# U.S. Department of Energy

Oakland Operations Office, Oakland, California

# FINAL RADIOLOGICAL PROTECTION PROGRAM

for the:

## LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH (LEHR) UNIVERSITY OF CALIFORNIA AT DAVIS, CALIFORNIA

*Submitted to:*

**U.S. Department of Energy**
Oakland Operations Office
1301 Clay Street
Oakland, CA 94612-5208

*Prepared by:*

**Weiss Associates**
5801 Christie Avenue, Suite 600
Emeryville, CA 94608-1827

November 19, 1999
Rev. 3

DOE Oakland Operations Contract DE-AC03-96SF20686

Weiss Associates
*Environmental and Geologic Services*

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Approvals Page

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# ACRONYMS

| | |
|---|---|
| ALARA | As-low-as-reasonably-achievable |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| D&D | Decontamination and Decommissioning |
| DOE | U. S. Department of Energy |
| EPA | U. S. Environmental Protection Agency |
| FFA | Federal Facility Agreement |
| RPP | Radiation Protection Program |
| LEHR | Laboratory for Energy-related Health Research |
| NPL | National Priority List |
| UC Davis | University of California at Davis |
| WA | Weiss Associates |

# RECORD OF REVISIONS/UPDATES

| Update Number | Description | Date |
|---|---|---|
| 1 | Final RPP, Rev. 1 | 06/08/95 |
| 2 | Draft RPP, Rev. 2B | 09/09/97 |
| 3 | Final RPP, Rev. 2 | 01/30/98 |
| 4 | Draft RPP, Rev. 3B (revision to include 10 CFR 835 Amendments of November 4, 1998) | 05/28/99 |
| 5 | Final RPP, Rev. 3 (addresses DOE comments on Draft RPP, Rev. 3B) | 11/19/99 |

# SUMMARY

The Laboratory for Energy-related Health Research (LEHR) is located approximately 1 mile south of the University of California at Davis (UC Davis) main campus, in Davis, California. In 1988, DOE's Office of Energy Research decided to discontinue the research program at LEHR, decommission LEHR, and return the facilities and site to UC Davis for unrestricted use. On May 31, 1994, the site was placed on the National Priority List (NPL).

The mission of the LEHR environmental restoration/waste management (ER/WM) project is to assess the nature and extent of site contamination, decontaminate and decommission (D&D) contaminated buildings, remove on-site radioactive, chemical, and potential mixed waste sources, remediate soil, and underground tank systems, as required, and verify that the site and associated facilities are adequately cleaned and can be released in accordance with applicable DOE, state and federal requirements and/or agreements.

The prime contractor to DOE for LEHR is Weiss Associates (WA). WA is responsible for ensuring compliance with LEHR's RPP. The requirements of 10 CFR 835 and the LEHR RPP will be passed on contractually, as applicable, to subcontractors and/or suppliers. Subcontractors will be responsible for compliance with the RPP as it applies to their specific scope of activities.

The content and format of this RPP is based upon meeting the requirements of 10 CFR Part 835 as applied using a graded approach. In addition, the implementation of this RPP includes "Lessons Learned" from: several years of site operations by WA; the findings and resulting corrective actions of internal audits; and, the findings and resulting corrective action of DOE audits. Contractual activities and associated radiological conditions surrounding LEHR site activities warrant review and implementation of the 10 CFR 835 requirements.

No additional funding beyond that required for maintaining compliance with the RPP is required at this time for DOE work tasks that are within the scope of current active task plans.

# 1. GENERAL INFORMATION

## 1.1 Policy

It is Weiss Associates' (WA) policy to ensure full compliance with the requirements established by the U.S. Department of Energy (DOE); prevent unnecessary radiation exposure to employees and the public; and, prevent harmful effects to the environment. We fully endorse DOE's policy as follows: "It is the policy of DOE to conduct its radiological operations in a manner that ensures the health and safety of all its employees, contractors, and the general public. In achieving this objective, DOE shall ensure that radiation exposures to its workers and the public and releases of radioactivity to the environment are maintained below regulatory limits and deliberate efforts are taken to further reduce exposures or releases as low as reasonably achievable (ALARA). The DOE is fully committed to implementing a radiological control program of the highest quality that consistently reflects this policy."

## 1.2 Purpose

The Radiation Protection Program (RPP) is the documented program including the plans, schedules, and other measures developed and implemented to achieve and ensure compliance with Title 10 Code of Federal Regulations Part 835 (10 CFR 835) and to apply the ALARA process to occupational exposure. As such, the purpose of the RPP, which includes the Laboratory for Energy-related Health Research's (LEHR's) implementation strategy, is to meet the requirements of 10 CFR Part 835, "Occupational Radiation Protection." The intent of this RPP is to act as a tool for occupational radiation protection in conformance with 10 CFR Part 835 as applicable to activities conducted in support of environmental restoration/waste management at the LEHR project site. This RPP implements the requirements of 10 CFR 835 using a graded approach (i.e., ensuring worker protection is adequate for the radiological conditions and work tasks at LEHR while maintaining worker dose ALARA). This Final RPP (Rev.3) is an update of the RPP (Rev. 2), dated January 30, 1998, and addresses the 10 CFR 835 Amendments promulgated on November 4, 1998. This Final RPP incorporates required DOE changes.

## 1.3 Facility Background and Mission

Facility Background: LEHR is located approximately 1 mile south of the University of California at Davis (UC Davis) main campus, in Davis, California. Davis is situated 13 miles west of Sacramento, California. The LEHR facility, which occupies approximately 15 acres, was operated by UC Davis for the DOE for more than 30 years to conduct studies of the long-term radiological

effects of low-level radiation exposure on laboratory animals. More than 1,000 beagles were studied in these projects, which primarily involved the use of strontium-90 ($^{90}Sr$) and radium-226 ($^{226}Ra$).

In 1988, DOE's Office of Energy Research decided to discontinue the research program, decommission LEHR, and return the facilities and site to UC Davis for unrestricted use. UC Davis and DOE initiated, and are continuing, investigations to fully characterize the nature and extent of possible environmental contamination at LEHR.

On May 31, 1994, the site was placed on the National Priority List (NPL). The schedule for clean-up activities is being negotiated with U.S. EPA and is expected to be formalized as part of the site Federal Facility Agreement (FFA).

Mission: The mission of the LEHR environmental restoration/waste management (ER/WM) project is to: assess the nature and extent of site contamination; decontaminate and decommission (D&D) contaminated buildings, remove on-site radioactive, chemical, and potential mixed waste sources; remediate soil, and underground tank systems, as required; and verify that the site and associated facilities are adequately cleaned and can be released in accordance with applicable DOE, state and federal requirements and/or agreements.

## 1.4 Contractors, Subcontractors, and Suppliers

The prime contractor to DOE for LEHR is WA. WA is responsible for ensuring compliance with LEHR's RPP. Subcontractors and suppliers provide service and/or products that aid WA in completing the mission for LEHR. The requirements of 10 CFR 835 and the LEHR RPP will be passed on contractually, as applicable, to subcontractors and/or suppliers. Subcontractors will be responsible for compliance with the RPP as it applies to their specific scope of activities.

## 1.5 Content and Format

The content and format of this RPP is based upon meeting the requirements of 10 CFR Part 835 as applied using a graded approach. In addition, the implementation of this RPP includes "Lessons Learned" from: several years of site operations by WA; the findings and resulting corrective actions of internal audits; and, the findings and resulting corrective action of DOE audits. Contractual activities and associated radiological conditions surrounding LEHR site activities warrant review and implementation of the 10 CFR 835 requirements. This RPP addresses each requirement of 10 CFR 835.

Appendix A contains a compliance matrix table that identifies all of the 10 CFR 835 requirements, presents the LEHR compliance statement, and references the LEHR written procedures that facilitate 10 CFR 835 compliance. The column entitled, 'Procedure Reference Information', within this RPP Compliance Matrix table may change as LEHR project documents are revised, project scope or activities change, or DOE modifies the requirements of 10 CFR 835 All definitions presented in 10 CFR 835.2 are incorporated into LEHR's procedures, plans and/or manuals by reference.

# 2. APPLICABILITY

This RPP applies to DOE funded activities for the LEHR ER/WM managed by WA and supports DOE's mission at LEHR related to Occupational Radiation Protection, 10 CFR Part 835.

As a general rule, no person shall take, or cause to be taken, any action inconsistent with the requirements of 10 CFR 835 or any program, plan, schedule, or other process established by 10 CFR 835. The DOE may direct or make modifications to this RPP in conjunction with WA concurrence. However, nothing in the requirements found in this RPP, nor 10 CFR 835, shall be construed as limiting actions necessary for the protection of worker health and safety. WA is responsible for compliance with the requirements of 10 CFR 835.

Requirements of 10 CFR 835 not applicable to LEHR activities include:

- 10 CFR 835.1(b)(1), (2),(3) and (5), Exclusion;
- 10 CFR 835.3 (c), No DOE Contractor;
- 10 CFR 835.204, Planned special exposures;
- 10 CFR 835.402 (c) and 835.402 (d), Individual Monitoring (internal)
- 10 CFR 835.502 (c) and 835.603 (c), Very high radiation areas;
- 10 CFR 835.604 (b) (3), Activated Radioactive Material;
- 10 CFR 835.1002, Facility design and modification; and,
- 10 CFR 835 Subpart N, Emergency Exposure Situations.

The description of the reasons for non-applicability can be found in the related article in the compliance matrix found in Appendix A. The LEHR program has prepared technical basis documents detailing pertinent issues and applicability for both internal and external dosimetry monitoring at LEHR (IT, 1999a and IT 1999b, respectively). The Memorandum of Agreement dated June 23, 1997 and associated future Building Release Agreements between the DOE and UC Davis reflect the buildings and areas for which UC Davis (the Site Landlord) has use, control, and responsibility. The RPP is not applicable to those buildings and areas for which UC Davis is responsible.

For those activities that are required by §§ 835.102, 835.901(e), 835.1202(a), and 835.1202(b), the time interval to conduct these activities may be extended by a period not to exceed 30 days to accommodate scheduling needs.

Since the activities conducted at LEHR involve decontamination and decommissioning (D&D), waste management, and remedial activities under CERCLA, the applicability of some of the articles may vary when applied to specific activities. The details of applicability will be applied utilizing a graded approach, an approach tailoring the requirements of the RPP to the scope and depth of activities to be conducted for each task. The extent of applicability and implementation will be discussed in site work plans and/or manuals, which control the work activity in these areas. A DOE

activity will be conducted in compliance with this RPP as approved by DOE. The scope of LEHR activities that the LEHR RPP covers are:

1) completion of decontamination and decommissioning (D&D) activities;

2) removal of on-site radioactive sources;

3) remediation and/or removal of soil contamination at DOE burial areas, leach fields, and outdoor dog pens;

4) closure or removal of underground tanks;

5) verification of cleanup completion; and

6) waste management of low-level and mixed waste D&D and remediation activity.

DOE is primarily responsible at LEHR for the cleanup of: the Southwest Trenches; the Radium/Strontium (Ra/Sr) Treatment System; the Domestic Septic Tanks; and, the Eastern and Western Dog Pens. The DOE restoration strategy focuses on removal actions utilizing streamlined CERCLA and DOE guidance and practices.

The majority of D&D has been completed, however, some facilities and buildings have remained in use and will have to undergo possible D&D and final release surveys after this use is no longer needed. Some of these facilities are the Mixed Waste Storage Facility, Geriatrics 1 (a waste storage area) and portions of Animal Hospital 1 (AH-1.)

Some legacy sources still remain on-site. These include: U-238 and a thorium nitrate source; 439 cubic meters of metal debris; Ra-226 sources/standards totaling 14 mCi; and, 21 other radioactive sources and standards (i.e. Am-241 Standard, Th-228 Sources, etc.).

Currently the sources/standards are slated for recycling/reuse by another facility, but, if this can not be accomplished, they will be packaged and shipped off-site for disposal.

Remediation and/or removal of solid contamination of DOE burial areas, leach fields and outdoor dog pens includes excavating and containerizing contaminated soil and debris from areas used in past operation of the site that have become radiologically impacted. This also includes sampling and utilization of an on-site lab to verify that all the contamination has been removed from an area.

Closure or removal of underground tanks includes the removal of the Imhoff and Radium 226 treatment system tanks and associated structures and closure or removal of the 7 domestic septic tanks and associated structures.

Verification of clean-up completion includes field activities, such as boring, drilling, and sampling, to verify that clean up goals have been met

LEHR's waste management scope as it applies to LEHR's RPP includes management, characterization, storage, packaging, and transportation for either disposal, recycling, or off-site storage of mixed, low-level radioactive material/waste generated as part of past research, D&D, and environmental restoration activities. It is anticipated that approximately 3,065 cubic yards more of low-level radioactive waste and approximately 43 cubic yards of mixed waste will be managed prior to completion of the project.

# 3. SAFETY AND IMPLEMENTATION GUIDES AND TECHNICAL STANDARDS

Appropriate safety and implementation guides and technical standards used for implementation of the RPP will be referenced in LEHR project documents.

Radiological units used in reports and/or records required by 10 CFR 835 shall use the special units of curie, rad, roentgen, or rem including multiples and subdivisions of these units. Other radiological units, as specified in 10 CFR 835, are acceptable for use.

Written procedures shall be developed and implemented as necessary to ensure compliance with 10 CFR 835, commensurate with the radiological hazards created by the activity and consistent with the education, training, and skills of the individuals exposed to those hazards.

# 4. AS-LOW-AS-REASONABLY-ACHIEVABLE

The ALARA Program at LEHR covers the requirements of 10 CFR 835, and is described in the LEHR Final As-Low-as-Reasonably-Achievable (ALARA) Program (LEHR, 1999a, or latest revision thereof). Given the scope of work at LEHR, most ALARA dose reduction actions will focus on containment of contaminants and the three basic ALARA principles of time, distance, and shielding. To this end, appropriate field monitoring becomes an integral part of the ALARA program.

According to DOE Guidance (DOE G 441.1-2), ALARA plans and measures should address the following elements at a level commensurate with the radiological hazards associated with the DOE activity:

- Policy and Management Commitments,
- ALARA Training,
- Plans and Procedures & Radiological Work Administration and Planning,
- Internal Assessments/Audits,
- ALARA Design Review, and
- Records.

The following are the sections referenced above that are taken from the LEHR ALARA Program.

## 4.1 Policy and Management Commitments

### *4.1.1 DOE ALARA Policy*

The importance of the ALARA concept was stressed in DOE Policy P 441.1, DOE RADIOLOGICAL HEALTH AND SAFETY POLICY, which states:

*It is the policy of the Department of Energy to conduct its radiological operations in a manner that ensures the health and safety of all its employees, contractors, and the general public. In achieving this objective, the Department shall ensure that radiation exposures to its workers and the public and releases of radioactivity to the environment are maintained below regulatory limits and deliberate efforts are taken to further reduce exposures and releases as low as reasonably achievable. The Department is fully committed to implementing a radiological control program of the highest quality that consistently reflects this policy.*

### *4.1.2 LEHR ALARA Policy*

It is the policy of the LEHR Environmental Restoration/Waste Management Program to conduct the site activities in a manner to protect the health and safety of site workers and the public, and ensure compliance with applicable federal, state, and local laws and regulations concerning radiation protection of workers, the public, and the environment. The management team of Weiss Associates (the LEHR prime contractor) and subcontractors are committed, in all its activities, to reduce any safety or health risks associated with radioactive materials ionizing radiation and exposures to the work force, general public, and the environment to levels that ALARA taking into account social, technical, economic, practical, and public policy considerations.

The LEHR ALARA Program is the formal program which management has the responsibility of implementing and maintaining to ensure that exposures to workers and the public are consistent with this policy.

### *4.1.3 Management Commitment*

Management support and commitment to reducing individual and collective exposures and controlling radioactive contamination to further reduce external and internal exposures is critical to the success of the LEHR ALARA Program. This commitment, which is an important part the LEHR 10 CFR 835 Radiation Protection Program, is demonstrated by management's allocation of sufficient resources to ALARA program activities (e.g., providing personnel, training, and material to ensure the implementation of the ALARA program).

## 4.2 ALARA Training

ALARA training and retraining shall be documented, and conducted at a sufficient frequency (retraining shall be required every 2 years per 10 CFR 835.902) to ensure each contractor, subcontractor and individual involved in the site restoration and waste management activities is implementing the ALARA program. The objectives and content of the training courses or modules shall be specific to the individual's job assignments, e.g., training for general employees; radiation workers; radiation protection technicians; engineers and programmers; managers and task leaders. The focus of these training programs shall be to heighten individual awareness of ALARA principle, principle of ALARA, basic ALARA techniques, dose and contamination reduction techniques, and to inform individuals of their responsibilities for implementing the program. Training shall, at a minimum, comply with the requirements set forth in LEHR RPP.

## 4.3 Plans and Procedures & Radiological Work Administration and Planning

Work Plans and procedures for conduct of environmental restoration/waste management activities will be prepared and include reference to ALARA considerations for minimizing doses to workers and the public. ALARA considerations include engineering controls (e.g., shielding), administrative controls (e.g., hazardous work permits), scheduling of work, briefing and debriefing of

workers, and documenting and analyzing past work experiences. Such Plans or procedures will be approved, issued, and updated by LEHR management as needed. LEHR management will ensure that Plans or procedures are implemented so that ALARA considerations are optimized.

## 4.4 Internal Assessments/Audits

Periodic internal audits of the overall ALARA Program will be performed, with audit results reported to LEHR's Radiological Control Manager (10 CFR 835.102). Decisions regarding corrective actions would be promptly rendered and followed by timely implementation. The LEHR Radiological Control Manager will be responsible for ensuring periodic internal audit(s) of the overall ALARA program for the LEHR environmental restoration activities are conducted. Such audit(s) will be conducted on a schedule no less then every 36 months as required in the LEHR RPP. Audit findings will be tracked by management, and corrective actions will be implemented in a timely manner.

## 4.5 ALARA Design Review

LEHR's Scope of Activities and Mission are such that there is limited design for radiological facilities. However, if circumstances warrant design, then work Programs will be developed that integrate ALARA into development and review of the designs.

## 4.6 Records

The management of radiological records is essential to the ALARA Program, since the applicable records are maintained for accuracy and historical purposes. The required storage, retention, and records that are generated by the ALARA Program are managed in compliance with 10CFR835 as detailed with the procedures referenced in Appendix A of this RPP.

The records will include copies of all documentation used to justify ALARA decisions in the design, operations, and cleanup phases. Documentation of the ALARA committee meetings will also be maintained.

# 5. EXEMPTION/EXCEPTIONS

A request for exception for DOELAP accreditation for external dosimetry monitoring (WA, 1999b) has been submitted to DOE.

# 6. CHANGES/MODIFICATIONS TO THE RADIOLOGICAL PROTECTION PROGRAM

If changes are needed to the LEHR RPP, an RPP Change Request Form shall be completed. This form (see Appendix B) indicates the nature of the change, the justification for the change, and the impact on the RPP. Changes, additions, or updates to the RPP will become effective without prior DOE approval only if the changes do not decrease the effectiveness of the RPP. Proposed changes that decrease the effectiveness of the RPP will not be implemented without submittal to and approval of the DOE.

The RPP, as changed, must continue to meet the requirements of 10 CFR 835. Proposed changes or tasks that are outside of the original scope of the RPP, or that decrease effectiveness of the RPP, shall not be implemented without submittal to and approval by DOE. An updated RPP must be submitted within 180 days of a change request or the effective date of any DOE modifications to 10 CFR 835. The RPP is considered approved 180 days after submission unless rejected by DOE earlier than 180 days. DOE may direct or make modifications to the LEHR RPP.

All updates to the RPP Compliance Matrix (Table A-1) will be transmitted to the DOE Project Manager when the RPP document is updated.

# 7. RADIOLOGICAL PROTECTION PROGRAM AUDITS

Internal audits of all functional elements of the radiation protection program shall be conducted no less frequently than every 36 months and shall include program content and implementation, (10 CFR 835.102).

# 8. REFERENCES

Technical Basis for Monitoring of Internal Dose to Individuals, 1999a, The IT Group, Knoxville, Tennessee, November 18, 1999.

Technical Basis for Monitoring of External Dose to Individuals, 1999b, The IT Group, Knoxville, Tennessee, November 18, 1999.

Request for Exception to DOELAP Accreditation for External Dosimetry Monitoring, 1999b, Weiss Associates, Emeryville, California, November 19, 1999.

Final As Low As Reasonably Achievable (ALARA) Program, Weiss Associates, Emeryville, California, Rev. 3, July 20, 1999.

U.S. Department of Energy (DOE), 1998. Occupational Radiation Protection, Final Rule (10 CFR 835): Federal Register Vol. 58, No. 238 (P. 65458-66612), December 14, 1993, and as amended in the Federal Register Vol. 63, No. 213 (p. 59679-59689), November 4, 1998.

