA Job/Experiment/Task (JET) Review

The ALARA Job/Experiment/Task (JET) review should be based on radiological conditions in existence or expected prior to implementation of the job-specific engineering and administrative controls. Non-job specific controls such as facility ventilation or CAMs may be presumed to be present. At a minimum, identify and evaluate the following when conducting an ALARA JET review.

1. The scope of the ALARA JET review.
   a. Identify the operation or tasks that are under review.
   b. Identify relevant written procedures/documents associated with the ALARA JET scope.

2. The reason for the ALARA JET review. (See Section 5.1.) If relevant, include:
   a. The calendar year-to-date dose for affected workers.
   b. The projected dose for individuals.
   c. The accumulated and projected collective dose.
   d. Previous years’ individual and cumulative dose.

3. Aspects of the operation that contribute significantly to dose/contamination potential.

4. Dose/contamination reduction methods.
   a. Identify controls currently in place.
   b. Identify additional or alternate controls that would be effective in reducing dose/contamination.
   c. Consider process controls, such as:
      — Elimination or reduction of radioactivity through product substitution and decontamination.
      — Use of work processes and special tooling to reduce time in the work area.
      — Staging and preparation of necessary materials and special tools.
      — Identification of points where signatures and second party or independent verifications are required.
      — Provisions for waste minimization and disposal.
   d. Consider engineered controls, such as:
      — Use of engineered controls to minimize the spread of contamination and generation of airborne radioactivity.
Engineering, design, and use of temporary shielding to reduce radiation levels.

Use of mock-ups for high exposure or complex tasks.

Maximization of prefabrication and shop work.

e. For jobs with high dose/contamination potential, consider administrative controls, such as:

- Using mock ups or computer simulations to estimate stay times, dose rates, and the resultant dose to the workers. Use of mockup training can significantly enhance the worker’s ability to minimize their dose by applying ALARA planning and practicing work techniques in background dose rate and uncontaminated environments.

- Requiring a walk-down or dry-run of the activity using applicable procedures.

- Review of abnormal and emergency procedures and plans.

5. Consider barriers to implementation. For example, if new material/equipment needs to be purchased/fabricated, identify:

a. The cost of the material/equipment, and whether or not funding is available (if known).

b. The timeframe for implementation (e.g., is the control immediately available? Will it take months to procure and install?)

6. If cost is a reason for not implementing a control, conduct an optimization analysis. (See Section 4.1.)

7. Document the ALARA JET review using the following form.
ALARA Job / Experiment / Task (JET) Review

Job / Experiment / Task name/number:

Associated Work Control documents:

Review conducted by:

ES&H Team health physicist concurrence:

Responsible Individual concurrence:

Authorizing Individual concurrence:

ALARA JET review date:

1. Scope of the ALARA JET Review

Specify the reason for the ALARA JET review. (See Section 5.1.)

Specify the scope of ALARA JET review, including associated hazardous materials, as appropriate.

2. Radiological Source Term

Identify aspects of the operation that contribute significantly to dose/contamination potential. Include an estimate of the source term, including dose rates and/or radionuclides and chemical and physical forms, as applicable.

3 Controls

Specify controls required and Best Management Practice (BMP) controls. Write ‘NA’ for non-applicable elements.

<table>
<thead>
<tr>
<th>Controls</th>
<th>Required</th>
<th>Best Management Practice</th>
</tr>
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<tbody>
<tr>
<td>Special dosimetry</td>
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<td></td>
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<tr>
<td>Respiratory protection</td>
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<tr>
<td>Existing dose reduction</td>
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<tr>
<td>techniques</td>
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Controls

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<tr>
<td>Existing contamination reduction techniques</td>
<td></td>
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<tr>
<td>Radiological hold points (decision points)</td>
<td></td>
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<tr>
<td>Radiological suspension points (scope of work)</td>
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<tr>
<td>New or modified engineered controls</td>
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<tr>
<td>New or modified process controls</td>
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<tr>
<td>New or modified administrative controls</td>
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</tbody>
</table>

4 Barriers to Implementation and Optimization Analysis

Identify barriers to implementation (e.g., if new material/equipment needs to be purchased/fabricated, identify the timeframe for implementation).

If ‘optimization analysis’ is used to justify NOT implementing an engineered control, attach the analysis.

5 Administrative Control Levels

Indicate the expected annual whole body dose to the maximally exposed worker under normal operations, presuming controls are in place. ACLs must be established if the expected dose is likely to be >0.1 rem/y.

[ ] < 0.1 rem
[ ] 0.1 rem to 0.5 rem
[ ] 0.5 rem to 1 rem – Requires RCM approval
[ ] 1 rem to 1.5 rem – Requires RCM and PAD approval
[ ] 1.5 rem to 2 rem – Requires RCM and Deputy Director approval

6 Distribution

Distribute the completed ALARA JET review to the RI, AI, ES&H Team health physicist, and the RCM.