# APPENDIX A

## RADIOLOGICAL PROTECTION PROGRAM COMPLIANCE MATRIX

Table A-1. Radiological Protection Program (RPP) Compliance Matrix

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | | **SUBPART A - GENERAL PROVISIONS** | |
| | | **Definitions** | |
| 1(a) | *General.* The rules in this part establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities. | LEHR's plans integrate this general statement as follows:<br>The rules in this part establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities. | RPP, Appendix A |
| 1(b) | Exclusion. Except as discussed in paragraph(c) of this section, the requirements in this part do not apply to: | LEHR's plans integrate these exclusions, as follows: | RPP, Appendix A |
| | (1) Activities than are regulated through a license by the Nuclear Regulatory Commission, including activities certified by the Nuclear Regulatory Commission under section 1701 of the Atomic Energy Act; | Not applicable to LEHR. | NA |
| | (2) Activities conducted under the authority of the Director, Naval Nuclear Propulsion Program, as directed by Pub. L. 98-525; | Not applicable to LEHR | NA |
| | (3) Activities conducted under the Nuclear Explosives and Weapons Surety Program relating to the prevention of accidental or unauthorized nuclear detonations; | Not applicable to LEHR | NA |
| | (4) Radioactive material transportation as defined in this part; | Radioactive material transportation is applicable to the LEHR project. | RPP, Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | (5) DOE activities conducted outside the United States on territory under th4e jurisdiction of a foreign government to the extent governed by occupational radiation protection requirements agreed to between the United States and the cognizant government; or | Not applicable to LEHR | NA |
| | (6) Background radiation, radiation doses received as a patient for the purposes of medical diagnosis or therapy, or radiation doses received from participation as a subject in medical research programs. | Applicable to LEHR | RPP, Appendix A |
| | (c) Occupational doses received as a result of excluded activities and radioactive material transportation, as listed in paragraphs (b)(1) through (b)(5) of this section, shall be considered when determining compliance with the occupational dose limits at §§835.202 and 835.207, and with the limits for the embryo/fetus at §835.206. Occupational doses resulting from authorized emergency exposures and planned special exposures shall not be considered when determining compliance with the dose limits at §§835.202 and 835.207. | Applicable to LEHR | RPP, Appendix A |
| 2(a).01 | *Accountable sealed radioactive source* means a sealed radioactive source having a half-life equal to or greater than 30 days and an isotopic activity equal to or greater than the corresponding value provided in appendix E of this part. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Accountable sealed radioactive source* means a sealed radioactive source having a half-life equal to or greater than 30 days and an isotopic activity equal to or greater than the corresponding value provided in appendix E of 10 CFR 835. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).02 | *Airborne radioactive material or airborne radioactivity* means radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Airborne radioactive material or airborne radioactivity* means radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases. | RPP, Section 1.5 and Appendix A |
| 2(a).03 | *Airborne radioactivity area* means any area, accessible to individuals, where:<br>(1) The concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed the derived air concentration (DAC) values listed in appendix A or appendix C of this part; or<br>(2) An individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-hours in a week. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Airborne radioactivity area* means any area, accessible to individuals, where:<br>(1) The concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed the derived air concentration (DAC) values listed in appendix A or appendix C of 10 CFR 835; or<br>(2) An individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-hours in a week. | RPP, Section 1.5 and Appendix A |
| 2(a).04 | *ALARA* means "As Low As is Reasonably Achievable," which is the approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. As used in this part, ALARA is not a dose limit but a process which has the objective of attaining doses as far below the applicable limits of this part as is reasonably achievable. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*ALARA* means "As Low As is Reasonably Achievable," which is the approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. As used in 10 CFR 835, ALARA is not a dose limit but a process which has the objective of attaining doses as far below the applicable limits of 10 CFR 835 as is reasonably achievable. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).05 | *Annual limit on intake (ALI)* means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man (ICRP Publication 23) that would result in a committed effective dose equivalent of 5 rems (0.05 sievert) or a committed dose equivalent of 50 rems (0.5 sievert) to any individual organ or tissue. ALI values for intake by ingestion and inhalation of selected radionuclides are based on Table 1 of the U.S. Environmental Protection Agency's Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, published September 1988. This document is available from the National Technical Information Service, Springfield, VA. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Annual limit on intake (ALI)* means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man (ICRP Publication 23) that would result in a committed effective dose equivalent of 5 rems (0.05 sievert) or a committed dose equivalent of 50 rems (0.5 sievert) to any individual organ or tissue. ALI values for intake by ingestion and inhalation of selected radionuclides are based on Table 1 of the U.S. Environmental Protection Agency's Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, published September 1988. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).06 | *Background* means radiation from:<br>(i). Naturally occurring radioactive materials which have not been technologically enhanced;<br>(ii). Cosmic sources;<br>(iii). Global fallout as it exists in the environment (such as from the testing of nuclear explosive devices);<br>(iv). Radon and its progeny in concentrations or levels existing in buildings or the environment which have not been elevated as a result of current or prior activities; and<br>(v). Consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Background* means radiation from:<br>(i). Naturally occurring radioactive materials which have not been technologically enhanced;<br>(ii). Cosmic sources;<br>(iii). Global fallout as it exists in the environment (such as from the testing of nuclear explosive devices);<br>(iv). Radon and its progeny in concentrations or levels existing in buildings or the environment which have not been elevated as a result of current or prior activities; and<br>(v). Consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation. | RPP, Section 1.5 and Appendix A |
| 2(a).07 | *Bioassay* means the determination of kinds, quantities, or concentrations, and, in some cases, locations of radioactive material in the human body, whether by direct measurement or by analysis, and evaluation of radioactive materials excreted or removed from the human body. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Bioassay* means the determination of kinds, quantities, or concentrations, and, in some cases, locations of radioactive material in the human body, whether by direct measurement or by analysis, and evaluation of radioactive materials excreted or removed from the human body. | RPP, Section 1.5 and Appendix A |
| 2(a).08 | *Calibration* means to adjust and/or determine either:<br>(i). The response or reading of an instrument relative to a standard (e.g., primary, secondary, or tertiary) or to a series of conventionally true values; or<br>(ii). The strength of a radiation source relative to a standard (e.g., primary, secondary, or tertiary) or conventionally true value. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Calibration* means to adjust and/or determine either:<br>(i). The response or reading of an instrument relative to a standard (e.g., primary, secondary, or tertiary) or to a series of conventionally true values; or<br>(ii). The strength of a radiation source relative to a standard (e.g., primary, secondary, or tertiary) or conventionally true value. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).09 | *Contamination area* means any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in appendix D of this part, but do not exceed 100 times those values. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Contamination area* means any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in appendix D of 10 CFR 835, but do not exceed 100 times those values. | RPP, Section 1.5 and Appendix A |
| 2(a).10 fix rest of numbers | *Contractor* means any entity under contract with the Department of Energy with the responsibility to perform activities at a DOE site or facility. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Contractor* means any entity under contract with the Department of Energy with the responsibility to perform activities at a DOE site or facility. | RPP, Section 1.5 and Appendix A |
| 2(a).11 | *Controlled area* means any area to which access is managed by or for DOE to protect individuals from exposure to radiation and/or radioactive material. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Controlled area* means any area to which access is managed by or for DOE to protect individuals from exposure to radiation and/or radioactive material. | RPP, Section 1.5 and Appendix A |
| 2(a).12 | *Declared pregnant worker* means 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 § 835.206. This declaration may be revoked, in writing, at any time by the declared pregnant worker. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Declared pregnant worker* means 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 § 835.206. This declaration may be revoked, in writing, at any time by the declared pregnant worker. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).13 | *Derived air concentration (DAC)* means for the radionuclides listed in Appendix A of this part, the airborne concentration that equals the ALI divided by the volume of air breathed by an average worker for a working year of 2000 hours (assuming a breathing volume of 2400 $m^3$). For the radionuclides listed in Appendix C of this part, the air immersion DACs were calculated for a continuous, non-shielded exposure via immersion in a semi-infinite atmospheric cloud. The value is based upon the derived airborne concentration found in Table 1 of the U.S. Environmental Protection Agency's Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, published September 1988. This document is available from the National Technical Information Service, Springfield, VA. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Derived air concentration (DAC)* means for the radionuclides listed in Appendix A of 10 CFR 835, the airborne concentration that equals the ALI divided by the volume of air breathed by an average worker for a working year of 2000 hours (assuming a breathing volume of 2400 $m^3$). For the radionuclides listed in Appendix C of 10 CFR 835, the air immersion DACs were calculated for a continuous, non-shielded exposure via immersion in a semi-infinite atmospheric cloud. The value is based upon the derived airborne concentration found in Table 1 of the U.S. Environmental Protection Agency's Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, published September 1988. | RPP, Section 1.5 and Appendix A |
| 2(a).14 | *Derived air concentration-hour (DAC-hour)* means the product of the concentration of radioactive material in air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide, in hours. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Derived air concentration-hour (DAC-hour)* means the product of the concentration of radioactive material in air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide, in hours. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).15 | *DOE activity* means an activity taken for or by DOE in a DOE operation or facility that has the potential to result in the occupational exposure of an individual to radiation or radioactive material. The activity may be, but is not limited to, design, construction, operation, or decommissioning. To the extent appropriate, the activity may involve a single DOE facility or operation or a combination of facilities and operations, possibly including an entire site or multiple DOE sites. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*DOE activity* means an activity taken for or by DOE in a DOE operation or facility that has the potential to result in the occupational exposure of an individual to radiation or radioactive material. The activity may be, but is not limited to, design, construction, operation, or decommissioning. To the extent appropriate, the activity may involve a single DOE facility or operation or a combination of facilities and operations, possibly including an entire site or multiple DOE sites. | RPP, Section 1.5 and Appendix A |
| 2(a).16 | *Entrance or access point* means any location through which an individual could gain access to areas controlled for the purposes of radiation protection. This includes entry or exit portals of sufficient size to permit human entry, irrespective of their intended use. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Entrance or access point* means any location through which an individual could gain access to areas controlled for the purposes of radiation protection. This includes entry or exit portals of sufficient size to permit human entry, irrespective of their intended use. | RPP, Section 1.5 and Appendix A |
| 2(a).17 | *General employee* means an individual who is either a DOE or 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. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*General employee* means an individual who is either a DOE or 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. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).18 | *High contamination area* means 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 this part. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*High contamination area* means 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 10 CFR 835. | RPP, Section 1.5 and Appendix A |
| 2(a).19 | *High radiation area* means any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.1 rem (0.001 sievert) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*High radiation area* means any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.1 rem (0.001 sievert) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. | RPP, Section 1.5 and Appendix A |
| 2(a).20 | *Individual* means any human being. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Individual* means any human being. | RPP, Section 1.5 and Appendix A |
| 2(a).21 | *Member of the public* means an individual who is not a general employee. An individual is not a "member of the public" during any period in which the individual receives an occupational dose. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Member of the public* means an individual who is not a general employee. An individual is not a "member of the public" during any period in which the individual receives an occupational dose. | RPP, Section 1.5 and Appendix A |
| 2(a).22 | *Minor* means an individual less than 18 years of age. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Minor* means an individual less than 18 years of age. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).23 | *Monitoring* means 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. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Monitoring* means 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. | RPP, Section 1.5 and Appendix A |
| 2(a).24 | *Nonstochastic effects* means effects due to radiation exposure for which the severity varies with the dose and for which a threshold normally exists (e.g., radiation-induced opacities within the lens of the eye). | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Nonstochastic effects* means effects due to radiation exposure for which the severity varies with the dose and for which a threshold normally exists (e.g., radiation-induced opacities within the lens of the eye). | RPP, Section 1.5 and Appendix A |
| 2(a).25 | *Occupational dose* means an individual's ionizing radiation dose (external and internal) as a result of that individual's 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. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Occupational dose* means an individual's ionizing radiation dose (external and internal) as a result of that individual's 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. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).26 | *Person* means any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency, any State or political subdivision of, or any political entity within a State, any foreign government or nation or other entity, and any legal successor, representative, agent or agency of the foregoing; provided that person does not include the Department or the United States Nuclear Regulatory Commission. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Person* means any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency, any State or political subdivision of, or any political entity within a State, any foreign government or nation or other entity, and any legal successor, representative, agent or agency of the foregoing; provided that person does not include the Department or the United States Nuclear Regulatory Commission. | RPP, Section 1.5 and Appendix A |
| 2(a).27 | *Radiation* means ionizing radiation: alpha particles: beta particles; gamma rays; X-rays; neutrons; high-speed electrons; high-speed protons; and, other particles capable of producing ions. Radiation as used in this part, does not include non-ionizing radiation, such as radio- or micro-waves, or visible, infrared, or ultraviolet light. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Radiation* means 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 10 CFR 835, does not include non-ionizing radiation, such as radio- or micro-waves, or visible, infrared, or ultraviolet light. | RPP, Section 1.5 and Appendix A |
| 2(a).28 | *Radiation area* means any area accessible to individuals in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.005 rem (0.05 millisievert) in 1 hour at 30 centimeters from the source or from any surface that the radiation penetrates. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Radiation area* means any area accessible to individuals in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.005 rem (0.05 millisievert) in 1 hour at 30 centimeters from the source or from any surface that the radiation penetrates. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).29 | *Radioactive material area* means any area within a controlled area, accessible to individuals, in which items or containers of radioactive material exist and the total activity of radioactive material exceeds the applicable values provided in appendix E of this part. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Radioactive material area* means any area within a controlled area, accessible to individuals, in which items or containers of radioactive material exist and the total activity of radioactive material exceeds the applicable values provided in appendix E of 10 CFR 835. | RPP, Section 1.5 and Appendix A |
| 2(a).30 | *Radioactive material transportation* means the movement of radioactive material by aircraft, rail, vessel, or highway vehicle when such movement is subject to Department of Transportation regulations or DOE Orders that govern such movements. Radioactive material transportation does not include preparation of material or packagings for transportation, monitoring required by 10 CFR 835, storage of material awaiting transportation, or application of markings and labels required for transportation. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Radioactive material transportation* means the movement of radioactive material by aircraft, rail, vessel, or highway vehicle when such movement is subject to Department of Transportation regulations or DOE Orders that govern such movements. Radioactive material transportation does not include preparation of material or packagings for transportation, monitoring required by 10 CFR 835, storage of material awaiting transportation, or application of markings and labels required for transportation. | RPP, Section 1.5 and Appendix A |
| 2(a).31 | *Radiological area* means any area within a controlled area defined in this section as a "radiation area," "high radiation area," "very high radiation area," "contamination area," "high contamination area," or "airborne radioactivity area." | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Radiological area* means any area within a controlled area defined in this section as a "radiation area," "high radiation area," "very high radiation area," "contamination area," "high contamination area," or "airborne radioactivity area." | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).32 | *Radiological worker* means a general employee whose job assignment involves operation of radiation producing devices or working with radioactive materials, or who is likely to be routinely occupationally exposed above 0.1 rem (0.001 sievert) per year total effective dose equivalent. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Radiological worker* means a general employee whose job assignment involves operation of radiation producing devices or working with radioactive materials, or who is likely to be routinely occupationally exposed above 0.1 rem (0.001 sievert) per year total effective dose equivalent. | RPP, Section 1.5 and Appendix A |
| 2(a).33 | *Real-time air monitoring* means measurement of the concentrations or quantities of airborne radioactive materials on a continuous basis. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Real-time air monitoring* means measurement of the concentrations or quantities of airborne radioactive materials on a continuous basis. | RPP, Section 1.5 and Appendix A |
| 2(a).34 | *Respiratory protective device* means an apparatus, such as a respirator, worn by an individual for the purpose of reducing the individual's intake of airborne radioactive materials. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Respiratory protective device* means an apparatus, such as a respirator, worn by an individual for the purpose of reducing the individual's intake of airborne radioactive materials. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).35 | *Sealed radioactive source* means a radioactive source manufactured, obtained, or retained for the purpose of utilizing the emitted radiation. The sealed radioactive source consists of a known or estimated quantity of radioactive material contained within a sealed capsule, sealed between layer(s) of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material. Sealed radioactive sources do not include reactor fuel elements, nuclear explosive devices, and radioisotope thermoelectric generators. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Sealed radioactive source* means a radioactive source manufactured, obtained, or retained for the purpose of utilizing the emitted radiation. The sealed radioactive source consists of a known or estimated quantity of radioactive material contained within a sealed capsule, sealed between layer(s) of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material. Sealed radioactive sources do not include reactor fuel elements, nuclear explosive devices, and radioisotope thermoelectric generators. | RPP, Section 1.5 and Appendix A |
| 2(a).36 | *Source leak test* means a test to determine if a sealed radioactive source is leaking radioactive material. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Source leak test* means a test to determine if a sealed radioactive source is leaking radioactive material. | RPP, Section 1.5 and Appendix A |
| 2(a).37 | *Stochastic effects* means malignant and hereditary diseases for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose without a threshold for radiation protection purposes. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Stochastic effects* means malignant and hereditary diseases for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose without a threshold for radiation protection purposes. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(a).38 | *Very high radiation area* means any area accessible to individuals in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in one hour at 1 meter from a radiation source or from any surface that the radiation penetrates. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Very high radiation area* means any area accessible to individuals in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in one hour at 1 meter from a radiation source or from any surface that the radiation penetrates. | RPP, Section 1.5 and Appendix A |
| 2(a).39 | *Week* means a period of seven consecutive days. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Week* means a period of seven consecutive days. | RPP, Section 1.5 and Appendix A |
| 2(a).40 | *Year* means the period of time beginning on or near January 1 and ending on or near December 31 of that same year used to determine compliance with the provisions of 10 CFR 835. The starting and ending date of the year used to determine compliance may be changed provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Year* means the period of time beginning on or near January 1 and ending on or near December 31 of that same year used to determine compliance with the provisions of 10 CFR 835. The starting and ending date of the year used to determine compliance may be changed provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years. | RPP, Section 1.5 and Appendix A |
| 2(b).01 | *Absorbed dose (D)* means the energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray). | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Absorbed dose (D)* means the energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray). | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(b).02 | *Committed dose equivalent ($H_{T,50}$)* means the dose equivalent calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem (or sievert). | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Committed dose equivalent ($H_{T,50}$)* means the dose equivalent calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem (or sievert). | RPP, Section 1.5 and Appendix A |
| 2(b).03 | *Committed effective dose equivalent ($H_{E,50}$)* means the sum of the committed dose equivalents to various tissues in the body ($H_{T,50}$), each multiplied by the appropriate weighting factor ($w_T$)--that is, $H_{E,50} = \Sigma w_T H_{T,50}$. Committed effective dose equivalent is expressed in units of rem (or sievert). | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Committed effective dose equivalent ($H_{E,50}$)* means the sum of the committed dose equivalents to various tissues in the body ($H_{T,50}$), each multiplied by the appropriate weighting factor ($w_T$)--that is, $H_{E,50} = \Sigma w_T H_{T,50}$. Committed effective dose equivalent is expressed in units of rem (or sievert). | RPP, Section 1.5 and Appendix A |
| 2(b).04 | *Cumulative total effective dose equivalent* means the sum of all total effective dose equivalent values recorded for an individual, where available, for each year occupational dose was received, beginning January 1, 1989. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Cumulative total effective dose equivalent* means the sum of all total effective dose equivalent values recorded for an individual, where available, for each year occupational dose was received, beginning January 1, 1989. | RPP, Section 1.5 and Appendix A |
| 2(b).05 | *Deep dose equivalent* means the dose equivalent derived from external radiation at a depth of 1 cm in tissue. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Deep dose equivalent* means the dose equivalent derived from external radiation at a depth of 1 cm in tissue. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(b).06 | *Dose* is a general term for absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent as defined in 10 CFR 835. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Dose* is a general term for absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent as defined in 10 CFR 835. | RPP, Section 1.5 and Appendix A |
| 2(b).07 | *Dose equivalent (H)* means the product of absorbed dose (D) in rad (or gray) in tissue, a quality factor (Q), and other modifying factors (N). Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert). | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Dose equivalent (H)* means the product of absorbed dose (D) in rad (or gray) in tissue, a quality factor (Q), and other modifying factors (N). Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert). | RPP, Section 1.5 and Appendix A |
| 2(b).08 | *Effective dose equivalent ($H_E$)* means the summation of the products of the dose equivalent received by specified tissues of the body ($H_T$) and the appropriate weighting factor ($w_T$)--that is, $H_E = \Sigma w_T H_T$. It includes the dose from radiation sources internal and/or external to the body. For purposes of compliance with 10 CFR 835, deep dose equivalent to the whole body may be used as effective dose equivalent for external exposures. The effective dose equivalent is expressed in units of rem (or sievert). | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Effective dose equivalent ($H_E$)* means the summation of the products of the dose equivalent received by specified tissues of the body ($H_T$) and the appropriate weighting factor ($w_T$)--that is, $H_E = \Sigma w_T H_T$. It includes the dose from radiation sources internal and/or external to the body. For purposes of compliance with 10 CFR 835, deep dose equivalent to the whole body may be used as effective dose equivalent for external exposures. The effective dose equivalent is expressed in units of rem (or sievert). | RPP, Section 1.5 and Appendix A |
| 2(b).09 | *External dose or exposure* means that portion of the dose equivalent received from radiation sources outside the body (i.e., "external sources"). | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*External dose or exposure* means that portion of the dose equivalent received from radiation sources outside the body (i.e., "external sources"). | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(b).10 | *Extremity* means hands and arms below the elbow or feet and legs below the knee. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Extremity* means hands and arms below the elbow or feet and legs below the knee. | RPP, Section 1.5 and Appendix A |
| 2(b).11 | *Internal dose or exposure* means that portion of the dose equivalent received from radioactive material taken into the body (e.g., "internal sources"). | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Internal dose or exposure* means that portion of the dose equivalent received from radioactive material taken into the body (e.g., "internal sources"). | RPP, Section 1.5 and Appendix A |
| 2(b).12 | *Lens of the eye dose equivalent* means the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 cm. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Lens of the eye dose equivalent* means the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 cm. | RPP, Section 1.5 and Appendix A |
| 2(b).13 | *Quality factor (Q)* means the modifying factor used to calculate the dose equivalent from the absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate quality factor.<br>(i) The quality factors to be used for determining dose equivalent in rem are listed in 10 CFR 835. When spectral data are insufficient to identify the energy of the neutrons, a quality factor of 10 shall be used.<br>(ii) When spectral data are sufficient to identify the energy of the neutrons, the following mean quality factor values as listed in 10 CFR 835 may be used. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>*Quality factor (Q)* means the modifying factor used to calculate the dose equivalent from the absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate quality factor.<br>(i) The quality factors to be used for determining dose equivalent in rem are listed in 10 CFR 835.<br>When spectral data are insufficient to identify the energy of the neutrons, a quality factor of 10 shall be used.<br>(ii) When spectral data are sufficient to identify the energy of the neutrons, the following mean quality factor values as listed in 10 CFR 835 may be used. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(b).14 | *Shallow dose equivalent* means the dose equivalent deriving from external radiation at a depth of 0.007 cm in tissue. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Shallow dose equivalent* means the dose equivalent deriving from external radiation at a depth of 0.007 cm in tissue. | RPP, Section 1.5 and Appendix A |
| 2(b).15 | *Total effective dose equivalent (TEDE)* means the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Total effective dose equivalent (TEDE)* means the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). | RPP, Section 1.5 and Appendix A |
| 2(b).16 | *Weighting factor ($w_T$)* means 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 listed in 10 CFR 835. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Weighting factor ($w_T$)* means 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 listed in 10 CFR 835. | RPP, Section 1.5 and Appendix A |
| 2(b).17 | *Whole body* means for the purposes of external exposure, head, trunk (including male gonads), arms above and including the elbow, or legs above and including the knee. | LEHR's procedures, plans, and/or manuals integrate this definition as stated: *Whole body* means for the purposes of external exposure, head, trunk (including male gonads), arms above and including the elbow, or legs above and including the knee. | RPP, Section 1.5 and Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 2(c) | Terms defined in the Atomic Energy Act and not defined in 10 CFR 835 are used consistent with the meanings given in the Act. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>Terms defined in the Atomic Energy Act and not defined in 10 CFR 835 are used consistent with the meanings given in the Act. | RPP, Section 1.5 and Appendix A |
| 2(d) | As used in this part, words in the singular also include the plural and words in the masculine gender also include the feminine and vice versa, as the case may be. | LEHR's procedures, plans, and/or manuals integrate this definition as stated:<br>As used in this part, words in the singular also include the plural and words in the masculine gender also include the feminine and vice versa, as the case may be. | RPP, Appendix A |
| | | **General Rule** | |
| 3(a) | No person or DOE personnel SHALL take or cause to be taken any action inconsistent with the requirements of:<br>(1) 10 CFR 835; or<br>(2) Any program, plan, schedule, or other process established by 10 CFR 835. | LEHR's RPP includes a statement which requires the following:<br>No person or DOE personnel SHALL take or cause to be taken any action inconsistent with the requirements of:<br>(1) 10 CFR 835; or<br>(2) Any program, plan, schedule, or other process established by 10 CFR 835. | RPP, Section 2.0 |
| 3(b) | With respect to a particular DOE activity, contractor management SHALL be responsible for compliance with the requirements of 10 CFR 835. | LEHR's RPP includes a statement which requires the following:<br>With respect to a particular DOE activity, contractor management SHALL be responsible for compliance with the requirements of 10 CFR 835. | RPP, Section 2.0 |
| 3(c) | Where there is no contractor for a DOE activity, DOE SHALL ensure implementation of and compliance with the requirements of 10 CFR 835. | This element is not applicable to the LEHR site as Weiss Associates is currently DOE's prime contractor. | Not Applicable (NA) |
| 3(d) | Nothing in 10 CFR 835 SHALL be construed as limiting actions that may be necessary to protect health and safety. | LEHR's RPP includes a statement which requires the following:<br>Nothing in 10 CFR 835 SHALL be construed as limiting actions that may be necessary to protect health and safety. | RPP, Section 2.0 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 3(e) | For those activities that are required by §§ 835.102, 835.901(e), 835.1202(a), and 835.1202(b), the time interval to conduct these activities may be extended by a period not to exceed 30 days to accommodate scheduling needs. | LEHR's RPP includes a statement which requires the following: For those activities that are required by §§ 835.102, 835.901(e), 835.1202(a), and 835.1202(b), the time interval to conduct these activities may be extended by a period not to exceed 30 days to accommodate scheduling needs. | RPP, Section 2.0 |
| | | **Radiological Units** | |
| 4 | Unless otherwise specified, the quantities used in the records required by 10 CFR 835 shall be clearly indicated in special units of curie, rad, roentgen, or rem, including multiples and subdivisions of these units. The SI units, becquerel (Bq), gray (Gy), and sievert (Sv), are only provided parenthetically in 10 CFR 835 for reference with scientific standards. | LEHR's RPP includes a statement which requires the following: Unless otherwise specified, the quantities used in the records required by 10 CFR 835 shall be clearly indicated in special units of curie, rad, roentgen, or rem, including multiples and subdivisions of these units. The SI units, becquerel (Bq), gray (Gy), and sievert (Sv), are only provided parenthetically in 10 CFR 835 for reference with scientific standards. | RPP, Section 3.0 |
| | **SUBPART B – MANAGEMENT AND ADMINISTRATION REQUIREMENTS** | | |
| | | **Radiation Protection Programs** | |
| 101(a) | A DOE activity SHALL be conducted in compliance with a documented radiation protection program (RPP) as approved by the DOE. | LEHR's RPP includes a statement which requires the following A DOE activity SHALL be conducted in compliance with a documented radiation protection program (RPP) as approved by the DOE. | RPP, Section 2.0 |
| 101(b) | The DOE MAY direct or make modifications to a RPP. | LEHR's RPP includes a statement which requires the following: The DOE MAY direct or make modifications to a RPP. | RPP, Section 2.0 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 101 (c) | The content of each RPP SHALL be commensurate with the nature of the activities performed and shall include formal plans and measures for applying the as low as reasonably achievable (ALARA) process to occupational exposure. | LEHR's procedures, plans, and/or manuals address the following: The content of each RPP SHALL be commensurate with the nature of the activities performed and shall include formal plans and measures for applying the as low as reasonably achievable (ALARA) process to occupational exposure. | RPP, Section 4.0 and ALARA Program |
| 101(d).01 | The RPP SHALL specify the existing and/or anticipated operational tasks that are intended to be within the scope of the RPP. | LEHR's RPP includes a statement which requires the following: LEHR's RPP SHALL specify the existing and/or anticipated operational tasks that are intended to be within the scope of the RPP. | RPP, Section 2.0 |
| 101(d).02 | Except as provided in §835.101(h), any task outside the scope of a RPP SHALL not be initiated until an update of the RPP is approved by DOE. | LEHR's RPP includes a statement which requires the following: Except as provided in §835.101(h), any task outside the scope of a RPP SHALL not be initiated until an update of the RPP is approved by DOE. | RPP, Section 6.0 |
| 101(e) | The content of the RPP shall address, but shall not necessarily be limited to, each requirement in 10 CFR 835. | LEHR's RPP includes a statement which requires the following: The content of the RPP shall address, but shall not necessarily be limited to, each requirement in 10 CFR 835. | RPP, Section 1.5 and Appendix A |
| 101(f) | The RPP shall include plans, schedules, and other measures for achieving compliance with regulations of 10 CFR 835. Unless otherwise specified in 10 CFR 835, compliance with amendments to 10 CFR 835 shall be achieved no later than 180 days following approval of the revised RPP by DOE. Compliance with the requirements of § 835.402(d) for radiobioassay program accreditation shall be achieved no later than January 1, 2002. | LEHR's RPP includes a statement which requires the following: The RPP shall include plans, schedules, and other measures for achieving compliance with regulations of 10 CFR 835. Unless otherwise specified in 10 CFR 835, compliance with amendments to 10 CFR 835 shall be achieved no later than 180 days following approval of the revised RPP by DOE. Compliance with the requirements of § 835.402(d) for radiobioassay program accreditation shall be achieved no later than January 1, 2002. | RPP, Section 5.0 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 101(g)(1) | An update of the RPP SHALL be submitted to DOE: Whenever a change or an addition to the RPP is made; | LEHR's RPP includes a statement which requires the following: An update of the RPP SHALL be submitted to DOE: Whenever a change or an addition to the RPP is made; | RPP, Section 6.0 |
| 101(g)(2) | An update of the RPP SHALL be submitted to DOE: Prior to the initiation of a task not within the scope of the RPP; or | LEHR's RPP includes a statement which requires the following: An update of the RPP SHALL be submitted to DOE: Prior to the initiation of a task not within the scope of the RPP; or | RPP, Section 6.0 |
| 101(g)(3) | An update of the RPP SHALL be submitted to DOE: Within 180 days of the effective date of any modifications to 10 CFR 835. | LEHR's RPP includes a statement which requires the following: An update of the RPP SHALL be submitted to DOE: Within 180 days of the effective date of any modifications to 10 CFR 835. | RPP, Section 6.0 |
| 101(h).01 | Changes, additions, or updates to the RPP MAY become effective without prior Department approval only if the changes do not decrease the effectiveness of the RPP and the RPP, as changed, continues to meet the requirements of 10 CFR 835. | LEHR's RPP includes a statement which requires the following: Changes, additions, or updates to the RPP MAY become effective without prior Department approval only if the changes do not decrease the effectiveness of the RPP and the RPP, as changed, continues to meet the requirements of 10 CFR 835. | RPP, Section 6.0 |
| 101(h).02 | Proposed changes that decrease the effectiveness of the RPP SHALL not be implemented without submittal to and approval by the Department. | LEHR's RPP includes a statement which requires the following: Proposed changes that decrease the effectiveness of the RPP SHALL not be implemented without submittal to and approval by the Department. | RPP, Section 6.0 |
| 101(i) | An initial RPP or an update SHALL be considered approved 180 days after its submission unless rejected by DOE at an earlier date. | LEHR's RPP includes a statement which requires the following: An initial RPP or an update SHALL be considered approved 180 days after its submission unless rejected by DOE at an earlier date. | RPP, Section 6.0 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | | **Internal Audits** | |
| 102 | Internal audits of the radiation protection program, including examination of program content and implementation, shall be conducted through a process that ensures that all functional elements are reviewed no less frequently than every 36 months. | LEHR's RPP includes a statement which requires the following: Internal audits of the radiation protection program, including examination of program content and implementation, shall be conducted through a process that ensures that all functional elements are reviewed no less frequently than every 36 months. | RPP, Section 7.0<br>SOP 38.4, Sections 6.0 and 6.1.1. |
| | | **Education, Training and Skills** | |
| 103 | Individuals responsible for developing and implementing measures necessary for ensuring compliance with the requirements of 10 CFR 835 shall have the appropriate education, training, and skills to discharge these responsibilities. | LEHR's RPP includes a statement which requires the following: Individuals responsible for developing and implementing measures necessary for ensuring compliance with the requirements of 10 CFR 835 shall have the appropriate education, training, and skills to discharge these responsibilities. | HSP 20.1, Section 6.1.11 |
| | | **Written Procedures** | |
| 104 | Written procedures shall be developed and implemented as necessary to ensure compliance with 10 CFR 835, commensurate with the radiological hazards created by the activity and consistent with the education, training, and skills of the individuals exposed to those hazards. | LEHR's RPP includes a statement which requires the following: Written procedures shall be developed and implemented as necessary to ensure compliance with 10 CFR 835, commensurate with the radiological hazards created by the activity and consistent with the education, training, and skills of the individuals exposed to those hazards. | RPP, Section 3.0 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | **SUBPART C - STANDARDS FOR INTERNAL AND EXTERNAL EXPOSURE** | | |
| | **Occupational Dose Limits for General Employees** | | |
| 202(a)(1) | Except for planned special exposures conducted consistent with § 835.204 and emergency exposures authorized in accordance with § 835.1302, the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year: A total effective dose equivalent of 5 rems (0.05 sievert); | LEHR's procedures, plans, and/or manuals address the following: Except for planned special exposures conducted consistent with § 835.204 and emergency exposures authorized in accordance with § 835.1302, the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year: A total effective dose equivalent of 5 rems (0.05 sievert); | HSP 15.1, Section 5.2.1 |
| 202(a)(2) | Except for planned special exposures conducted consistent with § 835.204 and emergency exposures authorized in accordance with § 835.1302, the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year: The sum of the deep dose equivalent for external exposures and the committed dose equivalent to any organ or tissue other than the lens of the eye of 50 rems (0.5 sievert). | LEHR's procedures, plans, and/or manuals address the following: Except for planned special exposures conducted consistent with § 835.204 and emergency exposures authorized in accordance with § 835.1302, the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year: The sum of the deep dose equivalent for external exposures and the committed dose equivalent to any organ or tissue other than the lens of the eye of 50 rems (0.5 sievert). | HSP 15.1, Section 5.2.1 |
| 202(a)(3) | Except for planned special exposures conducted consistent with § 835.204 and emergency exposures authorized in accordance with § 835.1302, the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year: A lens of the eye dose equivalent of 15 rems (0.15 sievert). | LEHR's procedures, plans, and/or manuals address the following: Except for planned special exposures conducted consistent with § 835.204 and emergency exposures authorized in accordance with § 835.1302, the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year: A lens of the eye dose equivalent of 15 rems (0.15 sievert). | HSP 15.1, Section 5.2.1 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 202(a)(4) | Except for planned special exposures conducted consistent with § 835.204 and emergency exposures authorized in accordance with § 835.1302, the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year: A shallow dose equivalent of 50 rems (0.5 sievert) to the skin or to any extremity. | LEHR's procedures, plans, and/or manuals address the following: Except for planned special exposures conducted consistent with § 835.204 and emergency exposures authorized in accordance with § 835.1302, the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year: A shallow dose equivalent of 50 rems (0.5 sievert) to the skin or to any extremity. | HSP 15.1, Section 5.2.1 |
| 202(b) | All occupational doses received during the current year, except doses resulting from planned special exposures conducted in compliance with § 835.204 and emergency exposures authorized in accordance with § 835.1302, shall be included when demonstrating compliance with §§ 835.202(a) and 835.207. | LEHR's procedures, plans, and/or manuals address the following: All occupational doses received during the current year, except doses resulting from planned special exposures conducted in compliance with § 835.204 and emergency exposures authorized in accordance with § 835.1302, shall be included when demonstrating compliance with §§ 835.202(a) and 835.207. | HSP 15.1, Section 5.2.1 |
| 202 (c) | Doses from background, therapeutic and diagnostic medical radiation, and participation as a subject in medical research programs shall not be included in dose records or in the assessment of compliance with the occupational dose limits. | LEHR's procedures, plans, and/or manuals address the following: Doses from background, therapeutic and diagnostic medical radiation, and participation as a subject in medical research programs shall not be included in dose records or in the assessment of compliance with the occupational dose limits. | HSP 15.1, Section 5.2.1 |
| | **Combining Internal and External Dose Equivalents** | | |
| 203(a) | The total effective dose equivalent during a year shall be determined by summing the effective dose equivalent from external exposures and the committed effective dose equivalent from intakes during the year. | LEHR's procedures, plans, and/or manuals address the following: The total effective dose equivalent during a year shall be determined by summing the effective dose equivalent from external exposures and the committed effective dose equivalent from intakes during the year. | HSP 16.1, Section 3.23 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 203(b) | Determinations of the effective dose equivalent SHALL be made using the weighting factor values provided in §835.2. | LEHR's procedures, plans, and/or manuals address the following: Determinations of the effective dose equivalent SHALL be made using the weighting factor values provided in §835.2. | HSP 16.1, Section 3.26 |
| | **Planned Special Exposures** | | |
| 204 | A planned special exposure MAY be authorized for a radiological worker to receive doses in addition to and accounted for separately from the doses received under the limits specified in §835.202(a), provided that each of the conditions in 835.204 is satisfied. | 835.204 is not applicable to the LEHR project as radioactive material conditions do not exist at LEHR which would call for a planned special exposure. If a planned special exposure is expected, plans will be developed to meet the requirements of the 10 CFR 835. | NA |
| | **Determination of Compliance for Non-uniform Exposure of the Skin** | | |
| 205(a) | Non-uniform exposures of the skin from X-rays, beta radiation, and/or radioactive material on the skin ARE TO BE assessed as specified in this section. | LEHR's procedures, plans, and/or manuals address the following: Non-uniform exposures of the skin from X-rays, beta radiation, and/or radioactive material on the skin ARE TO BE assessed as specified in this section. | HSP 15.1, Section 5.10.3<br>HSP 18.1, Section 6.4 |
| 205(b)(1) | For purposes of demonstrating compliance with §835.202(a)(4), assessments SHALL be conducted as follows:<br>*Area of skin irradiated is 100 cm$^2$ or more.* The non-uniform dose equivalent received during the year SHALL be averaged over the 100 cm$^2$ of the skin receiving the maximum dose, added to any uniform dose equivalent also received by the skin, and recorded as the shallow dose equivalent to any extremity or skin for the year. | LEHR's procedures, plans, and/or manuals address the following: For purposes of demonstrating compliance with §835.202(a)(4), assessments SHALL be conducted as follows:<br>*Area of skin irradiated is 100 cm$^2$ or more.* The non-uniform dose equivalent received during the year SHALL be averaged over the 100 cm$^2$ of the skin receiving the maximum dose, added to any uniform dose equivalent also received by the skin, and recorded as the shallow dose equivalent to any extremity or skin for the year. | HSP 15.1, Section 5.10.3<br>HSP 18.1, Section 6.4.1 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 205(b)(2) | For purposes of demonstrating compliance with §835.202(a)(4), assessments SHALL be conducted as follows: *Area of skin irradiated is 10 $cm^2$ or more, but is less than 100 $cm^2$.* The non-uniform dose equivalent (H) to the irradiated area received during the year SHALL be added to any uniform dose equivalent also received by the skin and recorded as the shallow dose equivalent to any extremity or skin for the year. H is the dose equivalent averaged over the 1 $cm^2$ of skin receiving the maximum absorbed dose, D, reduced by the fraction f, which is the irradiated area in $cm^2$ divided by 100 $cm^2$ (i.e., H=fD). In no case SHALL a value of f less than 0.1 be used. | LEHR's procedures, plans, and/or manuals address the following: For purposes of demonstrating compliance with §835.202(a)(4), assessments SHALL be conducted as follows: *Area of skin irradiated is 10 $cm^2$ or more, but is less than 100 $cm^2$.* The non-uniform dose equivalent (H) to the irradiated area received during the year SHALL be added to any uniform dose equivalent also received by the skin and recorded as the shallow dose equivalent to any extremity or skin for the year. H is the dose equivalent averaged over the 1 $cm^2$ of skin receiving the maximum absorbed dose, D, reduced by the fraction f, which is the irradiated area in $cm^2$ divided by 100 $cm^2$ (i.e., H=fD). In no case SHALL a value of f less than 0.1 be used. | HSP 15.1, Section 5.10.3 HSP 18.4, Section 6.4.1 |
| 205(b)(3) | For purposes of demonstrating compliance with §835.202(a)(4), assessments SHALL be conducted as follows: *Area of skin irradiated is less than 10 $cm^2$.* The non-uniform dose equivalent SHALL be averaged over the 1 $cm^2$ of skin receiving the maximum dose. This dose equivalent SHALL: (i) Be recorded in the individual's occupational exposure history as a special entry; and (ii) Not be added to any other shallow dose equivalent to any extremity or skin recorded as the dose equivalent for the year. | LEHR's procedures, plans, and/or manuals address the following: For purposes of demonstrating compliance with §835.202(a)(4), assessments SHALL be conducted as follows: *Area of skin irradiated is less than 10 $cm^2$.* The non-uniform dose equivalent SHALL be averaged over the 1 $cm^2$ of skin receiving the maximum dose. This dose equivalent SHALL: (i) Be recorded in the individual's occupational exposure history as a special entry; and (ii) Not be added to any other shallow dose equivalent to any extremity or skin recorded as the dose equivalent for the year. | HSP 18.1, Section 6.4.1 HSP 15.1, Section 5,10.3 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | | **Limits for the Embryo/Fetus** | |
| 206(a) | The dose equivalent limit for the embryo/fetus from the period of conception to birth, as a result of occupational exposure of a declared pregnant worker, IS 0.5 rem (0.005 sievert). | LEHR's procedures, plans, and/or manuals address the following: The dose equivalent limit for the embryo/fetus from the period of conception to birth, as a result of occupational exposure of a declared pregnant worker, IS 0.5 rem (0.005 sievert). | HSP 15.1, Section 5.2.1 (Table 1) HSP 19.1, Section 6.3.2 |
| 206(b) | Substantial variation above a uniform exposure rate that would satisfy the limits provided in §835.206(a) SHALL be avoided. | LEHR's procedures, plans, and/or manuals address the following: Substantial variation above a uniform exposure rate that would satisfy the limits provided in §835.206(a) SHALL be avoided. | HSP 15.1, Section 5.2.1 (Table 1) HSP 19.1, Section 6.3.2 |
| 206(c) | If the dose equivalent to the embryo/fetus is determined to have already exceeded 0.5 rem (0.005 sievert) by the time a worker declares her pregnancy, the declared pregnant worker SHALL not be assigned to tasks where additional occupational exposure is likely during the remaining gestation period. | LEHR's procedures, plans, and/or manuals address the following: If the dose equivalent to the embryo/fetus is determined to have already exceeded 0.5 rem (0.005 sievert) by the time a worker declares her pregnancy, the declared pregnant worker SHALL not be assigned to tasks where additional occupational exposure is likely during the remaining gestation period. | HSP 15.1, Section 5.2.1 (Table 1) HSP 19.1, Section 6.3.2 |
| | | **Occupational Dose Limits for Minors** | |
| 207 | The dose equivalent limits for minors occupationally exposed to radiation and/or radioactive materials at a DOE activity are 0.1 rem (0.001 sievert) total effective dose equivalent in a year and 10% of the occupational dose limits specified at § 835.202(a)(3) and (a)(4). | LEHR's procedures, plans, and/or manuals address the following: The dose equivalent limits for minors occupationally exposed to radiation and/or radioactive materials at a DOE activity are 0.1 rem (0.001 sievert) total effective dose equivalent in a year and 10% of the occupational dose limits specified at § 835.202(a)(3) and (a)(4). | HSP 15.1, Section 5.2.1 (Table 1) |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | **Limits for Members of the Public Entering a Controlled Area** | | |
| 208 | The total effective dose equivalent limit for members of the public exposed to radiation and/or radioactive material during access to a controlled area is 0.1 rem (0.001 sievert) in a year. | LEHR's procedures, plans, and/or manuals address the following: The total effective dose equivalent limit for members of the public exposed to radiation and/or radioactive material during access to a controlled area is 0.1 rem (0.001 sievert) in a year. | HSP 15.1, Section 5.2.1 (Table 1) |
| | **Concentrations of Radioactive Material in Air** | | |
| 209(a) | The derived air concentration (DAC) values given in appendices A and C of 10 CFR 835 SHALL be used in the control of occupational exposures to airborne radioactive material. | LEHR's procedures, plans, and/or manuals address the following: The derived air concentration (DAC) values given in appendices A and C to 10 CFR 835 SHALL be used in the control of occupational exposures to airborne radioactive material. | HSP 14.1, Section 6.1.9 |
| 209(b) | The estimation of internal dose SHALL be based on bioassay data rather than air concentration values unless bioassay data are:<br>(1) unavailable;<br>(2) inadequate; or<br>(3) internal dose estimates based on air concentration values are demonstrated to be as or more accurate. | LEHR's procedures, plans, and/or manuals address the following: The estimation of internal dose SHALL be based on bioassay data rather than air concentration values unless bioassay data are:<br>(1) unavailable;<br>(2) inadequate; or<br>(3) internal dose estimates based on air concentration values are demonstrated to be as or more accurate. | HSP 14.1, Section 6.6.6 |
| | **SUBPART E - MONITORING OF INDIVIDUALS AND AREAS** | | |
| | **General Requirements** | | |
| 401(a)(1) | Monitoring of individuals and areas SHALL be performed to: Demonstrate compliance with the regulations in 10 CFR 835; | LEHR's procedures, plans, and/or manuals address the following: Monitoring of individuals and areas SHALL be performed to: Demonstrate compliance with the regulations in 10 CFR 835. | SOP 25.1, Section 6.6 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 401(a)(2) | Monitoring of individuals and areas SHALL be performed to: Document radiological conditions; | LEHR's procedures, plans, and/or manuals address the following: Monitoring of individuals and areas SHALL be performed to: Document radiological conditions; | SOP 25.1, Section 6.6 |
| 401(a)(3) | Monitoring of individuals and areas SHALL be performed to: Detect changes in radiological conditions; | LEHR's procedures, plans, and/or manuals address the following: Monitoring of individuals and areas SHALL be performed to: Detect changes in radiological conditions; | SOP 25.1, Section 6.6 |
| 401(a)(4) | Monitoring of individuals and areas SHALL be performed to: Detect the gradual buildup of radioactive material; | LEHR's procedures, plans, and/or manuals address the following: Monitoring of individuals and areas SHALL be performed to: Detect the gradual buildup of radioactive material; | SOP 25.1, Section 6.6 |
| 401(a)(5) | Monitoring of individuals and areas SHALL be performed to: Verify the effectiveness of engineering and process controls in containing radioactive material and reducing radiation exposure; and, | LEHR's procedures, plans, and/or manuals address the following: Monitoring of individuals and areas SHALL be performed to: Verify the effectiveness of engineering and process controls in containing radioactive material and reducing radiation exposure; and, | SOP 25.1, Section 6.6 |
| 401(a)(6) | Identify and control potential sources of individual exposure to radiation and/or radioactive material. | LEHR's procedures, plans and/or manuals address the following: Identify and control potential sources of individual exposure to radiation and/or radioactive material. | SOP 25.1, Section 6.6 |
| 401(b)(1) | Instruments used for monitoring SHALL be: Periodically maintained and calibrated on an established frequency; | LEHR's procedures, plans, and/or manuals address the following: Instruments used for monitoring SHALL be: Periodically maintained and calibrated on an established; | SOP 25.1, Section 6.4.4 and 6.7.4 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 401(b)(2) | Instruments used for monitoring SHALL be:<br>Appropriate for the type(s), levels, and energies of the radiation(s) encountered; | LEHR's procedures, plans, and/or manuals address the following:<br>Instruments used for monitoring SHALL be:<br>Appropriate for the type(s), levels, and energies of the radiation(s) encountered; | SOP 25.1, Section 6.7.1 |
| 401(b)(3) | Instruments used for monitoring SHALL be:<br>Appropriate for existing environmental conditions; and | LEHR's procedures, plans, and/or manuals address the following:<br>Instruments used for monitoring SHALL be:<br>Appropriate for existing environmental conditions; and | SOP 25.1, Section 6.7.1 |
| 401(b)(4) | Instruments used for monitoring SHALL be:<br>Routinely tested for operability. | LEHR's procedures, plans, and/or manuals address the following:<br>Instruments used for monitoring SHALL be:<br>Routinely tested for operability. | SOP 25.1, Section 6.7.1 |
| | | **Individual Monitoring** | |
| 402(a)(1)(i) | For the purpose of monitoring individual exposures to external radiation, personnel dosimetry SHALL be provided to and used by:<br>Radiological workers who, under typical conditions, are likely to receive one or more of the following:<br>An effective dose equivalent to the whole body of 0.1 rem (0.001 sievert) or more in one year; | LEHR's procedures, plans, and/or manuals address the following:<br>For the purpose of monitoring individual exposures to external radiation, personnel dosimetry SHALL be provided to and used by:<br>Radiological workers who, under typical conditions, are likely to receive one or more of the following:<br>An effective dose equivalent to the whole body of 0.1 rem (0.001 sievert) or more in one year; | HSP 15.1, Section 5.2.4<br>SOP 38.2, Section 6.1.1 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 402(a)(1)(ii) | For the purpose of monitoring individual exposures to external radiation, personnel dosimetry SHALL be provided to and used by:<br>Radiological workers who, under typical conditions, are likely to receive one or more of the following:<br>A shallow dose equivalent to the skin or to any extremity of 5 rems (0.05 sievert) or more in a year; | LEHR's procedures, plans, and/or manuals address the following:<br>For the purpose of monitoring individual exposures to external radiation, personnel dosimetry SHALL be provided to and used by:<br>Radiological workers who, under typical conditions, are likely to receive one or more of the following:<br>A shallow dose equivalent to the skin or to any extremity of 5 rems (0.05 sievert) or more in a year; | HSP 15.1, Section 5.2.4<br>SOP 38.2, Section 6.1.1 |
| 402(a)(1)(iii) | For the purpose of monitoring individual exposures to external radiation, personnel dosimetry SHALL be provided to and used by:<br>Radiological workers who, under typical conditions, are likely to receive one or more of the following:<br>A lens of the eye dose equivalent of 1.5 rems (0.015 sievert) or more in a year; | LEHR's procedures, plans, and/or manuals address the following:<br>For the purpose of monitoring individual exposures to external radiation, personnel dosimetry SHALL be provided to and used by:<br>Radiological workers who, under typical conditions, are likely to receive one or more of the following:<br>A lens of the eye dose equivalent of 1.5 rems (0.015 sievert) or more in a year; | HSP 15.1, Section 5.2.4<br>SOP 38.2, Section 6.1.1 |
| 402(a)(2) | For the purpose of monitoring individual exposures to external radiation, personnel dosimetry SHALL be provided to and used by:<br>Declared pregnant workers who are likely to receive from external sources a dose equivalent to the embryo/fetus in excess of 10 percent of the applicable limit in §835.206 (a); | LEHR's procedures, plans and/or manuals address the following:<br>For the purpose of monitoring individual exposures to external radiation, personnel dosimetry SHALL be provided to and used by:<br>Declared pregnant workers who are likely to receive from external sources a dose equivalent to the embryo/fetus in excess of 10 percent of the applicable limit in §835.206. | HSP 15.1, Section 5.2.4<br>SOP 38.2, Section 6.1.1 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 402(a)(3) | For the purpose of monitoring individual exposures to external radiation, personnel dosimetry SHALL be provided to and used by: Occupationally exposed minors likely to receive a dose in excess of 50 percent of the applicable limits at § 835.207 in a year from external sources | LEHR's procedures, plans, and/or manuals address the following: For the purpose of monitoring individual exposures to external radiation, personnel dosimetry SHALL be provided to and used by: Occupationally exposed minors likely to receive a dose in excess of 50 percent of the applicable limits at § 835.207 in a year from external sources | HSP 15.1, Section 5.2.4 SOP 38.2, Section 6.1.1 |
| 402(a)(4) | Members of the public entering a controlled area likely to receive a dose in excess of 50 percent of the limit at § 835.208 in a year from external sources | Members of the public entering a controlled area likely to receive a dose in excess of 50 percent of the limit at § 835.208 in a year from external sources | HSP 15.1, Section 5.2.4 SOP 38.2, Section 6.1.1 |
| 402(a)(5) | For the purpose of monitoring individual exposures to external radiation, personnel dosimetry SHALL be provided to and used by: Individuals entering a high or very high radiation area. | LEHR's procedures, plans, and/or manuals address the following: For the purpose of monitoring individual exposures to external radiation, personnel dosimetry SHALL be provided to and used by: Individuals entering a high or very high radiation area. | HSP 15.1, Section 5.2.4 SOP 38.2, Section 6.1.1 |
| 402(b) | External dose monitoring programs implemented to demonstrate compliance with § 835.402(a) shall be adequate to demonstrate compliance with the dose limits established in subpart C of 10 CFR 835 and shall be: (1) Accredited, or excepted from accreditation, in accordance with the DOE Laboratory Accreditation Program for Personnel Dosimetry; or (2) Determined by the Secretarial Officer responsible for environment, safety and health matters to have performance substantially equivalent to that of programs accredited under the DOE Laboratory Accreditation Program for Personnel Dosimetry. | LEHR uses a laboratory for Dosimetry which is NVLAP-certified. External dose monitoring programs implemented to demonstrate compliance with § 835.402(a) shall be adequate to demonstrate compliance with the dose limits established in subpart C of 10 CFR 835 and shall be: (1) Accredited, or excepted from accreditation, in accordance with the DOE Laboratory Accreditation Program for Personnel Dosimetry; or (2) Determined by the Secretarial Officer responsible for environment, safety and health matters to have performance substantially equivalent to that of programs accredited under the DOE Laboratory Accreditation Program for Personnel Dosimetry. | SOP 38.2, Section 1.0 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 402(c)(1) | For the purpose of monitoring individual exposures to internal radiation, internal dosimetry programs (including routine bioassay programs) SHALL be conducted for:<br>(1) Radiological workers who, under typical conditions, are likely to receive a committed effective dose equivalent of 0.1 rem (0.001 sievert) or more from all occupational radionuclide intakes in a year; | LEHR's procedures, plans, and/or manuals address the following:<br>(1) No radiological workers, under typical conditions, are likely to receive a committed effective dose equivalent of 0.1 rem (0.001 sievert) or more from all occupational radionuclide intakes in a year and therefore this subpart is not applicable to LEHR. | NA<br>RPP, Section 2. |
| 402(c)(2) | For the purpose of monitoring individual exposures to internal radiation, internal dosimetry programs (including routine bioassay programs) SHALL be conducted for:<br>Declared pregnant workers likely to receive an intake or intakes resulting in a dose equivalent to the embryo/fetus in excess of 10 percent of the limit stated at § 835.206(a) | LEHR's procedures, plans, and/or manuals address the following:<br>No declared pregnant workers is likely to receive an intake or intakes resulting in a dose equivalent to the embryo/fetus in excess of 10 percent of the limit stated at § 835.206(a) and therefore this subpart is not applicable to LEHR. | NA<br>RPP Section 2. |
| 402(c)(3) | For the purpose of monitoring individual exposures to internal radiation, internal dosimetry programs (including routine bioassay programs) SHALL be conducted for:<br>Occupationally exposed minors who are likely to receive a dose in excess of 50 percent of the applicable limit stated at § 835.207 from all radionuclide intakes in a year | LEHR's procedures, plans, and/or manuals address the following:<br><br>No occupationally exposed minors are likely to receive a dose in excess of 50 percent of the applicable limit stated at § 835.207 from all radionuclide intakes in a year and therefore this subpart is not applicable to LEHR. | NA<br>RPP Section 2. |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 402(c)(4) | Members of the public entering a controlled area likely to receive a dose in excess of 50 percent of the limit stated at § 835.208 from all radionuclide intakes in a year. | LEHR's procedures, plans, and/or manuals address the following: No members of the public entering a controlled area are likely to receive a dose in excess of 50 percent of the limit stated at § 835.208 from all radionuclide intakes in a year and therefore this subpart is not applicable to LEHR. | NA<br>RPP Section 2. |
| 402(d) | Internal dose monitoring programs implemented to demonstrate compliance with § 835.402(c) shall be adequate to demonstrate compliance with the dose limits established in subpart C of 10 CFR 835 and shall be:<br>(1) Accredited, or excepted from accreditation, in accordance with the DOE Laboratory Accreditation Program for Radiobioassay; or<br>(2) Determined by the Secretarial Officer responsible for environment, safety and health matters to have performance substantially equivalent to that of programs accredited under the DOE Laboratory Accreditation Program for Radiobioassay. | LEHR's procedures, plans, and/or manuals address the following: Internal dose monitoring programs implemented to demonstrate compliance with § 835.402(c) are not required and therefore this subpart is not applicable to LEHR. | NA<br>RPP Section 2. |
| | | **Air Monitoring** | |
| 403(a)(1) | Monitoring of airborne radioactivity shall be performed: Where an individual is likely to receive an exposure of 40 or more DAC-hours in a year; or, | LEHR's procedures, plans, and/or manuals address the following: Monitoring of airborne radioactivity shall be performed: Where an individual is likely to receive an exposure of 40 or more DAC-hours in a year | HSP 14.1, Section 6.1.1 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 403(a)(2) | As necessary to characterize the airborne radioactivity hazard where respiratory protective devices for protection against airborne radionuclides have been prescribed. | LEHR's procedures, plans, and/or manuals address the following: As necessary to characterize the airborne radioactivity hazard where respiratory protective devices for protection against airborne radionuclides have been prescribed. | HSP 14.1, Section 6.1.1 |
| 403(b) | Real-time air monitoring shall be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material. | LEHR's procedures, plans, and/or manuals address the following: Real-time air monitoring shall be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material. | HSP 14.1, Section 6.1.8 |
| | **Receipt of Packages Containing Radioactive Material** | | |
| 405(a) | If packages containing quantities of radioactive material in excess of a Type A quantity (as defined at 10 CFR 71.4) are expected to be received from radioactive material transportation, arrangements shall be made to either:<br>(1) Take possession of the package when the carrier offers it for delivery; or<br>(2) Receive notification as soon as practicable after arrival of the package at the carrier's terminal and to take possession of the package expeditiously after receiving such notification. | LEHR's procedures, plans, and/or manuals address the following: If packages containing quantities of radioactive material in excess of a Type A quantity (as defined at 10 CFR 71.4) are expected to be received from radioactive material transportation, arrangements shall be made to either:<br>(1) Take possession of the package when the carrier offers it for delivery; or<br>(2) Receive notification as soon as practicable after arrival of the package at the carrier's terminal and to take possession of the package expeditiously after receiving such notification. | SOP 32.1, Section 6.9.4 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 405(b) | Upon receipt from radioactive material transportation, external surfaces of packages known to contain radioactive material shall be monitored if the package:<br>(1) Is labeled with a Radioactive White I, Yellow II, or Yellow III label (as specified at 49 CFR 172.403 and 172.436-440); or<br>(2) Has been transported as low specific activity material (as defined at 10 CFR 71.4) on an exclusive use vehicle (as defined at 10 CFR 71.4); or<br>(3) Has evidence of degradation, such as packages that are crushed, wet, or damaged. | LEHR's procedures, plans, and/or manuals address the following:<br>Upon receipt from radioactive material transportation, external surfaces of packages known to contain radioactive material shall be monitored if the package:<br>(1) Is labeled with a Radioactive White I, Yellow II, or Yellow III label (as specified at 49 CFR 172.403 and 172.436-440); or<br>(2) Has been transported as low specific activity material (as defined at 10 CFR 71.4) on an exclusive use vehicle (as defined at 10 CFR 71.4); or<br>(3) Has evidence of degradation, such as packages that are crushed, wet, or damaged. | SOP 25.1, Sections 6.3.4 and 6.3.5 |
| 405(c) | The monitoring required by paragraph (b) of this section shall include:<br>(1) Measurements of removable contamination levels, unless the package contains only special form (as defined at 10 CFR 71.4) or gaseous radioactive material; and<br>(2) Measurements of the radiation levels, unless the package contains less than a Type A quantity (as defined at 10 CFR 71.4) of radioactive material. | LEHR's procedures, plans, and/or manuals address the following:<br>The monitoring required by paragraph (b) of this section shall include:<br>(1) Measurements of removable contamination levels, unless the package contains only special form (as defined at 10 CFR 71.4) or gaseous radioactive material; and<br>(2) Measurements of the radiation levels, unless the package contains less than a Type A quantity (as defined at 10 CFR 71.4) of radioactive material. | SOP 25.1 Sections 6.3.4 and 6.2.3 |
| 405(d) | The monitoring required by paragraph (b) of this section shall be completed as soon as practicable following receipt of the package, but not later than 8 hours after the beginning of the working day following receipt of the package. | LEHR's procedures, plans, and/or manuals address the following:<br>The monitoring required by paragraph (b) of this section shall be completed as soon as practicable following receipt of the package, but not later than 8 hours after the beginning of the working day following receipt of the package. | SOP 25.1 Sections 6.2.5 and 6.3.6 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | **SUBPART F - ENTRY CONTROL PROGRAM** | | |
| | | **Radiological Areas** | |
| 501(a) | Personnel entry control SHALL be maintained for each radiological area. | LEHR's procedures, plans, and/or manuals address the following: Personnel entry control SHALL be maintained for each radiological area. | SOP 32.1, Section 6.3.1<br>SOP 24.1, Section 6.2 |
| 501(b) | The degree of (personnel entry) control SHALL be commensurate with existing and potential radiological hazards within the area. | LEHR's procedures, plans, and/or manuals address the following: The degree of (personnel entry) control SHALL be commensurate with existing and potential radiological hazards within the area. | SOP 32.1, Section 6.3.1 |
| 501(c) | One or more of the following methods SHALL be used to ensure (personnel entry) control:<br>(1) Signs and barricades;<br>(2) Control devices on entrances;<br>(3) Conspicuous visual and/or audible alarms;<br>(4) Locked entrance ways; or<br>(5) Administrative controls. | LEHR's procedures, plans, and/or manuals address the following: One or more of the following methods SHALL be used to ensure (personnel entry) control:<br>(1) Signs and barricades;<br>(2) Control devices on entrances;<br>(3) Conspicuous visual and/or audible alarms;<br>(4) Locked entrance ways; or<br>(5) Administrative controls. | SOP 32.1, Section 6.3.1 |
| 501(d) | Written authorizations shall be required to control entry into and perform work within radiological areas. These authorizations shall specify radiation protection measures commensurate with the existing and potential hazards. | LEHR's procedures, plans, and/or manuals address the following: Written authorizations shall be required to control entry into and perform work within radiological areas. These authorizations shall specify radiation protection measures commensurate with the existing and potential hazards. | SOP 32.1, Section 6.3 |
| 501(e) | No control(s) SHALL be installed at any radiological area exit that would prevent rapid evacuation of personnel under emergency conditions. | LEHR's procedures, plans, and/or manuals address the following: No control(s) SHALL be installed at any radiological area exit that would prevent rapid evacuation of personnel under emergency conditions. | SOP 32.1, Section 6.3.1 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | | **High and Very High Radiation Areas** | |
| 502(a) | The following measures shall be implemented for each entry into a high radiation area:<br>(1) The area shall be monitored as necessary during access to determine the exposure rates to which the individuals are exposed; and<br>(2) Each individual shall be monitored by a supplemental dosimetry device or other means capable of providing an immediate estimate of the individual's integrated deep dose equivalent during the entry. | LEHR's procedures, plans, and/or manuals address the following:<br>The following measures shall be implemented for each entry into a high radiation area:<br>(1) The area shall be monitored as necessary during access to determine the exposure rates to which the individuals are exposed; and<br>(2) Each individual shall be monitored by a supplemental dosimetry device or other means capable of providing an immediate estimate of the individual's integrated deep dose equivalent during the entry. | SOP 24.1, Section 6.2.4 |
| 502(b) | *Physical Controls.* One or more of the following features SHALL be used for each entrance or access point to a high radiation area where radiation levels exist such that an individual could exceed a deep dose equivalent to the whole body of 1 rem (0.01 sievert) in any one hour at 30 centimeters from the source or from any surface that the radiation penetrates:<br>(1) A control device that prevents entry to the area when high radiation levels exist or upon entry causes the radiation level to be reduced below that level defining a high radiation area;<br>(2) A device that functions automatically to prevent use or operation of the radiation source or field while individuals are in the area; | LEHR's currently scoped activities do invoke the following:<br>*Physical Controls.* One or more of the following features SHALL be used for each entrance or access point to a high radiation area where radiation levels exist such that an individual could exceed a deep dose equivalent to the whole body of 1 rem (0.01 sievert) in any one hour at 30 centimeters from the source or from any surface that the radiation penetrates:<br>(1) A control device that prevents entry to the area when high radiation levels exist or upon entry causes the radiation level to be reduced below that level defining a high radiation area;<br>(2) A device that functions automatically to prevent use or operation of the radiation source or field while individuals are in the area; | SOP 24.1, Section 6.2.4 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | (3) 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;<br>(4) Entryways that are locked. During periods when access to the area is required, positive control over each entry is maintained;<br>(5) Continuous direct or electronic surveillance that is capable of preventing unauthorized entry;<br>(6) A control device that will automatically generate audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source. | (3) 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;<br>(4) Entryways that are locked. During periods when access to the area is required, positive control over each entry is maintained;<br>(5) Continuous direct or electronic surveillance that is capable of preventing unauthorized entry;<br>(6) A control device that will automatically generate audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source. | |
| 502(c) | *Very high radiation areas.* In addition to the above requirements, additional measures SHALL be implemented to ensure individuals are not able to gain unauthorized or inadvertent access to very high radiation areas. | LEHR's currently scoped activities do not invoke *Very high radiation areas.* Therefore, LEHR's documents do not address Very High Radiation Areas. | NA |
| 502(d) | No control(s) shall be established in a high or very high radiation area that would prevent rapid evacuation of personnel. | LEHR's procedures, plans and/or manuals:<br>No control(s) shall be established in a high or very high radiation area that would prevent rapid evacuation of personnel. | SOP 24.1, Section 6.2.4 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | **SUBPART G - POSTING AND LABELING** | | |
| | **General Requirements** | | |
| 601(a) | Except as otherwise provided in this subpart, postings and labels required by this subpart shall include the standard radiation warning trefoil in black or magenta imposed upon a yellow background. | LEHR's procedures, plans, and/or manuals address the following: Except as otherwise provided in this subpart, postings and labels required by this subpart shall include the standard radiation warning trefoil in black or magenta imposed upon a yellow background. | SOP 24.1, Section 6.3.2 |
| 601(b) | Signs required by this subpart SHALL be clearly and conspicuously posted and may include radiological protection instructions. | LEHR's procedures, plans, and/or manuals address the following: Signs required by this subpart SHALL be clearly and conspicuously posted and may include radiological protection instructions. | SOP 24.1, Section 6.3.4 |
| 601(c) | The posting and labeling requirements in this subpart may be modified to reflect the special considerations of DOE activities conducted at private residences or businesses. Such modifications shall provide the same level of protection to individuals as the existing provisions in this subpart. | LEHR's procedures, plans, and/or manuals address the following: The posting and labeling requirements in this subpart MAY be modified to reflect the special considerations of DOE activities conducted at private residences or businesses. Such modifications shall provide the same level of protection to individuals as the existing provisions in this subpart. | RPP, Appendix A |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | | **Controlled Areas** | |
| 602(a) | Each access point to a controlled area (as defined at § 835.2) shall be posted whenever radiological areas or radioactive material areas exist in the area. Individuals who enter only controlled areas without entering radiological areas or radioactive material areas are not expected to receive a total effective dose equivalent of more than 0.1 rem (0.001 sievert) in a year. | LEHR's procedures, plans, and/or manuals address the following: Each access point to a controlled area (as defined in § 835.2) shall be posted whenever radiological areas or radioactive material areas exist in the area. Individuals who enter only controlled areas without entering radiological areas or radioactive material areas are not expected to receive a total effective dose equivalent of more than 0.1 rem (0.001 sievert) in a year. | SOP 24.1, Section 6.3.13 |
| 602(b) | Signs used for this purpose MAY be selected by the contractor to avoid conflict with local security requirements. | LEHR's procedures, plans, and/or manuals address the following: Signs used for this purpose MAY be selected by the contractor to avoid conflict with local security requirements. | SOP 24.1, Section 6.3.13 |
| | | **Radiological Areas and Radioactive Material Areas** | |
| 603 | Each access point to radiological areas and radioactive material areas (as defined at § 835.2) shall be posted with conspicuous signs bearing the wording provided in this section. | LEHR's procedures, plans, and/or manuals address the following: Each access point to radiological areas and radioactive material areas (as defined at § 835.2) shall be posted with conspicuous signs bearing the wording provided in this section. | SOP 24.1, Section 6.1 |
| 603(a) | *Radiation Area.* The words "Caution, Radiation Area" shall be posted at each radiation area. | LEHR's procedures, plans, and/or manuals address the following: *Radiation Area.* The words "Caution, Radiation Area" shall be posted at each radiation area. | SOP 24.1, Section 6.2 |
| 603(b) | *High Radiation Area.* The words "Caution, High Radiation Area" or "Danger, High Radiation Area" shall be posted at each high radiation area. | LEHR's currently scoped activities do not invoke the following: *High Radiation Area.* The words "Caution, High Radiation Area" or "Danger, High Radiation Area" shall be posted at each high radiation area. | SOP 24.1, Section 6.2 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 603 (c) | *Very High Radiation Area.* The words "Grave Danger, Very High Radiation Area" shall be posted at each very high radiation area. | LEHR currently does not have nor does not anticipate any areas that would classify as Very High Radiation Areas. | NA |
| 603(d) | *Airborne Radioactivity Area.* The words "Caution, Airborne Radioactivity Area" or "Danger, Airborne Radioactivity Area" shall be posted at each airborne radioactivity area. | LEHR's procedures, plans, and/or manuals address the following: *Airborne Radioactivity Area.* The words "Caution, Airborne Radioactivity Area" or "Danger, Airborne Radioactivity Area" shall be posted at each airborne radioactivity area. | SOP 24.1, Section 6.2 |
| 603(e) | *Contamination Area.* The words "Caution, Contamination Area" shall be posted at each contamination area. | LEHR's procedures, plans, and/or manuals address the following: *Contamination Area.* The words "Caution, Contamination Area" shall be posted at each contamination area. | SOP 24.1, Section 6.2 |
| 603(f) | *High Contamination Area.* The words "Caution, High Contamination Area" or "Danger, High Contamination Area" shall be posted at each high contamination area. | LEHR's currently scoped activities do not invoke the following: *High Contamination Area.* The words "Caution, High Contamination Area" or "Danger, High Contamination Area" shall be posted at each high contamination area. | SOP 24.1, Section 6.2 |
| 603(g) | The words "Caution, Radioactive Material(s)" shall be posted at each radioactive material area. | The words "Caution, Radioactive Material(s)" shall be posted at each radioactive material area. | SOP 24.1, Section 6.2 |
| | **Exceptions to Posting Requirements** | | |
| 604(a) | Areas may be excepted from the posting requirements of § 835.603 for periods of less than 8 continuous hours when placed under continuous observation and control of an individual knowledgeable of, and empowered to implement, required access and exposure control measures. | LEHR's procedures, plans, and/or manuals address the following: Areas may be excepted from the posting requirements of § 835.603 for periods of less than 8 continuous hours when placed under continuous observation and control of an individual knowledgeable of, and empowered to implement, required access and exposure control measures. | SOP 24.1, Section 6.3.1 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 604(b) | Areas may be excepted from the radioactive material area posting requirements of § 835.603(g) when:<br><br>(1) Posted in accordance with § 835.603(a) through (f); or<br>(2) Each item or container of radioactive material is labeled in accordance with this subpart such that individuals entering the area are made aware of the hazard; or<br>(3) The radioactive material of concern consists solely of structures or installed components which have been activated (i.e. such as by being exposed to neutron radiation or particles produced in an accelerator). | LEHR's procedures, plans, and/or manuals address the following: Areas may be excepted from the radioactive material area posting requirements of § 835.603(g) when:<br>(1) Posted in accordance with § 835.603(a) through (f); or<br>(2) Each item or container of radioactive material is labeled in accordance with this subpart such that individuals entering the area are made aware of the hazard; or<br>(3) The radioactive material of concern consists solely of structures or installed components which have been activated (i.e. such as by being exposed to neutron radiation or particles produced in an accelerator). | SOP 24.1, Section 6.2.10 and 6.3.12 with 604(b)(3) not applicable. |
| 604(c) | Areas containing only packages received from radioactive material transportation labeled and in non-degraded condition need not be posted in accordance with § 835.603 until the packages are monitored in accordance with § 835.405. | LEHR's procedures, plans, and/or manuals address the following: Areas containing only packages received from radioactive material transportation labeled and in non-degraded condition need not be posted in accordance with § 835.603 until the packages are monitored in accordance with § 835.405. | SOP 24.1, Section 6.3.1 |
| | | **Labeling Items and Containers** | |
| 605 | Except as provided in § 835.606, each item or container of radioactive material shall bear a durable, clearly visible label bearing the standard radiation warning trefoil and the words "Caution, Radioactive Material" or "Danger, Radioactive Material." The label shall also provide sufficient information to permit individuals handling, using, or working in the vicinity of the items or containers, to take precautions to avoid or control exposures. | LEHR's procedures, plans, and/or manuals address the following: Except as provided in § 835.606, each item or container of radioactive material shall bear a durable, clearly visible label bearing the standard radiation warning trefoil and the words "Caution, Radioactive Material" or "Danger, Radioactive Material." The label shall also provide sufficient information to permit individuals handling, using, or working in the vicinity of the items or containers, to take precautions to avoid or control exposures. | SOP 24.1, Sections 6.3.13, 6.3.14, and 6.3.12 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | **Exceptions to Labeling Requirements** | | |
| 606(a)(1) | Items and containers may be excepted from the radioactive material labeling requirements of § 835.605 when:<br><br>(1) Used, handled, or stored in areas posted and controlled in accordance with this subpart and sufficient information is provided to permit individuals to take precautions to avoid or control exposures; or<br>(2) The quantity of radioactive material is less than one tenth of the values specified in Appendix E of this part; or<br>(3) Packaged, labeled, and marked in accordance with the regulations of the Department of Transportation or DOE Orders governing radioactive material transportation; or<br>(4) Inaccessible, or accessible only to individuals authorized to handle or use them, or to work in the vicinity; or<br>(5) Installed in manufacturing, process, or other equipment, such as reactor components, piping, and tanks; or<br>(6) The radioactive material consists solely of nuclear weapons or their components. | LEHR's procedures, plans, and/or manuals address the following: Items and containers may be excepted from the radioactive material labeling requirements of § 835.605 when:<br>(1) Used, handled, or stored in areas posted and controlled in accordance with this subpart and sufficient information is provided to permit individuals to take precautions to avoid or control exposures; or<br><br>(2) The quantity of radioactive material is less than one tenth of the values specified in Appendix E of this part; or<br>(3) Packaged, labeled, and marked in accordance with the regulations of the Department of Transportation or DOE Orders governing radioactive material transportation; or<br><br>(4) Inaccessible, or accessible only to individuals authorized to handle or use them, or to work in the vicinity; or<br><br>(5) Installed in manufacturing, process, or other equipment, such as reactor components, piping, and tanks; or<br>(6) The radioactive material consists solely of nuclear weapons or their components. | SOP 32.1, Sections 6.10.11 |
| 606(b) | Radioactive material labels applied to sealed radioactive sources may be excepted from the color specifications of § 835.601(a). | Radioactive material labels applied to sealed radioactive sources may be excepted from the color specifications of § 835.601(a). | SOP 32.1, Section 6.10.11 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | | **SUBPART H - RECORDS** | |
| | | **General Provisions** | |
| 701(a) | Records SHALL be maintained to document compliance with 10 CFR 835 and with radiation protection programs required by §835.101. | LEHR's procedures, plans, and/or manuals address the following: Records SHALL be maintained to document compliance with 10 CFR 835 and with radiation protection programs required by §835.101. | SOP 38.3, Section 7.1 |
| 701(b) | Unless otherwise specified in this subpart, records SHALL be retained until final disposition is authorized by DOE. | LEHR's procedures, plans, and/or manuals address the following: Unless otherwise specified in this subpart, records SHALL be retained until final disposition is authorized by DOE. | SOP 38.3, Section 7.2 |
| | | **Individual Monitoring Records** | |
| 702(a) | Records shall be maintained to document doses received by all individuals for whom monitoring was required pursuant to § 835.402 and to document doses received during planned special exposures, unplanned doses exceeding the monitoring thresholds of § 835.402, and authorized emergency exposures. | LEHR's procedures, plans, and/or manuals address the following: Records shall be maintained to document doses received by all individuals for whom monitoring was required pursuant to § 835.402 and to document doses received during planned special exposures, unplanned doses exceeding the monitoring thresholds of § 835.402, and authorized emergency exposures. | SOP 38.3, Section 7.5 |
| 702(b) | The results of individual external and internal dose monitoring that is performed, but not required by §835.402 SHALL be recorded. Recording of the non-uniform shallow dose equivalent to the skin is not required if the dose is less than 2 percent of the limit specified for the skin at 835.202(a)(4). | LEHR's procedures, plans, and/or manuals address the following: The results of individual external and internal dose monitoring that is performed, but not required by §835.402 SHALL be recorded. Recording of the non-uniform shallow dose equivalent to the skin is not required if the dose is less than 2 percent of the limit specified for the skin at 835.202(a)(4). | SOP 38.3, Section 7.10 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 702 (c)(1) | The records required by this section SHALL:<br>Be sufficient to evaluate compliance with subpart C of this part. | LEHR's procedures, plans, and/or manuals address the following:<br>The (individual monitoring) records required by this section SHALL:<br>Be sufficient to evaluate compliance with subpart C of 10 CFR 835. | SOP 38.3, Section 7.6 |
| 702 (c)(2) | The (individual monitoring) records required by this section SHALL:<br>Be sufficient to provide dose information necessary to complete reports required by subpart I of 10 CFR 835; | LEHR's procedures, plans, and/or manuals address the following:<br>The (individual monitoring) records required by this section SHALL:<br>Be sufficient to provide dose information necessary to complete reports required by subpart I of 10 CFR 835; | SOP 38.3, Section 7.12 |
| 702 (c)(3) (i) | The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for external dose received during the year:<br>The effective dose equivalent from external sources of radiation (deep dose equivalent MAY be used as effective dose equivalent for external exposure); | LEHR's procedures, plans, and/or manuals address the following:<br>The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for external dose received during the year:<br>The effective dose equivalent from external sources of radiation (deep dose equivalent MAY be used as effective dose equivalent for external exposure); | SOP 38.3, Section 7.13 |
| 702(c)(3) (ii) | The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for external dose received during the year:<br>The lens of the eye dose equivalent; | LEHR's procedures, plans and/or manuals address the following:<br>The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for external dose received during the year:<br>The lens of the eye dose equivalent; | SOP 38.3, Section 7.13 |
| 702(c)(3) (iii) | The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for external dose received during the year:<br>The shallow dose equivalent to the skin; and | LEHR's procedures, plans, and/or manuals address the following:<br>The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for external dose received during the year:<br>The shallow dose equivalent to the skin; and | SOP 38.3, Section 7.13 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 702(c)(3)(iv) | The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for external dose received during the year:<br>The shallow dose equivalent to the extremities. | LEHR's procedures, plans, and/or manuals address the following:<br>The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for external dose received during the year:<br>The shallow dose equivalent to the extremities. | SOP 38.3, Section 7.13 |
| 702(c)(4) | The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for internal dose resulting from intakes received during the year:<br>(i) Committed effective dose equivalent;<br>(ii) Committed dose equivalent to any organ or tissue of concern; and,<br>(iii) Identity of radionuclides. | LEHR's procedures, plans, and/or manuals address the following:<br>The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for internal dose resulting from intakes received during the year:<br>(i) Committed effective dose equivalent;<br>(ii) Committed dose equivalent to any organ or tissue of concern; and,<br>(iii) Identity of radionuclides. | SOP 38.3, Section 7.14 |
| 702(c)(5)(i) | The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for the summation of the external and internal dose:<br>Total effective dose equivalent in a year; | LEHR's procedures, plans, and/or manuals address the following:<br>The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for the summation of the external and internal dose:<br>Total effective dose equivalent in a year; | SOP 38.3, Section 7.15 |
| 702(c)(5)(ii) | The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for the summation of the external and internal dose:<br>For any organ or tissue assigned an internal dose during the year, the sum of the deep dose equivalent from external exposures and the committed dose equivalent to that organ or tissue; and | LEHR's procedures, plans, and/or manuals address the following:<br>The (individual monitoring) records required by this section SHALL:<br>Include the following quantities for the summation of the external and internal dose:<br>For any organ or tissue assigned an internal dose during the year, the sum of the deep dose equivalent from external exposures and the committed dose equivalent to that organ or tissue; and | SOP 38.3, Section 7.15 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 702(c)(5)(iii) | The (individual monitoring) records required by this section SHALL: Include the following quantities for the summation of the external and internal dose: Cumulative total effective dose equivalent. | LEHR's procedures, plans, and/or manuals address the following: The (individual monitoring) records required by this section SHALL: Include the following quantities for the summation of the external and internal dose: Cumulative total effective dose equivalent. | SOP 38.3, Section 7.15 |
| 702(c)(6) | The (individual monitoring) records required by this section SHALL: Include the dose equivalent to the embryo/fetus of a declared pregnant worker. | LEHR's procedures, plans, and/or manuals address the following: The (individual monitoring) records required by this section SHALL: Include the dose equivalent to the embryo/fetus of a declared pregnant worker. | SOP 38.3, Section 7.7 |
| 702(d) | Documentation of all occupational doses received during the current year, except for doses resulting from planned special exposures conducted in compliance with § 835.204 and emergency exposures authorized in accordance with § 835.1302(d), shall be obtained to demonstrate compliance with § 835.202(a). If complete records documenting previous occupational dose during the year cannot be obtained, a written estimate signed by the individual may be accepted to demonstrate compliance. | LEHR's procedures, plans, and/or manuals address the following: Documentation of all occupational doses received during the current year, except for doses resulting from planned special exposures conducted in compliance with § 835.204 and emergency exposures authorized in accordance with § 835.1302(d), shall be obtained to demonstrate compliance with § 835.202(a). If complete records documenting previous occupational dose during the year cannot be obtained, a written estimate signed by the individual may be accepted to demonstrate compliance. | SOP 38.3, Section 7.10 |
| 702(e) | For radiological workers whose occupational dose is monitored in accordance with § 835.402, reasonable efforts shall be made to obtain complete records of prior years occupational internal and external doses. | LEHR's procedures, plans, and/or manuals address the following: For radiological workers whose occupational dose is monitored in accordance with § 835.402, reasonable efforts shall be made to obtain complete records of prior years occupational internal and external doses. | HSP 15.1, Section 5.6.3<br>SOP 38.3, Section 7.12 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 702(f) | The records specified in this section that are identified with a specific individual SHALL be readily available to that individual. | LEHR's procedures, plans, and/or manuals address the following: The records specified in this section that are identified with a specific individual SHALL be readily available to that individual. | HSP 38.3, Section 7.8 |
| 702(g) | Data necessary to allow future verification or reassessment of the recorded doses SHALL be recorded. | LEHR's procedures, plans, and/or manuals address the following: Data necessary to allow future verification or reassessment of the recorded doses SHALL be recorded. | SOP 38.3, Section 7.9 |
| 702(h) | All records required by this section SHALL be transferred to the DOE upon cessation of activities at the site that could cause exposure to individuals. | LEHR's procedures, plans, and/or manuals address the following: All records required by this section SHALL be transferred to the DOE upon cessation of activities at the site that could cause exposure to individuals. | SOP 38.3, Section 7.3 |
| | | **Other Monitoring Records** | |
| 703(a) | The following information SHALL be documented and maintained: Results of monitoring for radiation and radioactive material as required by subparts E and L of 10 CFR 835, except for monitoring required by § 835.1102(d); | LEHR's procedures, plans, and/or manuals address the following: The following information SHALL be documented and maintained: Results of monitoring for radiation and radioactive material as required by subparts E and L of 10 CFR 835, except for monitoring required by § 835.1102(d); | SOP 38.3, Section 7.18 |
| 703(b) | The following information SHALL be documented and maintained: Results of monitoring used to determine individual occupational dose from external and internal sources; | LEHR's procedures, plans, and/or manuals address the following: The following information SHALL be documented and maintained: Results of monitoring used to determine individual occupational dose from external and internal sources; | HSP 15.1, Section 6.1<br>SOP 38.3, Section 7.18 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 703(c) | The following information SHALL be documented and maintained: Results of monitoring for the release and control of material and equipment as required by § 835.1101; and | LEHR's procedures, plans, and/or manuals address the following: The following information SHALL be documented and maintained: Results of monitoring for the release and control of material and equipment as required by § 835.1101; and | SOP 38.3, Section 6.2.2 |
| 703(d) | The following information SHALL be documented and maintained: Results of maintenance and calibration performed on instruments and equipment as required by § 835.401(b). | LEHR's procedures, plans, and/or manuals address the following: The following information SHALL be documented and maintained: Results of maintenance and calibration performed on instruments and equipment as required by § 835.401(b). | SOP 38.3, Section 6.2.1 |
| | | **Administrative Records** | |
| 704(a) | Training records SHALL be maintained, as necessary, to demonstrate compliance with §835.901. | LEHR's procedures, plans, and/or manuals address the following: Training records SHALL be maintained, as necessary, to demonstrate compliance with §835.901. | SOP 38.3, Section 6.4.3 |
| 704(b) | Actions taken to maintain occupational exposures as low as reasonably achievable, including the actions required for this purpose by §835.101, as well as facility design and control actions required by §835.1001, §835.1002, and §835.1003, SHALL be documented. | LEHR's procedures, plans, and/or manuals address the following: Actions taken to maintain occupational exposures as low as reasonably achievable, including the actions required for this purpose by §835.101, as well as facility design and control actions required by §835.1001, §835.1002, and §835.1003, SHALL be documented. | HSP 15.1, Section 6.2 SOP 38.3, Section 6.4.4 |
| 704(c) | Records SHALL be maintained to document the results of internal audits and other reviews of program content and implementation. | LEHR's procedures, plans, and/or manuals address the following: Records SHALL be maintained to document the results of internal audits and other reviews of program content and implementation. | SOP 38.4, Section 7.0 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 704(d) | Written declarations of pregnancy, including the estimated date of conception, and revocations of declarations of pregnancy shall be maintained. | LEHR's procedures, plans, and/or manuals address the following: Written declarations of pregnancy, including the estimated date of conception, and revocations of declarations of pregnancy shall be maintained. | SOP 38.3, Section 6.4.2 |
| 704(e) | Changes in equipment, techniques, and procedures used for monitoring SHALL be documented. | LEHR's procedures, plans, and/or manuals address the following: Changes in equipment, techniques, and procedures used for monitoring SHALL be documented. | SOP 25.1, Section 7.0 |
| 704(f) | Records shall be maintained as necessary to demonstrate compliance with the requirements of 835.1201 and 835.1202 for sealed radioactive source control, inventory, and source leak tests. | LEHR's procedures, plans, and/or manuals address the following: Records shall be maintained as necessary to demonstrate compliance with the requirements of 835.1201 and 835.1202 for sealed radioactive source control, inventory, and source leak tests. | SOP 38.3, Section 7.19 |
| | **SUBPART I - REPORTS TO INDIVIDUALS** | | |
| | **Reports to Individuals** | | |
| 801(a) | Radiation exposure data for individuals monitored in accordance with § 835.402 shall be reported as specified in this section. The information shall include the data required under § 835.702(c). Each notification and report shall be in writing and include: the DOE site or facility name, the name of the individual, and the individual's social security number, employee number, or other unique identification number. | LEHR's procedures, plans, and/or manuals address the following: Radiation exposure data for individuals monitored in accordance with § 835.402 shall be reported as specified in this section. The information shall include the data required under § 835.702(c). Each notification and report shall be in writing and include: the DOE site or facility name, the name of the individual, and the individual's social security number, employee number, or other unique identification number. | SOP 38.5, Section 6.2.1 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 801(b).01 | Upon the request from an individual terminating employment, records of exposure SHALL be provided to that individual as soon as the data are available, but not later than 90 days after termination. | LEHR's procedures, plans, and/or manuals address the following: Upon the request from an individual terminating employment, records of exposure SHALL be provided to that individual as soon as the data are available, but not later than 90 days after termination. | SOP 38.5, Section 6.2.2 |
| 801(b).02 | A written estimate of the radiation dose received by that employee based on available information SHALL be provided at the time of termination, if requested. | LEHR's procedures, plans, and/or manuals address the following: A written estimate of the radiation dose received by that employee based on available information SHALL be provided at the time of termination, if requested. | SOP 38.5, Section 6.2.2 |
| 801(c) | Each DOE- or DOE-contractor-operated site or facility SHALL, on an annual basis, provide a radiation dose report to each individual monitored during the year at that site or facility in accordance with §835.402. | LEHR's procedures, plans, and/or manuals address the following: Each DOE- or DOE-contractor-operated site or facility SHALL, on an annual basis, provide a radiation dose report to each individual monitored during the year at that site or facility in accordance with §835.402. | SOP 38.5, Section 6.2.3 |
| 801(d) | Detailed information concerning any individual's exposure SHALL be made available to the individual upon request of that individual, consistent with the provisions of the Privacy Act (5 U.S.C. 552a). | LEHR's procedures, plans, and/or manuals address the following: Detailed information concerning any individual's exposure SHALL be made available to the individual upon request of that individual, consistent with the provisions of the Privacy Act (5 U.S.C. 552a). | SOP 38.5, Section 6.2.5 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 801(e).01 | When a DOE contractor is required to report to the Department, pursuant to Departmental requirements for occurrence reporting and processing, any exposure of an individual to radiation and/or radioactive material, or planned special exposure in accordance with §835.204(e), the contractor SHALL also provide that individual with a report on his or her exposure data included therein. | LEHR's procedures, plans, and/or manuals address the following: When a DOE contractor is required to report to the Department, pursuant to Departmental requirements for occurrence reporting and processing, any exposure of an individual to radiation and/or radioactive material, or planned special exposure in accordance with §835.204(e), the contractor SHALL also provide that individual with a report on his or her exposure data included therein. | SOP 38.5, Section 6.2.6 |
| 801(e).02 | Such report (radiation exposure data report) SHALL be transmitted at a time not later than the transmittal to the Department. | LEHR's procedures, plans, and/or manuals address the following: Such report (radiation exposure data report) SHALL be transmitted at a time not later than the transmittal to the Department. | SOP 38.5, Section 6.2.6 |
| | **SUBPART J - RADIATION SAFETY TRAINING** | | |
| 901(a) | Each individual shall complete radiation safety training on the topics established at § 835.901(c) commensurate with the hazards in the area and the required controls: (1) Before being permitted unescorted access to controlled areas; and (2) Before receiving occupational dose during access to controlled areas at a DOE site or facility. | LEHR's procedures, plans, and/or manuals address the following: Each individual shall complete radiation safety training on the topics established at § 835.901(c) commensurate with the hazards in the area and the required controls: (1) Before being permitted unescorted access to controlled areas; and (2) Before receiving occupational dose during access to controlled areas at a DOE site or facility. | HSP 20.1, Sections 6.1.4 and 6.1.5 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 901(b) | Each individual shall demonstrate knowledge of the radiation safety training topics established in § 835.901(c), commensurate with the hazards in the area and required controls, by successful completion of an examination and performance demonstrations:<br>(1) Before being permitted unescorted access to radiological areas; and<br>(2) Before performing unescorted assignments as a radiological worker. | LEHR's procedures, plans, and/or manuals address the following:<br>Each individual shall demonstrate knowledge of the radiation safety training topics established in § 835.901(c), commensurate with the hazards in the area and required controls, by successful completion of an examination and performance demonstrations:<br>(1) Before being permitted unescorted access to radiological areas; and<br>(2) Before performing unescorted assignments as a radiological worker. | HSP 20.1, Sections 6.1.4 and 6.1.5 |
| 901(c) | Radiation safety training 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:<br>(1) Risks of exposure to radiation and radioactive materials, including prenatal radiation exposure;<br>(2) Basic radiological fundamentals and radiation protection concepts;<br>(3) Physical design features, administrative controls, limits, policies, procedures, alarms, and other measures implemented at the facility to manage doses and maintain doses ALARA, including both routine and emergency actions;<br>(4) Individual rights and responsibilities as related to implementation of the facility radiation protection program;<br>(5) Individual responsibilities for implementing ALARA measures required by § 835.101; and<br>(6) Individual exposure reports that may be requested in accordance with § 835.801. | LEHR's procedures, plans, and/or manuals address the following:<br>Radiation safety training 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:<br>(1) Risks of exposure to radiation and radioactive materials, including prenatal radiation exposure;<br>(2) Basic radiological fundamentals and radiation protection concepts;<br>(3) Physical design features, administrative controls, limits, policies, procedures, alarms, and other measures implemented at the facility to manage doses and maintain doses ALARA, including both routine and emergency actions;<br>(4) Individual rights and responsibilities as related to implementation of the facility radiation protection program;<br>(5) Individual responsibilities for implementing ALARA measures required by § 835.101; and<br>(6) Individual exposure reports that may be requested in accordance with § 835.801. | HSP 20.1, Sections 6.1.4 and 6.1.6<br>SOP 38.1, Section 3.13 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 901(d) | When an escort is used in lieu of training in accordance with paragraph (a) or (b) of this section, the escort shall:<br>(1) Have completed radiation safety training, examinations, and performance demonstrations required for entry to the area and performance of the work; and<br>(2) Ensure that all escorted individuals comply with the documented radiation protection program. | LEHR's procedures, plans, and/or manuals address the following: When an escort is used in lieu of training in accordance with paragraph (a) or (b) of this section, the escort shall:<br>(1) Have completed radiation safety training, examinations, and performance demonstrations required for entry to the area and performance of the work; and<br>(2) Ensure that all escorted individuals comply with the documented radiation protection program. | SOP 24.1, Section 6.2.12<br>HSP 20.1, Section 6.1.9 |
| 901(e) | Radiation safety training shall be provided to individuals when there is a significant change to radiation protection policies and procedures that may affect the individual and at intervals not to exceed 24 months. Such training provided for individuals subject to the requirements of § 835.901(b)(1) and (b)(2) shall include successful completion of an examination. | LEHR's procedures, plans, and/or manuals address the following: Radiation safety training shall be provided to individuals when there is a significant change to radiation protection policies and procedures that may affect the individual and at intervals not to exceed 24 months. Such training provided for individuals subject to the requirements of § 835.901(b)(1) and (b)(2) shall include successful completion of an examination. | HSP 20.1, Section 6.1.4 |
| | **SUBPART K - DESIGN AND CONTROL** | | |
| | **Design and Control** | | |
| 1001(a) | Measures shall be taken to maintain radiation exposure in controlled areas ALARA through physical design features and administrative control. The primary methods used shall be physical design features (e.g., confinement, ventilation, remote handling, and shielding). Administrative controls shall be employed only as supplemental methods to control radiation exposure. | LEHR's procedures, plans, and/or manuals address the following: Measures shall be taken to maintain radiation exposure in controlled areas ALARA through physical design features and administrative control. The primary methods used shall be physical design features (e.g., confinement, ventilation, remote handling, and shielding). Administrative controls shall be employed only as supplemental methods to control radiation exposure. | RPP Section 4.0<br>HSP 15.1, Section 5.14 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 1001(b) | For specific activities where use of physical design features is demonstrated to be impractical, administrative controls shall be used to maintain radiation exposures ALARA. | LEHR's procedures, plans, and/or manuals address the following: For specific activities where use of physical design features is demonstrated to be impractical, administrative controls shall be used to maintain radiation exposures ALARA. | HSP 15.1, Section 5.14 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | | **Facility Design and Modifications** | |
| 1002 | During the design of new facilities or modification of existing facilities, the following objectives shall be adopted:<br>(a) Optimization methods shall be used to assure that occupational exposure is maintained ALARA in developing and justifying facility design and physical controls.<br>(b) The design objective for controlling personnel exposure from external sources of radiation in areas of continuous occupational occupance (2000 hours per year) shall be to maintain exposure levels below an average of 015 mrem (5 microsieverts) per hour and as far below this average as is reasonably achievable. The design objectives for exposure rates for potential exposure to a radiological worker where occupancy differs from the above shall be ALARA and shall not exceed 20 percent of the applicable standards in § 835.202.<br>(c) Regarding the control of airborne radioactive material, the design objective shall be, under normal conditions, to avoid releases to the workplace atmosphere and in any situation, to control the inhalation of such material by workers to levels that are ALARA; confinement and ventilation shall normally be used.<br>(d) The design or modification of a facility and the selection of materials shall include features that facilitate operations, maintenance, decontamination, and decommissioning. | LEHR's current scope does not include designing or modifying a facility for future use. | NA |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | | **Workplace Controls** | |
| 1003(a) | During routine operations, the combination of physical design features and administrative controls shall provide that: The anticipated occupational dose to general employees shall not exceed the limits established at § 835.202; and | LEHR's procedures, plans, and/or manuals address the following: During routine operations, the combination of physical design features and administrative controls shall provide that: The anticipated occupational dose to general employees shall not exceed the limits established at § 835.202. | HSP 15.1, Section 5.15 |
| 1003(b) | During routine operations, the combination of physical design features and administrative controls shall provide that: The ALARA process is utilized for personnel exposures to ionizing radiation. | LEHR's procedures, plans, and/or manuals address the following: During routine operations, the combination of physical design features and administrative controls shall provide that: The ALARA process is utilized for personnel exposures to ionizing radiation. | HSP 15.1, Section 5.14 |
| | | **SUBPART L - RADIOACTIVE CONTAMINATION CONTROL** | |
| | | **Control of Material and Equipment** | |
| 1101(a) | (a) Except as provided in paragraphs (b) and (c) of this section, material and equipment in contamination areas, high contamination areas, and airborne radioactivity areas shall not be released to a controlled area if: (1) Removable surface contamination levels on accessible surfaces exceed the removable surface contamination values specified in appendix D of 10 CFR 835; or (2) Prior use suggests that the removable surface contamination levels on inaccessible surfaces are likely to exceed the removable surface contamination values specified in appendix D of 10 CFR 835. | LEHR's procedures, plans, and/or manuals address the following: (a) Except as provided in paragraphs (b) and (c) of this section, material and equipment in contamination areas, high contamination areas, and airborne radioactivity areas shall not be released to a controlled area if: (1) Removable surface contamination levels on accessible surfaces exceed the removable surface contamination values specified in appendix D of 10 CFR 835; or (2) Prior use suggests that the removable surface contamination levels on inaccessible surfaces are likely to exceed the removable surface contamination values specified in appendix D of 10 CFR 835. | SOP 32.1, Section 6.7.1 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 1101(b) | Material and equipment exceeding the removable surface contamination values specified in appendix D of 10 CFR 835 may be conditionally released for movement on-site from one radiological area for immediate placement in another radiological area only if appropriate monitoring is performed and appropriate controls for the movement are established and exercised. | LEHR's procedures, plans, and/or manuals address the following: Material and equipment exceeding the removable surface contamination values specified in appendix D of 10 CFR 835 may be conditionally released for movement on-site from one radiological area for immediate placement in another radiological area only if appropriate monitoring is performed and appropriate controls for the movement are established and exercised. | SOP 32.1, Section 6.7.2 |
| 1101(c) | Material and equipment with fixed contamination levels that exceed the total surface contamination values specified in appendix D of 10 CFR 835 may be released for use in controlled areas outside of radiological areas only under the following conditions:<br>(1) Removable surface contamination levels are below the removable surface contamination values specified in appendix D of 10 CFR 835; and<br>(2) The material or equipment is routinely monitored and clearly marked or labeled to alert personnel of the contaminated status. | LEHR's procedures, plans, and/or manuals address the following: Material and equipment with fixed contamination levels that exceed the total surface contamination values specified in appendix D of 10 CFR 835 may be released for use in controlled areas outside of radiological areas only under the following conditions:<br>(1) Removable surface contamination levels are below the removable surface contamination values specified in appendix D of 10 CFR 835; and<br>(2) The material or equipment is routinely monitored and clearly marked or labeled to alert personnel of the contaminated status. | SOP 32.1, Section 6.7.3 |
| | | **Control of Areas** | |
| 1102(a) | Appropriate controls shall be maintained and verified which prevent the inadvertent transfer of removable contamination to locations outside of radiological areas under normal operating conditions. | LEHR's procedures, plans, and/or manuals address the following: Appropriate controls shall be maintained and verified which prevent the inadvertent transfer of removable contamination to locations outside of radiological areas under normal operating conditions. | SOP 32.1, Section 6.1.3 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 1102(b) | Any area in which contamination levels exceed the values specified in appendix D of 10 CFR 835 shall be controlled in a manner commensurate with the physical and chemical characteristics of the contaminant, the radionuclides present, and the fixed and removable surface contamination levels. | LEHR's procedures, plans, and/or manuals address the following: Any area in which contamination levels exceed the values specified in appendix D of 10 CFR 835 shall be controlled in a manner commensurate with the physical and chemical characteristics of the contaminant, the radionuclides present, and the fixed and removable surface contamination levels. | SOP 32.1, Section 6.1.4 |
| 1102(c) | Areas accessible to individuals where the measured total surface contamination levels exceed, but the removable surface contamination levels are less than, corresponding surface contamination values specified in appendix D of 10 CFR 835, shall be controlled as follows when located outside of radiological areas:<br>(1) The area shall be routinely monitored to ensure the removable surface contamination level remains below the removable surface contamination values specified in appendix D of 10 CFR 835; and<br>(2) The area shall be conspicuously marked to warn individuals of the contaminated status. | LEHR's procedures, plans, and/or manuals address the following: Areas accessible to individuals where the measured total surface contamination levels exceed, but the removable surface contamination levels are less than, corresponding surface contamination values specified in appendix D of 10 CFR 835, shall be controlled as follows when located outside of radiological areas:<br>(1) The area shall be routinely monitored to ensure the removable surface contamination level remains below the removable surface contamination values specified in appendix D of 10 CFR 835; and<br>(2) The area shall be conspicuously marked to warn individuals of the contaminated status. | SOP 32.1, Section 6.1.5 |
| 1102(d) | Individuals exiting contamination, high contamination, or airborne radioactivity areas shall be monitored, as appropriate, for the presence of surface contamination. | LEHR's procedures, plans, and/or manuals address the following: Individuals exiting contamination, high contamination, or airborne radioactivity areas shall be monitored, as appropriate, for the presence of surface contamination. | SOP 32.1, Section 6.1.6 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 1102(e) | Protective clothing shall be required for entry to areas in which removable contamination exists at levels exceeding the removable surface contamination values specified in appendix D of 10 CFR 835. | LEHR's procedures, plans, and/or manuals address the following: Protective clothing shall be required for entry to areas in which removable contamination exists at levels exceeding the removable surface contamination values specified in appendix D of 10 CFR 835. | SOP 32.1, Section 6.3.1 |
| | **SUBPART M – SEALED RADIOACTIVE SOURCE CONTROL** | | |
| | **Sealed Radioactive Source Control** | | |
| 1201 | Sealed radioactive sources shall be used, handled, and stored in a manner commensurate with the hazards associated with operations involving the sources. | Sealed radioactive sources shall be used, handled, and stored in a manner commensurate with the hazards associated with operations involving the sources. | SOP 32.1, Section 6.10.1 |
| | **Accountable Sealed Radioactive Sources** | | |
| 1202(a) | Each accountable sealed radioactive source shall be inventoried at intervals not to exceed six months. This inventory shall:<br>(1) Establish the physical location of each accountable sealed radioactive source;<br>(2) Verify the presence and adequacy of associated postings and labels; and<br>(3) Establish the adequacy of storage locations, containers, and devices. | Each accountable sealed radioactive source shall be inventoried at intervals not to exceed six months. This inventory shall:<br>(1) Establish the physical location of each accountable sealed radioactive source;<br>(2) Verify the presence and adequacy of associated postings and labels; and<br>(3) Establish the adequacy of storage locations, containers, and devices. | SOP 32.1, Section 6.10.3 |
| 1202(b) | Except for sealed radioactive sources consisting solely of gaseous radioactive material or tritium, each accountable sealed radioactive source shall be subject to a source leak test upon receipt, when damage is suspected, and at intervals not to exceed six months. Source leak tests shall be capable of detecting radioactive material leakage equal to or exceeding 0.005 microcurie. | Except for sealed radioactive sources consisting solely of gaseous radioactive material or tritium, each accountable sealed radioactive source shall be subject to a source leak test upon receipt, when damage is suspected, and at intervals not to exceed six months. Source leak tests shall be capable of detecting radioactive material leakage equal to or exceeding 0.005 microcurie. | SOP 32.1, Section 6.10.4 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| 1202(c) | Notwithstanding the requirements of paragraph (b) of this section, an accountable sealed radioactive source is not subject to periodic source leak testing if that source has been removed from service. Such sources shall be stored in a controlled location, subject to periodic inventory as required by paragraph (a) of this section, and subject to source leak testing prior to being returned to service. | Notwithstanding the requirements of paragraph (b) of this section, an accountable sealed radioactive source is not subject to periodic source leak testing if that source has been removed from service. Such sources shall be stored in a controlled location, subject to periodic inventory as required by paragraph (a) of this section, and subject to source leak testing prior to being returned to service. | SOP 32.1, Section 6.10.5 |
| 1202(d) | Notwithstanding the requirements of paragraphs (a) and (b) of this section, an accountable sealed radioactive source is not subject to periodic inventory and source leak testing if that source is located in an area that is unsafe for human entry or otherwise inaccessible. | Notwithstanding the requirements of paragraphs (a) and (b) of this section, an accountable sealed radioactive source is not subject to periodic inventory and source leak testing if that source is located in an area that is unsafe for human entry or otherwise inaccessible. | SOP 32.1, Section 6.10.6 |
| 1202(e) | An accountable sealed radioactive source found to be leaking radioactive material shall be controlled in a manner that minimizes the spread of radioactive contamination. | An accountable sealed radioactive source found to be leaking radioactive material shall be controlled in a manner that minimizes the spread of radioactive contamination. | SOP 32.1, Section 6.10.7 |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | **SUBPART N - EMERGENCY EXPOSURE SITUATIONS** | | |
| | | **General Provisions** | |
| 1301 | (a) A general employee whose occupational dose has exceeded the numerical value of any of the limits specified in § 835.202 as a result of an authorized emergency exposure may be permitted to return to work in radiological areas during the current year providing that all of the following conditions are met:<br>(1) Approval is first obtained from the contractor management and the Head of the responsible DOE field organization;<br>(2) The individual receives counseling from radiological protection and medical personnel regarding the consequences of receiving additional occupational exposure during the year; and<br>(3) The affected employee agrees to return to radiological work.<br>(b) All doses exceeding the limits specified in § 835.202 shall be recorded in the affected individual's occupational dose record.<br>(c) When the conditions under which a dose was received in excess of the limits specified in § 835.202, except those doses received in accordance with § 835.204, have been eliminated, operating management shall notify the Head of the responsible DOE field organization. | LEHR's activities and radioactive material concentrations would preclude invoking the requirements of §835.1301 since no individuals covered by this RPP are permitted to engage in emergency exposure situations. | NA. |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| | (d) Operations after a dose was received in excess of the limits specified in § 835.202, except those received in accordance with §835.204, may be resumed only with the approval of DOE. | | |
| | | **Emergency Exposure Situations** | |
| 1302 | (a) The risk of injury to those individuals involved in rescue and recovery operations shall be minimized.<br>(b) Operating management shall weigh actual and potential risks against the benefits to be gained.<br>(c) No individual shall be required to perform rescue action that might involve substantial personal risk.<br>(d) Each individual authorized to perform emergency actions likely to result in occupational doses exceeding the values of the limits provided at § 835.202(a) shall be trained in accordance with § 835.901(b) and briefed beforehand on the known or anticipated hazards to which the individual will be subjected. | LEHR's activities and radioactive material concentrations would preclude invoking the requirements of §835.1302. | NA |
| | | **Nuclear Accident Dosimetry** | |
| 1304 | Installations possessing sufficient quantities of fissile material to potentially constitute a critical mass, such that the excessive exposure of individuals to radiation from a nuclear accident is possible, SHALL provide nuclear accident dosimetry for those personnel. | LEHR has insufficient quantities of fissile materials that could potentially result in a critical mass and therefore the requirements of §835.1304 are not addressed in LEHR documents. | NA |

Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

| Article | 10 CFR 835 Statement | LEHR Compliance Statement | Procedure Reference Information *(abbreviation key at end)* |
|---|---|---|---|
| **APPENDIX A TO PART 835 - DERIVED AIR CONCENTRATIONS (DAC) FOR CONTROLLING RADIATION EXPOSURE TO WORKERS AT DOE FACILITIES** | | | |
| **Appendices to 10 CFR 835** | | | |
| Appendices A, C, D and E | Appendices A, C, D and E | By reference, the following appendices are incorporated in LEHR procedures, plans, and/or manuals: Appendices A, C, D and E | RPP, Appendix C |

RPP Supporting Procedure Titles

| Procedure ID | Procedure Title |
|---|---|
| SOP 24.1 | Radiological Areas and Posting |
| SOP 25.1 | Radiological Surveys and Instrumentation |
| SOP 25.2 | Radiological Survey Forms |
| SOP 32.1 | Contamination Control |
| SOP 37.1 | Tenelec Series 5 Low Background Counting System |
| SOP 37.2 | Liquid Scintillation Analyzer (LSC) |
| SOP 38.1 | Check-In and Orientation for Radiological Workers, General Employees and Members of the Public |
| SOP 38.2 | External Dosimetry Issuance |
| SOP 38.3 | Radiation Protection Records |
| SOP 38.4 | Radiological Protection Program Audits |
| SOP 38.5 | Occupational Exposure Reports |
| SOP 39.1 | LEHR Site Inspections |
| HSP 14.1 | Airborne Radioactivity Monitoring |
| HSP 15.1 | External Radiation Exposure Control |
| HSP 17.1 | Hazardous Work Permits |
| HSP 18.1 | Personnel Contamination |
| HSP 19.1 | Embryo-Fetus Protection Program |
| HSP 20.1 | Employee and Subcontractor Training Requirements |

## Table A-1. Radiological Protection Program (RPP) Compliance Matrix (continued)

Abbreviations

RPP = Radiological Protection Program
HSP = Health and Safety Procedure
SOP = Standard Operating Procedure

NA = Not applicable to the LEHR Project

Note: Procedures (HSPs and SOPs) may be revised or added in accordance with the provisions of the LEHR Quality Assurance Project Plan and the LEHR Project Health and Safety Plan on the condition that the procedure maintains compliance with 10 CFR 835 and maintains equivalent effectiveness of the RPP. An updated list of procedures will be maintained at the project site. Please refer to the latest revision or update of any consulted procedure or plan. Procedure sections referenced in this table are provided to guide the reader in locating the most pertinent information to facilitate 10 CFR 835 compliance. As procedures are revised, updated, or developed, the sections referenced may not remain current. Changes in section numbers or procedures will not necessarily be the basis for a revision of this RPP. However, when the RPP is revised, references to applicable procedures and sections will also be revised. Other applicable reference within procedures, plans, and/or manuals may exist in addition to the above reference provided under the column entitled "Procedure Reference Information." In the event of a conflict among procedures, plans or manuals, the least restrictive procedure, plan or manual maintaining compliance with 10 CFR 835 will apply. Content of procedures, plans, or manuals not specifically required for compliance with 10 CFR 835 shall not be used as a basis for non-compliance.

# APPENDIX B

## LEHR RADIATION PROTECTION PROGRAM CHANGE REQUEST FORM

# LEHR RADIATION PROTECTION PROGRAM

## Change Request Form

Person/Organization Requesting Change: _____

_____

Date Requested: _____

| Description of Requested Change: |
|---|
| |

| 10 CFR 835 Article Affected (list out article and indicate impact): |
|---|
| |

| Reason and Justification for Change: |
|---|
| |

| Impacts of Change: |
|---|
| |

| Cost of Requested Change: | Concur with Change _____ |
|---|---|
| | Reject Change _____ |

# APPENDIX C

## 10 CFR 835, OCCUPATIONAL RADIATION PROTECTION

(ii) *Independent Assessment.* Independent assessments shall be planned and conducted to measure item and service quality, to measure the adequacy of work performance, and to promote improvement. The group performing independent assessments shall have sufficient authority and freedom from the line to carry out its responsibilities. Persons conducting independent assessments shall be technically qualified and knowledgeable in the areas assessed.

## Subpart B—Design [Reserved]

## Subpart C—Operations [Reserved]

## Subpart D—Material Management [Reserved]

# PART 835—OCCUPATIONAL RADIATION PROTECTION

### Subpart A—General Provisions

Sec.
835.1 Scope.
835.2 Definitions.
835.3 General rule.
835.4 Radiological units.

### Subpart B—Management and Administrative Requirements

835.101 Radiation protection programs.
835.102 Internal audits.
835.103 Education, training and skills.
835.104 Written procedures.

### Subpart C—Standards for Internal and External Exposure

835.201 [Reserved]
835.202 Occupational dose limits for general employees.
835.203 Combining internal and external dose equivalents.
835.204 Planned special exposures.
835.205 Determination of compliance for non-uniform exposure of the skin.
835.206 Limits for the embryo/fetus.
835.207 Occupational dose limits for minors.
835.208 Limits for members of the public entering a controlled area.
835.209 Concentrations of radioactive material in air.

### Subpart D [Reserved]

### Subpart E—Monitoring of Individuals and Areas

835.401 General requirements.
835.402 Individual monitoring.
835.403 Air monitoring.
835.404 [Reserved]
835.405 Receipt of packages containing radioactive material.

### Subpart F—Entry Control Program

835.501 Radiological areas.
835.502 High and very high radiation areas.

### Subpart G—Posting and Labeling

835.601 General requirements.
835.602 Controlled areas.
835.603 Radiological areas and radioactive material areas.
835.604 Exceptions to posting requirements.
835.605 Labeling items and containers.
835.606 Exceptions to labeling requirements.

### Subpart H—Records

835.701 General provisions.
835.702 Individual monitoring records.
835.703 Other monitoring records.
835.704 Administrative records.

### Subpart I—Reports to Individuals

835.801 Reports to individuals.

### Subpart J—Radiation Safety Training

835.901 Radiation safety training.
835.902–835.903 [Reserved]

### Subpart K—Design and Control

835.1001 Design and control.
835.1002 Facility design and modifications.
835.1003 Workplace controls.

### Subpart L—Radioactive Contamination Control

835.1101 Control of material and equipment.
835.1102 Control of areas.

### Subpart M—Sealed Radioactive Source Control

835.1201 Sealed radioactive source control.
835.1202 Accountable sealed radioactive sources.

### Subpart N—Emergency Exposure Situations

835.1301 General provisions.
835.1302 Emergency exposure situations.
835.1303 [Reserved]

835.1304 Nuclear accident dosimetry.
APPENDIX A TO PART 835—DERIVED AIR CONCENTRATIONS (DAC) FOR CONTROLLING RADIATION EXPOSURE TO WORKERS AT DOE FACILITIES
APPENDIX B TO PART 835 [RESERVED]
APPENDIX C TO PART 835—DERIVED AIR CONCENTRATIONS (DAC) FOR WORKERS FROM EXTERNAL EXPOSURE DURING IMMERSION IN A CONTAMINATED ATMOSPHERIC CLOUD
APPENDIX D TO PART 835—SURFACE CONTAMINATION VALUES
APPENDIX E TO PART 835—VALUES FOR ESTABLISHING SEALED RADIOACTIVE SOURCE ACCOUNTABILITY AND RADIOACTIVE MATERIAL POSTING AND LABELING REQUIREMENTS

AUTHORITY: 42 U.S.C. 2201; 7191.

SOURCE: 58 FR 65485, Dec. 14, 1993, unless otherwise noted.

## Subpart A—General Provisions

### § 835.1 Scope.

(a) *General.* The rules in this part establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities.

(b) *Exclusion.* Except as discussed in paragraph (c) of this section, the requirements in this part do not apply to:

(1) Activities that are regulated through a license by the Nuclear Regulatory Commission or a State under an Agreement with the Nuclear Regulatory commission, including activities certified by the Nuclear Regulatory Commission under section 1701 of the Atomic Energy Act;

(2) Activities conducted under the authority of the Director, Naval Nuclear Propulsion Program, as described in Pub. L. 98-525;

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

(4) Radioactive material transportation as defined in this part;

(5) DOE activities conducted outside the United States on territory under the jurisdiction of a foreign government to the extent governed by occupational radiation protection requirements agreed to between the United States and the cognizant government; or

(6) Background radiation, radiation doses received as a patient for the purposes of medical diagnosis or therapy, or radiation doses received from participation as a subject in medical research programs.

(c) Occupational doses received as a result of excluded activities and radioactive material transportation, as listed in paragraphs (b)(1) through (b)(5) of this section, shall be considered when determining compliance with the occupational dose limits at §§835.202 and 835.207, and with the limits for the embryo/fetus at §835.206. Occupational doses resulting from authorized emergency exposures and planned special exposures shall not be considered when determining compliance with the dose limits at §§835.202 and 835.207.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59679, Nov. 4, 1998]

### § 835.2 Definitions.

(a) As used in this part:

*Accountable sealed radioactive source* means a sealed radioactive source having a half-life equal to or greater than 30 days and an isotopic activity equal to or greater than the corresponding value provided in appendix E of this part.

*Airborne radioactive material or airborne radioactivity* means radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases.

*Airborne radioactivity area* means any area, accessible to individuals, where:

(1) The concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed the derived air concentration (DAC) values listed in appendix A or appendix C of this part; or

(2) An individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-hours in a week.

*ALARA* means "As Low As is Reasonably Achievable," which is the approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. As used in this part, ALARA is not a dose

limit but a process which has the objective of attaining doses as far below the applicable limits of this part as is reasonably achievable.

*Annual limit on intake (ALI)* means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man (ICRP Publication 23) that would result in a committed effective dose equivalent of 5 rems (0.05 sievert) or a committed dose equivalent of 50 rems (0.5 sievert) to any individual organ or tissue. ALI values for intake by ingestion and inhalation of selected radionuclides are based on Table 1 of the U.S. Environmental Protection Agency's Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion,* published September 1988. This document is available from the National Technical Information Service, Springfield, VA.

*Background* means radiation from:

(i) Naturally occurring radioactive materials which have not been technologically enhanced;

(ii) Cosmic sources;

(iii) Global fallout as it exists in the environment (such as from the testing of nuclear explosive devices);

(iv) Radon and its progeny in concentrations or levels existing in buildings or the environment which have not been elevated as a result of current or prior activities; and

(v) Consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation.

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

*Calibration* means to adjust and/or determine either:

(i) The response or reading of an instrument relative to a standard (e.g., primary, secondary, or tertiary) or to a series of conventionally true values; or

(ii) The strength of a radiation source relative to a standard (e.g., primary, secondary, or tertiary) or conventionally true value.

*Contamination area* means any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in appendix D of this part, but do not exceed 100 times those values.

*Contractor* means any entity under contract with the Department of Energy with the responsibility to perform activities at a DOE site or facility.

*Controlled area* means any area to which access is managed by or for DOE to protect individuals from exposure to radiation and/or radioactive material.

*Declared pregnant worker* means 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 at § 835.206. This declaration may be revoked, in writing, at any time by the declared pregnant worker.

*Derived air concentration (DAC)* means, for the radionuclides listed in appendix A of this part, the airborne concentration that equals the ALI divided by the volume of air breathed by an average worker for a working year of 2000 hours (assuming a breathing volume of 2400 $m^3$). For the radionuclides listed in appendix C of this part, the air immersion DACs were calculated for a continuous, non-shielded exposure via immersion in a semi-infinite atmospheric cloud. The value is based upon the derived airborne concentration found in Table 1 of the U.S. Environmental Protection Agency's Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion,* published September 1988. This document is available from the National Technical Information Service, Springfield, VA.

*Derived air concentration-hour (DAC-hour)* means the product of the concentration of radioactive material in air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide, in hours.

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

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

*General employee* means an individual who is either a DOE or 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.

*High contamination area* means 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 this part.

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

*Individual* means any human being.

*Member of the public* means an individual who is not a general employee. An individual is not a "member of the public" during any period in which the individual receives an occupational dose.

*Minor* means an individual less than 18 years of age.

*Monitoring* means 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.

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

*Occupational dose* means an individual's ionizing radiation dose (external and internal) as a result of that individual's 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.

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

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

*Radiation area* means any area accessible to individuals in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.005 rem (0.05 millisievert) in 1 hour at 30 centimeters from the source or from any surface that the radiation penetrates.

*Radioactive material area* means any area within a controlled area, accessible to individuals, in which items or containers of radioactive material exist and the total activity of radioactive material exceeds the applicable values provided in appendix E of this part.

*Radioactive material transportation* means the movement of radioactive material by aircraft, rail, vessel, or

highway vehicle when such movement is subject to Department of Transportation regulations or DOE Orders that govern such movements. Radioactive material transportation does not include preparation of material or packagings for transportation, monitoring required by this part, storage of material awaiting transportation, or application of markings and labels required for transportation.

*Radiological area* means any area within a controlled area defined in this section as a "radiation area," "high radiation area," "very high radiation area," "contamination area," "high contamination area," or "airborne radioactivity area."

*Radiological worker* means a general employee whose job assignment involves operation of radiation producing devices or working with radioactive materials, or who is likely to be routinely occupationally exposed above 0.1 rem (0.001 sievert) per year total effective dose equivalent.

*Real-time air monitoring* means measurement of the concentrations or quantities of airborne radioactive materials on a continuous basis.

*Respiratory protective device* means an apparatus, such as a respirator, worn by an individual for the purpose of reducing the individual's intake of airborne radioactive materials.

*Sealed radioactive source* means a radioactive source manufactured, obtained, or retained for the purpose of utilizing the emitted radiation. The sealed radioactive source consists of a known or estimated quantity of radioactive material contained within a sealed capsule, sealed between layer(s) of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material. Sealed radioactive sources do not include reactor fuel elements, nuclear explosive devices, and radioisotope thermoelectric generators.

*Source leak test* means a test to determine if a sealed radioactive source is leaking radioactive material.

*Stochastic effects* means malignant and hereditary diseases for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose without a threshold for radiation protection purposes.

*Very high radiation area* means any area accessible to individuals in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in one hour at 1 meter from a radiation source or from any surface that the radiation penetrates.

*Week* means a period of seven consecutive days.

*Year* means the period of time beginning on or near January 1 and ending on or near December 31 of that same year used to determine compliance with the provisions of this part. The starting and ending date of the year used to determine compliance may be changed provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years.

(b) As used in this part to describe various aspects of radiation dose:

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

*Committed dose equivalent* ($H_{T,50}$) means the dose equivalent calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem (or sievert).

*Committed effective dose equivalent* ($H_{E,50}$) means the sum of the committed dose equivalents to various tissues in the body ($H_{T,50}$), each multiplied by the appropriate weighting factor ($w_T$)—that is, $H_{E,50} = \Sigma\, w_T\, H_{T,50}$. Committed effective dose equivalent is expressed in units of rem (or sievert).

*Cumulative total effective dose equivalent* means the sum of all total effective dose equivalent values recorded for an individual, where available, for each year occupational dose was received, beginning January 1, 1989.

*Deep dose equivalent* means the dose equivalent derived from external radiation at a depth of 1 cm in tissue.

*Dose* is a general term for absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent as defined in this part.

*Dose equivalent (H)* means the product of absorbed dose (D) in rad (or gray) in tissue, a quality factor (Q), and other modifying factors (N). Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

*Effective dose equivalent* ($H_E$) means the summation of the products of the dose equivalent received by specified tissues of the body ($H_T$) and the appropriate weighting factor ($w_T$)—that is, $H_E = \Sigma w_T H_T$. It includes the dose from radiation sources internal and/or external to the body. For purposes of compliance with this part, deep dose equivalent to the whole body may be used as effective dose equivalent for external exposures. The effective dose equivalent is expressed in units of rem (or sievert).

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

*Extremity* means hands and arms below the elbow or feet and legs below the knee.

*Internal dose or exposure* means that portion of the dose equivalent received from radioactive material taken into the body (e.g., "internal sources").

*Lens of the eye dose equivalent* means the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 cm.

*Quality factor (Q)* means the modifying factor used to calculate the dose equivalent from the absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate quality factor.

(i) The quality factors to be used for determining dose equivalent in rem are as follow:

QUALITY FACTORS

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

When spectral data are insufficient to identify the energy of the neutrons, a quality factor of 10 shall be used.

(ii) When spectral data are sufficient to identify the energy of the neutrons, the following mean quality factor values may be used:

QUALITY FACTORS FOR NEUTRONS

[Mean quality factors, $\bar{Q}$ (maximum value in a 30-cm dosimetry phantom), and values of neutron flux density that deliver in 40 hours, a maximum dose equivalent of 0.1 rem (0.001 sievert). Where neutron energy falls between listed values, the more restrictive mean quality factor shall be used.]

| Neutron energy (MeV) | Mean quality factor | Neutron flux density ($cm^{-2}s^{-1}$) |
|---|---|---|
| $2.5\times10^{-8}$ thermal | 2 | 680 |
| $1\times10^{-7}$ | 2 | 680 |
| $1\times10^{-6}$ | 2 | 560 |
| $1\times10^{-5}$ | 2 | 560 |
| $1\times10^{-4}$ | 2 | 580 |
| $1\times10^{-3}$ | 2 | 680 |
| $1\times10^{-2}$ | 2.5 | 700 |
| $1\times10^{-1}$ | 7.5 | 115 |
| $5\times10^{-1}$ | 11 | 27 |
| 1 | 11 | 19 |
| 2.5 | 9 | 20 |
| 5 | 8 | 16 |
| 7 | 7 | 17 |
| 10 | 6.5 | 17 |
| 14 | 7.5 | 12 |
| 20 | 8 | 11 |
| 40 | 7 | 10 |
| 60 | 5.5 | 11 |
| $1\times10^{2}$ | 4 | 14 |
| $2\times10^{2}$ | 3.5 | 13 |
| $3\times10^{2}$ | 3.5 | 11 |
| $4\times10^{2}$ | 3.5 | 10 |

*Shallow dose equivalent* means the dose equivalent deriving from external radiation at a depth of 0.007 cm in tissue.

*Total effective dose equivalent* (TEDE) means the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

*Weighting factor* ($w_T$) means 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 as follows:

WEIGHTING FACTORS FOR VARIOUS ORGANS AND TISSUES

| Organs or tissues, T | Weighting factor, $w_T$ |
|---|---|
| Gonads | 0.25 |
| Breasts | 0.15 |
| Red bone marrow | 0.12 |
| Lungs | 0.12 |
| Thyroid | 0.03 |
| Bone surfaces | 0.03 |
| Remainder [1] | 0.30 |
| Whole body [2] | 1.00 |

[1] "Remainder" means the five other organs or tissues, excluding the skin and lens of the eye, with the highest dose (e.g., liver, kidney, spleen, thymus, adrenal, pancreas, stomach, small intestine, and upper large intestine). The weighting factor for each remaining organ or tissue is 0.06.

[2] For the case of uniform external irradiation of the whole body, a weighting factor ($w_T$) equal to 1 may be used in determination of the effective dose equivalent.

*Whole body* means, for the purposes of external exposure, head, trunk (including male gonads), arms above and including the elbow, or legs above and including the knee.

(c) Terms defined in the Atomic Energy Act and not defined in this part are used consistent with the meanings given in the Act.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59680, Nov. 4, 1998]

### § 835.3 General rule.

(a) No person or DOE personnel shall take or cause to be taken any action inconsistent with the requirements of:

(1) This part; or

(2) Any program, plan, schedule, or other process established by this part.

(b) With respect to a particular DOE activity, contractor management shall be responsible for compliance with the requirements of this part.

(c) Where there is no contractor for a DOE activity, DOE shall ensure implementation of and compliance with the requirements of this part.

(d) Nothing in this part shall be construed as limiting actions that may be necessary to protect health and safety.

(e) For those activities that are required by §§835.102, 835.901(e), 835.1202(a), and 835.1202(b), the time interval to conduct these activities may be extended by a period not to exceed 30 days to accommodate scheduling needs.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998]

### § 835.4 Radiological units.

Unless otherwise specified, the quantities used in the records required by this part shall be clearly indicated in special units of curie, rad, roentgen, or rem, including multiples and subdivisions of these units. The SI units, becquerel (Bq), gray (Gy), and sievert (Sv), are only provided parenthetically in this part for reference with scientific standards.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998]

## Subpart B—Management and Administrative Requirements

### § 835.101 Radiation protection programs.

(a) A DOE activity shall be conducted in compliance with a documented radiation protection program (RPP) as approved by the DOE.

(b) The DOE may direct or make modifications to a RPP.

(c) The content of each RPP shall be commensurate with the nature of the activities performed and shall include formal plans and measures for applying the as low as reasonably achievable (ALARA) process to occupational exposure.

(d) The RPP shall specify the existing and/or anticipated operational tasks that are intended to be within the scope of the RPP. Except as provided in §835.101(h), any task outside the scope of a RPP shall not be initiated until an update of the RPP is approved by DOE.

(e) The content of the RPP shall address, but shall not necessarily be limited to, each requirement in this part.

(f) The RPP shall include plans, schedules, and other measures for achieving compliance with regulations of this part. Unless otherwise specified in this part, compliance with amendments to this part shall be achieved no later than 180 days following approval of the revised RPP by DOE. Compliance with the requirements of §835.402(d) for radiobioassay program

accreditation shall be achieved no later than January 1, 2002.

(g) An update of the RPP shall be submitted to DOE:

(1) Whenever a change or an addition to the RPP is made;

(2) Prior to the initiation of a task not within the scope of the RPP; or

(3) Within 180 days of the effective date of any modifications to this part.

(h) Changes, additions, or updates to the RPP may become effective without prior Department approval only if the changes do not decrease the effectiveness of the RPP and the RPP, as changed, continues to meet the requirements of this part. Proposed changes that decrease the effectiveness of the RPP shall not be implemented without submittal to and approval by the Department.

(i) An initial RPP or an update shall be considered approved 180 days after its submission unless rejected by DOE at an earlier date.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998]

### § 835.102 Internal audits.

Internal audits of the radiation protection program, including examination of program content and implementation, shall be conducted through a process that ensures that all functional elements are reviewed no less frequently than every 36 months.

[63 FR 59682, Nov. 4, 1998]

### § 835.103 Education, training and skills.

Individuals responsible for developing and implementing measures necessary for ensuring compliance with the requirements of this part shall have the appropriate education, training, and skills to discharge these responsibilities.

[63 FR 59682, Nov. 4, 1998]

### § 835.104 Written procedures.

Written procedures shall be developed and implemented as necessary to ensure compliance with this part, commensurate with the radiological hazards created by the activity and consistent with the education, training, and skills of the individuals exposed to those hazards.

[63 FR 59682, Nov. 4, 1998]

## Subpart C—Standards for Internal and External Exposure

### § 835.201 [Reserved]

### § 835.202 Occupational dose limits for general employees.

(a) Except for planned special exposures conducted consistent with § 835.204 and emergency exposures authorized in accordance with § 835.1302, the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year:

(1) A total effective dose equivalent of 5 rems (0.05 sievert);

(2) The sum of the deep dose equivalent for external exposures and the committed dose equivalent to any organ or tissue other than the lens of the eye of 50 rems (0.5 sievert);

(3) A lens of the eye dose equivalent of 15 rems (0.15 sievert); and

(4) A shallow dose equivalent of 50 rems (0.5 sievert) to the skin or to any extremity.

(b) All occupational doses received during the current year, except doses resulting from planned special exposures conducted in compliance with § 835.204 and emergency exposures authorized in accordance with § 835.1302, shall be included when demonstrating compliance with §§ 835.202(a) and 835.207.

(c) Doses from background, therapeutic and diagnostic medical radiation, and participation as a subject in medical research programs shall not be included in dose records or in the assessment of compliance with the occupational dose limits.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998]

### § 835.203 Combining internal and external dose equivalents.

(a) The total effective dose equivalent during a year shall be determined by summing the effective dose equivalent from external exposures and the committed effective dose equivalent from intakes during the year.

(b) Determinations of the effective dose equivalent shall be made using the weighting factor values provided in § 835.2.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998]

### § 835.204 Planned special exposures.

(a) A planned special exposure may be authorized for a radiological worker to receive doses in addition to and accounted for separately from the doses received under the limits specified in § 835.202(a), provided that each of the following conditions is satisfied:

(1) The planned special exposure is considered only in an exceptional situation when alternatives that might prevent a radiological worker from exceeding the limits in § 835.202(a) are unavailable or impractical;

(2) The contractor management (and employer, if the employer is not the contractor) specifically requests the planned special exposure, in writing; and

(3) Joint written approval is received from the appropriate DOE Headquarters program office and the Secretarial Officer responsible for environment, safety and health matters.

(b) Prior to requesting an individual to participate in an authorized planned special exposure, the individual's dose from all previous planned special exposures and all doses in excess of the occupational dose limits shall be determined.

(c) An individual shall not receive a planned special exposure that, in addition to the doses determined in § 835.204(b), would result in a dose exceeding the following:

(1) In a year, the numerical values of the dose limits established at § 835.202(a); and

(2) Over the individual's lifetime, five times the numerical values of the dose limits established at § 835.202(a).

(d) Prior to a planned special exposure, written consent shall be obtained from each individual involved. Each such written consent shall include:

(1) The purpose of the planned operations and procedures to be used;

(2) The estimated doses and associated potential risks and specific radiological conditions and other hazards which might be involved in performing the task; and

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

(e) Records of the conduct of a planned special exposure shall be maintained and a written report submitted within 30 days after the planned special exposure to the approving organizations identified in § 835.204(a)(3).

(f) The dose from planned special exposures is not to be considered in controlling future occupational dose of the individual under § 835.202(a), but is to be included in records and reports required under this part.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998]

### § 835.205 Determination of compliance for non-uniform exposure of the skin.

(a) Non-uniform exposures of the skin from X-rays, beta radiation, and/or radioactive material on the skin are to be assessed as specified in this section.

(b) For purposes of demonstrating compliance with § 835.202(a)(4), assessments shall be conducted as follows:

(1) *Area of skin irradiated is 100 cm² or more.* The non-uniform dose equivalent received during the year shall be averaged over the 100 cm² of the skin receiving the maximum dose, added to any uniform dose equivalent also received by the skin, and recorded as the shallow dose equivalent to any extremity or skin for the year.

(2) *Area of skin irradiated is 10 cm² or more, but is less than 100 cm².* The non-uniform dose equivalent (H) to the irradiated area received during the year shall be added to any uniform dose equivalent also received by the skin and recorded as the shallow dose equivalent to any extremity or skin for the year. H is the dose equivalent averaged over the 1 cm² of skin receiving the maximum absorbed dose, D, reduced by the fraction f, which is the irradiated area in cm² divided by 100 cm² (i.e., H=fD). In no case shall a value of f less than 0.1 be used.

(3) *Area of skin irradiated is less than 10 cm².* The non-uniform dose equivalent shall be averaged over the 1 cm² of

skin receiving the maximum dose. This dose equivalent shall:

(i) Be recorded in the individual's occupational exposure history as a special entry; and

(ii) Not be added to any other shallow dose equivalent to any extremity or skin recorded as the dose equivalent for the year.

### § 835.206 Limits for the embryo/fetus.

(a) The dose equivalent limit for the embryo/fetus from the period of conception to birth, as a result of occupational exposure of a declared pregnant worker, is 0.5 rem (0.005 sievert).

(b) Substantial variation above a uniform exposure rate that would satisfy the limits provided in § 835.206(a) shall be avoided.

(c) If the dose equivalent to the embryo/fetus is determined to have already exceeded 0.5 rem (0.005 sievert) by the time a worker declares her pregnancy, the declared pregnant worker shall not be assigned to tasks where additional occupational exposure is likely during the remaining gestation period.

### § 835.207 Occupational dose limits for minors.

The dose equivalent limits for minors occupationally exposed to radiation and/or radioactive materials at a DOE activity are 0.1 rem (0.001 sievert) total effective dose equivalent in a year and 10% of the occupational dose limits specified at § 835.202(a)(3) and (a)(4).

[63 FR 59682, Nov. 4, 1998]

### § 835.208 Limits for members of the public entering a controlled area.

The total effective dose equivalent limit for members of the public exposed to radiation and/or radioactive material during access to a controlled area is 0.1 rem (0.001 sievert) in a year.

[63 FR 59682, Nov. 4, 1998]

### § 835.209 Concentrations of radioactive material in air.

(a) The derived air concentration (DAC) values given in appendices A and C of this part shall be used in the control of occupational exposures to airborne radioactive material.

(b) The estimation of internal dose shall be based on bioassay data rather than air concentration values unless bioassay data are:

(1) Unavailable;

(2) Inadequate; or

(3) Internal dose estimates based on air concentration values are demonstrated to be as or more accurate.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998]

## Subpart D [Reserved]

## Subpart E—Monitoring of Individuals and Areas

### § 835.401 General requirements.

(a) Monitoring of individuals and areas shall be performed to:

(1) Demonstrate compliance with the regulations in this part;

(2) Document radiological conditions;

(3) Detect changes in radiological conditions;

(4) Detect the gradual buildup of radioactive material;

(5) Verify the effectiveness of engineering and process controls in containing radioactive material and reducing radiation exposure; and

(6) Identify and control potential sources of individual exposure to radiation and/or radioactive material.

(b) Instruments and equipment used for monitoring shall be:

(1) Periodically maintained and calibrated on an established frequency;

(2) Appropriate for the type(s), levels, and energies of the radiation(s) encountered;

(3) Appropriate for existing environmental conditions; and

(4) Routinely tested for operability.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998]

### § 835.402 Individual monitoring.

(a) For the purpose of monitoring individual exposures to external radiation, personnel dosimeters shall be provided to and used by:

(1) Radiological workers who, under typical conditions, are likely to receive one or more of the following:

(i) An effective dose equivalent to the whole body of 0.1 rem (0.001 sievert) or more in a year;

(ii) A shallow dose equivalent to the skin or to any extremity of 5 rems (0.05 sievert) or more in a year;

(iii) A lens of the eye dose equivalent of 1.5 rems (0.015 sievert) or more in a year;

(2) Declared pregnant workers who are likely to receive from external sources a dose equivalent to the embryo/fetus in excess of 10 percent of the limit at § 835.206(a);

(3) Occupationally exposed minors likely to receive a dose in excess of 50 percent of the applicable limits at § 835.207 in a year from external sources;

(4) Members of the public entering a controlled area likely to receive a dose in excess of 50 percent of the limit at § 835.208 in a year from external sources; and

(5) Individuals entering a high or very high radiation area.

(b) External dose monitoring programs implemented to demonstrate compliance with § 835.402(a) shall be adequate to demonstrate compliance with the dose limits established in subpart C of this part and shall be:

(1) Accredited, or excepted from accreditation, in accordance with the DOE Laboratory Accreditation Program for Personnel Dosimetry; or

(2) Determined by the Secretarial Officer responsible for environment, safety and health matters to have performance substantially equivalent to that of programs accredited under the DOE Laboratory Accreditation Program for Personnel Dosimetry.

(c) For the purpose of monitoring individual exposures to internal radiation, internal dosimetry programs (including routine bioassay programs) shall be conducted for:

(1) Radiological workers who, under typical conditions, are likely to receive a committed effective dose equivalent of 0.1 rem (0.001 sievert) or more from all occupational radionuclide intakes in a year;

(2) Declared pregnant workers likely to receive an intake or intakes resulting in a dose equivalent to the embryo/fetus in excess of 10 percent of the limit stated at § 835.206(a);

(3) Occupationally exposed minors who are likely to receive a dose in excess of 50 percent of the applicable limit stated at § 835.207 from all radionuclide intakes in a year; or

(4) Members of the public entering a controlled area likely to receive a dose in excess of 50 percent of the limit stated at § 835.208 from all radionuclide intakes in a year.

(d) Internal dose monitoring programs implemented to demonstrate compliance with § 835.402(c) shall be adequate to demonstrate compliance with the dose limits established in subpart C of this part and shall be:

(1) Accredited, or excepted from accreditation, in accordance with the DOE Laboratory Accreditation Program for Radiobioassay; or,

(2) Determined by the Secretarial Officer responsible for environment, safety and health matters to have performance substantially equivalent to that of programs accredited under the DOE Laboratory Accreditation Program for Radiobioassy.

[63 FR 59683, Nov. 4, 1998]

### § 835.403 Air monitoring.

(a) Monitoring of airborne radioactivity shall be performed:

(1) Where an individual is likely to receive an exposure of 40 or more DAC-hours in a year; or

(2) As necessary to characterize the airborne radioactivity hazard where respiratory protective devices for protection against airborne radionuclides have been prescribed.

(b) Real-time air monitoring shall be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material.

[63 FR 59683, Nov. 4, 1998]

### § 835.404 [Reserved]

### § 835.405 Receipt of packages containing radioactive material.

(a) If packages containing quantities of radioactive material in excess of a Type A quantity (as defined at 10 CFR 71.4) are expected to be received from radioactive material transportation, arrangements shall be made to either:

(1) Take possession of the package when the carrier offers it for delivery; or

(2) Receive notification as soon as practicable after arrival of the package at the carrier's terminal and to take possession of the package expeditiously after receiving such notification.

(b) Upon receipt from radioactive material transportation, external surfaces of packages known to contain radioactive material shall be monitored if the package:

(1) Is labeled with a Radioactive White I, Yellow II, or Yellow III label (as specified at 49 CFR 172.403 and 172.436-440); or

(2) Has been transported as low specific activity material (as defined at 10 CFR 71.4) on an exclusive use vehicle (as defined at 10 CFR 71.4); or

(3) Has evidence of degradation, such as packages that are crushed, wet, or damaged.

(c) The monitoring required by paragraph (b) of this section shall include:

(1) Measurements of removable contamination levels, unless the package contains only special form (as defined at 10 CFR 71.4) or gaseous radioactive material; and

(2) Measurements of the radiation levels, unless the package contains less than a Type A quantity (as defined at 10 CFR 71.4) of radioactive material.

(d) The monitoring required by paragraph (b) of this section shall be completed as soon as practicable following receipt of the package, but not later than 8 hours after the beginning of the working day following receipt of the package.

[63 FR 59683, Nov. 4, 1998]

## Subpart F—Entry Control Program

### § 835.501 Radiological areas.

(a) Personnel entry control shall be maintained for each radiological area.

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

(c) One or more of the following methods shall be used to ensure control:

(1) Signs and barricades;

(2) Control devices on entrances;

(3) Conspicuous visual and/or audible alarms;

(4) Locked entrance ways; or

(5) Administrative controls.

(d) Written authorizations shall be required to control entry into and perform work within radiological areas. These authorizations shall specify radiation protection measures commensurate with the existing and potential hazards.

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

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59684, Nov. 4, 1998]

### § 835.502 High and very high radiation areas.

(a) The following measures shall be implemented for each entry into a high radiation area:

(1) The area shall be monitored as necessary during access to determine the exposure rates to which the individuals are exposed; and

(2) Each individual shall be monitored by a supplemental dosimetry device or other means capable of providing an immediate estimate of the individual's integrated deep dose equivalent during the entry.

(b) *Physical controls.* One or more of the following features shall be used for each entrance or access point to a high radiation area where radiation levels exist such that an individual could exceed a deep dose equivalent to the whole body of 1 rem (0.01 sievert) in any one hour at 30 centimeters from the source or from any surface that the radiation penetrates:

(1) A control device that prevents entry to the area when high radiation levels exist or upon entry causes the radiation level to be reduced below that level defining a high radiation area;

(2) A device that functions automatically to prevent use or operation of the radiation source or field while individuals are in the area;

(3) 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;

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

(5) Continuous direct or electronic surveillance that is capable of preventing unauthorized entry;

(6) A control device that will automatically generate audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source.

(c) *Very high radiation areas.* In addition to the above requirements, additional measures shall be implemented to ensure individuals are not able to gain unauthorized or inadvertent access to very high radiation areas.

(d) No control(s) shall be established in a high or very high radiation area that would prevent rapid evacuation of personnel.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59684, Nov. 4, 1998]

## Subpart G—Posting and Labeling

### § 835.601 General requirements.

(a) Except as otherwise provided in this subpart, postings and labels required by this subpart shall include the standard radiation warning trefoil in black or magenta imposed upon a yellow background.

(b) Signs required by this subpart shall be clearly and conspicuously posted and may include radiological protection instructions.

(c) The posting and labeling requirements in this subpart may be modified to reflect the special considerations of DOE activities conducted at private residences or businesses. Such modifications shall provide the same level of protection to individuals as the existing provisions in this subpart.

[63 FR 59684, Nov. 4, 1998]

### § 835.602 Controlled areas.

(a) Each access point to a controlled area (as defined at § 835.2) shall be posted whenever radiological areas or radioactive material areas exist in the area. Individuals who enter only controlled areas without entering radiological areas or radioactive material areas are not expected to receive a total effective dose equivalent of more than 0.1 rem (0.001 sievert) in a year.

(b) Signs used for this purpose may be selected by the contractor to avoid conflict with local security requirements.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59684, Nov. 4, 1998]

### § 835.603 Radiological areas and radioactive material areas.

Each access point to radiological areas and radioactive material areas (as defined at § 835.2) shall be posted with conspicuous signs bearing the wording provided in this section.

(a) *Radiation area.* The words "Caution, Radiation Area" shall be posted at each radiation area.

(b) *High radiation area.* The words "Caution, High Radiation Area" or "Danger, High Radiation Area" shall be posted at each high radiation area.

(c) *Very high radiation area.* The words "Grave Danger, Very High Radiation Area" shall be posted at each very high radiation area.

(d) *Airborne radioactivity area.* The words "Caution, Airborne Radioactivity Area" or "Danger, Airborne Radioactivity Area" shall be posted at each airborne radioactivity area.

(e) *Contamination area.* The words "Caution, Contamination Area" shall be posted at each contamination area.

(f) *High contamination area.* The words "Caution, High Contamination Area" or "Danger, High Contamination Area" shall be posted at each high contamination area.

(g) *Radioactive material area.* The words "Caution, Radioactive Material(s)" shall be posted at each radioactive material area.

[63 FR 59684, Nov. 4, 1998]

### § 835.604 Exceptions to posting requirements.

(a) Areas may be excepted from the posting requirements of § 835.603 for periods of less than 8 continuous hours when placed under continuous observation and control of an individual knowledgeable of, and empowered to implement, required access and exposure control measures.

(b) Areas may be excepted from the radioactive material area posting requirements of § 835.603(g) when:

(1) Posted in accordance with §§ 835.603(a) through (f); or

(2) Each item or container of radioactive material is labeled in accordance with this subpart such that individuals entering the area are made aware of the hazard; or

(3) The radioactive material of concern consists solely of structures or installed components which have been activated (i.e., such as by being exposed to neutron radiation or particles produced by an accelerator).

(c) Areas containing only packages received from radioactive material transportation labeled and in non-degraded condition need not be posted in accordance with § 835.603 until the packages are monitored in accordance with § 835.405.

[63 FR 59684, Nov. 4, 1998]

### § 835.605 Labeling items and containers.

Except as provided at § 835.606, each item or container of radioactive material shall bear a durable, clearly visible label bearing the standard radiation warning trefoil and the words "Caution, Radioactive Material" or "Danger, Radioactive Material." The label shall also provide sufficient information to permit individuals handling, using, or working in the vicinity of the items or containers to take precautions to avoid or control exposures.

[63 FR 59684, Nov. 4, 1998]

### § 835.606 Exceptions to labeling requirements.

(a) Items and containers may be excepted from the radioactive material labeling requirements of § 835.605 when:

(1) Used, handled, or stored in areas posted and controlled in accordance with this subpart and sufficient information is provided to permit individuals to take precautions to avoid or control exposures; or

(2) The quantity of radioactive material is less than one tenth of the values specified in appendix E of this part; or

(3) Packaged, labeled, and marked in accordance with the regulations of the Department of Transportation or DOE Orders governing radioactive material transportation; or

(4) Inaccessible, or accessible only to individuals authorized to handle or use them, or to work in the vicinity; or

(5) Installed in manufacturing, process, or other equipment, such as reactor components, piping, and tanks; or

(6) The radioactive material consists solely of nuclear weapons or their components.

(b) Radioactive material labels applied to sealed radioactive sources may be excepted from the color specifications of § 835.601(a).

[63 FR 59684, Nov. 4, 1998]

## Subpart H—Records

### § 835.701 General provisions.

(a) Records shall be maintained to document compliance with this part and with radiation protection programs required by § 835.101.

(b) Unless otherwise specified in this subpart, records shall be retained until final disposition is authorized by DOE.

### § 835.702 Individual monitoring records.

(a) Records shall be maintained to document doses received by all individuals for whom monitoring was required pursuant to § 835.402 and to document doses received during planned special exposures, unplanned doses exceeding the monitoring thresholds of § 835.402, and authorized emergency exposures.

(b) The results of individual external and internal dose monitoring that is performed, but not required by § 835.402, shall be recorded. Recording of non-uniform shallow dose equivalent to the skin is not required if the dose is less than 2 percent of the limit specified for the skin at § 835.202(a)(4).

(c) The records required by this section shall:

(1) Be sufficient to evaluate compliance with subpart C of this part;

(2) Be sufficient to provide dose information necessary to complete reports required by subpart I of this part;

(3) Include the following quantities for external dose received during the year:

(i) The effective dose equivalent from external sources of radiation (deep dose equivalent may be used as effective dose equivalent for external exposure);

(ii) The lens of the eye dose equivalent;

(iii) The shallow dose equivalent to the skin; and

(iv) The shallow dose equivalent to the extremities.

(4) Include the following information for internal dose resulting from intakes received during the year:

(i) Committed effective dose equivalent;

(ii) Committed dose equivalent to any organ or tissue of concern; and

(iii) Identity of radionuclides.

(5) Include the following quantities for the summation of the external and internal dose:

(i) Total effective dose equivalent in a year;

(ii) For any organ or tissue assigned an internal dose during the year, the sum of the deep dose equivalent from external exposures and the committed dose equivalent to that organ or tissue; and

(iii) Cumulative total effective dose equivalent.

(6) Include the dose equivalent to the embryo/fetus of a declared pregnant worker.

(d) Documentation of all occupational doses received during the current year, except for doses resulting from planned special exposures conducted in compliance with § 835.204 and emergency exposures authorized in accordance with § 835.1302(d), shall be obtained to demonstrate compliance with § 835.202(a). If complete records documenting previous occupational dose during the year cannot be obtained, a written estimate signed by the individual may be accepted to demonstrate compliance.

(e) For radiological workers whose occupational dose is monitored in accordance with § 835.402, reasonable efforts shall be made to obtain complete records of prior years occupational internal and external doses.

(f) The records specified in this section that are identified with a specific individual shall be readily available to that individual.

(g) Data necessary to allow future verification or reassessment of the recorded doses shall be recorded.

(h) All records required by this section shall be transferred to the DOE upon cessation of activities at the site that could cause exposure to individuals.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59685, Nov. 4, 1998]

### § 835.703 Other monitoring records.

The following information shall be documented and maintained:

(a) Results of monitoring for radiation and radioactive material as required by subparts E and L of this part, except for monitoring required by § 835.1102(d);

(b) Results of monitoring used to determine individual occupational dose from external and internal sources;

(c) Results of monitoring for the release and control of material and equipment as required by § 835.1101; and

(d) Results of maintenance and calibration performed on instruments and equipment as required by § 835.401(b).

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59685, Nov. 4, 1998]

### § 835.704 Administrative records.

(a) Training records shall be maintained, as necessary, to demonstrate compliance with §§ 835.901.

(b) Actions taken to maintain occupational exposures as low as reasonably achievable, including the actions required for this purpose by § 835.101, as well as facility design and control actions required by §§ 835.1001, 835.1002, and 835.1003, shall be documented.

(c) Records shall be maintained to document the results of internal audits and other reviews of program content and implementation.

(d) Written declarations of pregnancy, including the estimated date of conception, and revocations of declarations of pregnancy shall be maintained.

(e) Changes in equipment, techniques, and procedures used for monitoring shall be documented.

(f) Records shall be maintained as necessary to demonstrate compliance with the requirements of §§ 835.1201 and 835.1202 for sealed radioactive source control, inventory, and source leak tests.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59685, Nov. 4, 1998]

## Subpart I—Reports to Individuals

### § 835.801 Reports to individuals.

(a) Radiation exposure data for individuals monitored in accordance with § 835.402 shall be reported as specified in this section. The information shall include the data required under § 835.702(c). Each notification and report shall be in writing and include: the DOE site or facility name, the name of the individual, and the individual's social security number, employee number, or other unique identification number.

(b) Upon the request from an individual terminating employment, records of exposure shall be provided to that individual as soon as the data are available, but not later than 90 days after termination. A written estimate of the radiation dose received by that employee based on available information shall be provided at the time of termination, if requested.

(c) Each DOE- or DOE-contractor-operated site or facility shall, on an annual basis, provide a radiation dose report to each individual monitored during the year at that site or facility in accordance with § 835.402.

(d) Detailed information concerning any individual's exposure shall be made available to the individual upon request of that individual, consistent with the provisions of the Privacy Act (5 U.S.C. 552a).

(e) When a DOE contractor is required to report to the Department, pursuant to Departmental requirements for occurrence reporting and processing, any exposure of an individual to radiation and/or radioactive material, or planned special exposure in accordance with § 835.204(e), the contractor shall also provide that individual with a report on his or her exposure data included therein. Such report shall be transmitted at a time not later than the transmittal to the Department.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59685, Nov. 4, 1998]

## Subpart J—Radiation Safety Training

### § 835.901 Radiation safety training.

(a) Each individual shall complete radiation safety training on the topics established at § 835.901(c) commensurate with the hazards in the area and the required controls:

(1) Before being permitted unescorted access to controlled areas; and

(2) Before receiving occupational dose during access to controlled areas at a DOE site or facility.

(b) Each individual shall demonstrate knowledge of the radiation safety training topics established at § 835.901(c), commensurate with the hazards in the area and required controls, by successful completion of an examination and performance demonstrations:

(1) Before being permitted unescorted access to radiological areas; and

(2) Before performing unescorted assignments as a radiological worker.

(c) Radiation safety training 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:

(1) Risks of exposure to radiation and radioactive materials, including prenatal radiation exposure;

(2) Basic radiological fundamentals and radiation protection concepts;

(3) Physical design features, administrative controls, limits, policies, procedures, alarms, and other measures implemented at the facility to manage doses and maintain doses ALARA, including both routine and emergency actions;

(4) Individual rights and responsibilities as related to implementation of the facility radiation protection program;

(5) Individual responsibilities for implementing ALARA measures required by § 835.101; and

(6) Individual exposure reports that may be requested in accordance with § 835.801.

(d) When an escort is used in lieu of training in accordance with paragraph

(a) or (b) of this section, the escort shall:

(1) Have completed radiation safety training, examinations, and performance demonstrations required for entry to the area and performance of the work; and

(2) Ensure that all escorted individuals comply with the documented radiation protection program.

(e) Radiation safety training shall be provided to individuals when there is a significant change to radiation protection policies and procedures that may affect the individual and at intervals not to exceed 24 months. Such training provided for individuals subject to the requirements of § 835.901(b)(1) and (b)(2) shall include successful completion of an examination.

[63 FR 59685, Nov. 4, 1998]

**§§ 835.902–835.903 [Reserved]**

## Subpart K—Design and Control

**§ 835.1001 Design and control.**

(a) Measures shall be taken to maintain radiation exposure in controlled areas ALARA through physical design features and administrative control. The primary methods used shall be physical design features (e.g., confinement, ventilation, remote handling, and shielding). Administrative controls shall be employed only as supplemental methods to control radiation exposure.

(b) For specific activities where use of physical design features is demonstrated to be impractical, administrative controls shall be used to maintain radiation exposures ALARA.

[63 FR 59686, Nov. 4, 1998]

**§ 835.1002 Facility design and modifications.**

During the design of new facilities or modification of existing facilities, the following objectives shall be adopted:

(a) Optimization methods shall be used to assure that occupational exposure is maintained ALARA in developing and justifying facility design and physical controls.

(b) The design objective for controlling personnel exposure from external sources of radiation in areas of continuous occupational occupancy (2000 hours per year) shall be to maintain exposure levels below an average of 0.5 mrem (5 microsieverts) per hour and as far below this average as is reasonably achievable. The design objectives for exposure rates for potential exposure to a radiological worker where occupancy differs from the above shall be ALARA and shall not exceed 20 percent of the applicable standards in § 835.202.

(c) Regarding the control of airborne radioactive material, the design objective shall be, under normal conditions, to avoid releases to the workplace atmosphere and in any situation, to control the inhalation of such material by workers to levels that are ALARA; confinement and ventilation shall normally be used.

(d) The design or modification of a facility and the selection of materials shall include features that facilitate operations, maintenance, decontamination, and decommissioning.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59686, Nov. 4, 1998]

**§ 835.1003 Workplace controls.**

During routine operations, the combination of physical design features and administrative controls shall provide that:

(a) The anticipated occupational dose to general employees shall not exceed the limits established at § 835.202; and

(b) The ALARA process is utilized for personnel exposures to ionizing radiation.

[63 FR 59686, Nov. 4, 1998]

## Subpart L—Radioactive Contamination Control

SOURCE: 63 FR 59686, Nov. 4, 1998, unless otherwise noted.

**§ 835.1101 Control of material and equipment.**

(a) Except as provided in paragraphs (b) and (c) of this section, material and equipment in contamination areas, high contamination areas, and airborne radioactivity areas shall not be released to a controlled area if:

(1) Removable surface contamination levels on accessible surfaces exceed the

removable surface contamination values specified in appendix D of this part; or

(2) Prior use suggests that the removable surface contamination levels on inaccessible surfaces are likely to exceed the removable surface contamination values specified in appendix D of this part.

(b) Material and equipment exceeding the removable surface contamination values specified in appendix D of this part may be conditionally released for movement on-site from one radiological area for immediate placement in another radiological area only if appropriate monitoring is performed and appropriate controls for the movement are established and exercised.

(c) Material and equipment with fixed contamination levels that exceed the total contamination values specified in appendix D of this part may be released for use in controlled areas outside of radiological areas only under the following conditions:

(1) Removable surface contamination levels are below the removable surface contamination values specified in appendix D of this part; and

(2) The material or equipment is routinely monitored and clearly marked or labeled to alert personnel of the contaminated status.

### § 835.1102 Control of areas.

(a) Appropriate controls shall be maintained and verified which prevent the inadvertent transfer of removable contamination to locations outside of radiological areas under normal operating conditions.

(b) Any area in which contamination levels exceed the values specified in appendix D of this part shall be controlled in a manner commensurate with the physical and chemical characteristics of the contaminant, the radionuclides present, and the fixed and removable surface contamination levels.

(c) Areas accessible to individuals where the measured total surface contamination levels exceed, but the removable surface contamination levels are less than, corresponding surface contamination values specified in appendix D of this part, shall be controlled as follows when located outside of radiological areas:

(1) The area shall be routinely monitored to ensure the removable surface contamination level remains below the removable surface contamination values specified in appendix D of this part; and

(2) The area shall be conspicuously marked to warn individuals of the contaminated status.

(d) Individuals exiting contamination, high contamination, or airborne radioactivity areas shall be monitored, as appropriate, for the presence of surface contamination.

(e) Protective clothing shall be required for entry to areas in which removable contamination exists at levels exceeding the removable surface contamination values specified in appendix D of this part.

## Subpart M—Sealed Radioactive Source Control

SOURCE: 63 FR 59686, Nov. 4, 1998, unless otherwise noted.

### § 835.1201 Sealed radioactive source control.

Sealed radioactive sources shall be used, handled, and stored in a manner commensurate with the hazards associated with operations involving the sources.

### § 835.1202 Accountable sealed radioactive sources.

(a) Each accountable sealed radioactive source shall be inventoried at intervals not to exceed six months. This inventory shall:

(1) Establish the physical location of each accountable sealed radioactive source;

(2) Verify the presence and adequacy of associated postings and labels; and

(3) Establish the adequacy of storage locations, containers, and devices.

(b) Except for sealed radioactive sources consisting solely of gaseous radioactive material or tritium, each accountable sealed radioactive source shall be subject to a source leak test upon receipt, when damage is suspected, and at intervals not to exceed six months. Source leak tests shall be capable of detecting radioactive material leakage equal to or exceeding 0.005 microcurie.

(c) Notwithstanding the requirements of paragraph (b) of this section, an accountable sealed radioactive source is not subject to periodic source leak testing if that source has been removed from service. Such sources shall be stored in a controlled location, subject to periodic inventory as required by paragraph (a) of this section, and subject to source leak testing prior to being returned to service.

(d) Notwithstanding the requirements of paragraphs (a) and (b) of this section, an accountable sealed radioactive source is not subject to periodic inventory and source leak testing if that source is located in an area that is unsafe for human entry or otherwise inaccessible.

(e) An accountable sealed radioactive source found to be leaking radioactive material shall be controlled in a manner that minimizes the spread of radioactive contamination.

## Subpart N—Emergency Exposure Situations

### § 835.1301 General provisions.

(a) A general employee whose occupational dose has exceeded the numerical value of any of the limits specified in § 835.202 as a result of an authorized emergency exposure may be permitted to return to work in radiological areas during the current year providing that all of the following conditions are met:

(1) Approval is first obtained from the contractor management and the Head of the responsible DOE field organization;

(2) The individual receives counseling from radiological protection and medical personnel regarding the consequences of receiving additional occupational exposure during the year; and

(3) The affected employee agrees to return to radiological work.

(b) All doses exceeding the limits specified in § 835.202 shall be recorded in the affected individual's occupational dose record.

(c) When the conditions under which a dose was received in excess of the limits specified in § 835.202, except those received in accordance with § 835.204, have been eliminated, operating management shall notify the Head of the responsible DOE field organization.

(d) Operations after a dose was received in excess of the limits specified in § 835.202, except those received in accordance with § 835.204, may be resumed only with the approval of DOE.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59687, Nov. 4, 1998]

### § 835.1302 Emergency exposure situations.

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

(b) Operating management shall weigh actual and potential risks against the benefits to be gained.

(c) No individual shall be required to perform a rescue action that might involve substantial personal risk.

(d) Each individual authorized to perform emergency actions likely to result in occupational doses exceeding the values of the limits provided at § 835.202(a) shall be trained in accordance with § 835.901(b) and briefed beforehand on the known or anticipated hazards to which the individual will be subjected.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59687, Nov. 4, 1998]

### § 835.1303 [Reserved]

### § 835.1304 Nuclear accident dosimetry.

(a) Installations possessing sufficient quantities of fissile material to potentially constitute a critical mass, such that the excessive exposure of individuals to radiation from a nuclear accident is possible, shall provide nuclear accident dosimetry for those individuals.

(b) Nuclear accident dosimetry shall include the following:

(1) A method to conduct initial screening of individuals involved in a nuclear accident to determine whether significant exposures to radiation occurred;

(2) Methods and equipment for analysis of biological materials;

(3) A system of fixed nuclear accident dosimeter units; and

(4) Personal nuclear accident dosimeters.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59687, Nov. 4, 1998]

## APPENDIX A TO PART 835—DERIVED AIR CONCENTRATIONS (DAC) FOR CONTROLLING RADIATION EXPOSURE TO WORKERS AT DOE FACILITIES

The data presented in appendix A are to be used for controlling individual internal doses in accordance with §835.209, identifying the need for air monitoring in accordance with §835.403, and identifying the need for posting of airborne radioactivity areas in accordance with §835.603(d).

The DAC values are given for individual radionuclides. For known mixtures of radionuclides, determine the sum of the ratio of the observed concentration of a particular radionuclide and its corresponding DAC for all radionuclides in the mixture. If this sum exceeds unity (1), then the DAC has been exceeded. For unknown radionuclides, the most restrictive DAC (lowest value) for those isotopes not known to be absent shall be used.

The derived air concentrations (DAC) for limiting radiation exposures through inhalation of radionuclides by workers are listed in this appendix. The values are based on either a stochastic (committed effective dose equivalent) dose limit of 5 rems (0.05 Sv) or a nonstochastic (organ) dose limit of 50 rems (0.5 Sv) per year, whichever is more limiting.

NOTE: the 15 rems [0.15 Sv] dose limit for the lens of the eye does not appear as a critical organ dose limit.)

The columns in this appendix contain the following information: (1) Radionuclide; (2) inhaled air DAC for lung retention class D, W, and Y in units of μCi/ml; (3) inhaled air DAC for lung retention class D, W, and Y in units of Bq/m$^3$; and (4) an indication of whether or not the DAC for each class is controlled by the stochastic (effective dose equivalent) or nonstochastic (tissue) dose. The classes D, W, and Y have been established to describe the clearance of inhaled radionuclides from the lung. This classification refers to the approximate length of retention in the pulmonary region. Thus, the range of half-times for retention in the pulmonary region is less than 10 days for class D (days), from 10 to 100 days for class W (weeks), and greater than 100 days for class Y (years). The DACs are listed by radionuclide, in order of increasing atomic mass, and are based on the assumption that the particle size distribution of the inhaled material is unknown and an assumed particle size distribution of 1 μm is used. For situations where the particle size distribution is known to differ significantly from 1 μm, appropriate corrections can be made to both the estimated dose to workers and the DACs.

| Radionuclide | Inhaled air-lung retention class [3] | | | Inhaled air-lung retention class [3] | | | Stochastic or organ [1] |
|---|---|---|---|---|---|---|---|
| | μCi/ml | | | Bq/m$^3$ | | | |
| | D | W | Y | D | W | Y | ( D/ W/ Y) |
| H-3 (Water) [2] | 2.E-05 | 2.E-05 | 2.E-05 | 8.E+05 | 8.E+05 | 8.E+05 | St/St/St |
| H-3 (Elemental) [2] | 5.E-01 | 5.E-01 | 5.E-01 | 2.E+10 | 2.E+10 | 2.E+10 | St/St/St |
| Be-7 | – | 9.E-06 | 8.E-06 | – | 3.E+05 | 3.E+05 | /St/St |
| Be-10 | – | 6.E-08 | 6.E-09 | – | 2.E+03 | 2.E+02 | /St/St |
| C-11 (Org) [2] | 2.E-04 | 2.E-04 | 2.E-04 | 6.E+06 | 6.E+06 | 6.E+06 | St/St/St |
| C-11 (CO) [2] | 5.E-04 | 5.E-04 | 5.E-04 | 2.E+07 | 2.E+07 | 2.E+07 | St/St/St |
| C-11 ($CO_2$) [2] | 3.E-04 | 3.E-04 | 3.E-04 | 1.E+07 | 1.E+07 | 1.E+07 | St/St/St |
| C-14 (Org) [2] | 1.E-06 | 1.E-06 | 1.E-06 | 4.E+07 | 4.E+04 | 4.E+07 | St/St/St |
| C-14 (CO) [2] | 7.E-04 | 7.E-04 | 7.E-04 | 3.E+07 | 3.E+07 | 3.E+07 | St/St/St |
| C-14 ($CO_2$) [2] | 9.E-05 | 9.E-05 | 9.E-05 | 3.E+06 | 3.E+06 | 3.E+06 | St/St/St |
| F-18 | 3.E-05 | 4.E-05 | 3.E-05 | 1.E+06 | 1.E+06 | 1.E+06 | St/St/St |
| Na-22 | 3.E-07 | – | – | 1.E+04 | – | – | St/ / |
| Na-24 | 2.E-06 | – | – | 8.E+04 | – | – | St/ / |
| Mg-28 | 7.E-07 | 5.E-07 | – | 3.E+04 | 2.E+04 | – | St/St/ |
| Al-26 | 3.E-08 | 3.E-08 | – | 1.E+03 | 1.E+03 | – | St/St/ |
| Si-31 | 1.E-05 | 1.E-05 | 1.E-05 | 4.E+05 | 5.E+05 | 4.E+05 | St/St/St |
| Si-32 | 1.E-07 | 5.E-08 | 2.E-09 | 4.E+03 | 2.E+03 | 8.E+01 | St/St/St |
| P-32 | 4.E-07 | 2.E-07 | – | 1.E+04 | 6.E+03 | – | St/St/ |
| P-33 | 3.E-06 | 1.E-06 | – | 1.E+05 | 4.E+04 | – | St/St/ |
| S-35 | 7.E-06 | 9.E-07 | – | 3.E+05 | 3.E+04 | – | St/St/ |
| S-35 (Gas) | – | 6.E-06 | – | – | 2.E+05 | – | /St/ |
| Cl-36 | 1.E-06 | 1.E-07 | – | 4.E+04 | 4.E+03 | – | St/St/ |
| Cl-38 | 2.E-05 | 2.E-05 | – | 6.E+05 | 7.E+05 | – | St/St/ |
| Cl-39 | 2.E-05 | 2.E-05 | – | 8.E+05 | 9.E+05 | – | St/St/ |
| K-40 | 2.E-07 | – | – | 6.E+03 | – | – | St/ / |
| K-42 | 2.E-06 | – | – | 7.E+04 | – | – | St/ / |
| K-43 | 4.E-06 | – | – | 1.E+05 | – | – | St/ / |
| K-44 | 3.E-05 | – | – | 1.E+06 | – | – | St/ / |
| K-45 | 5.E-05 | – | – | 2.E+06 | – | – | St/ / |
| Ca-41 | – | 2.E-06 | – | – | 6.E+04 | – | /E/ |
| Ca-45 | – | 3.E-07 | – | – | 1.E+04 | – | /St/ |

| Radionuclide | Inhaled air-lung retention class [3] | | | Inhaled air-lung retention class [3] | | | Stochastic or organ [1] |
|---|---|---|---|---|---|---|---|
| | μCi/ml | | | Bq/m³ | | | |
| | D | W | Y | D | W | Y | ( D/ W/ Y) |
| Ca-47 | – | 4.E – 07 | – | – | 1.E + 04 | – | /St/ |
| Sc-43 | – | – | 1.E – 05 | – | – | 4.E + 05 | / /St |
| Sc-44m | – | – | 3.E – 07 | – | – | 1.E + 04 | / /St |
| Sc-44 | – | – | 5.E – 06 | – | – | 2.E + 05 | / /St |
| Sc-46 | – | – | 1.E – 07 | – | – | 4.E + 03 | / /St |
| Sc-47 | – | – | 1.E – 06 | – | – | 5.E + 04 | / /St |
| Sc-48 | – | – | 6.E – 07 | – | – | 2.E + 04 | / /St |
| Sc-49 | – | – | 2.E – 05 | – | – | 8.E + 05 | / /St |
| Ti-44 | 5.E – 09 | 1.E – 08 | 2.E – 09 | 2.E + 02 | 4.E + 02 | 9.E + 01 | St/St/St |
| Ti-45 | 1.E – 05 | 1.E – 05 | 1.E – 05 | 4.E + 05 | 5.E + 05 | 5.E + 05 | St/St/St |
| V-47 | 4.E – 05 | 4.E – 05 | – | 1.E + 06 | 1.E + 06 | – | St/St/ |
| V-48 | 4.E – 07 | 3.E – 07 | – | 2.E + 04 | 1.E + 04 | – | St/St/ |
| V-49 | 1.E – 05 | 7.E – 06 | – | 5.E + 05 | 3.E + 05 | – | BS/St/ |
| Cr-48 | 5.E – 06 | 3.E – 06 | 3.E – 06 | 2.E + 05 | 1.E + 05 | 1.E + 05 | St/St/St |
| Cr-49 | 3.E – 05 | 4.E – 05 | 4.E – 05 | 1.E + 06 | 2.E + 06 | 1.E + 06 | St/St/St |
| Cr-51 | 2.E – 05 | 1.E – 05 | 8.E – 06 | 7.E + 05 | 4.E + 05 | 3.E + 05 | St/St/St |
| Mn-51 | 2.E – 05 | 2.E – 05 | – | 8.E + 05 | 9.E + 05 | – | St/St/ |
| Mn-52m | 4.E – 05 | 4.E – 05 | – | 1.E + 06 | 2.E + 06 | – | St/St/ |
| Mn-52 | 5.E – 07 | 4.E – 07 | – | 2.E + 04 | 1.E + 04 | – | St/St/ |
| Mn-53 | 5.E – 06 | 5.E – 06 | – | 2.E + 05 | 2.E + 05 | – | BS/St/ |
| Mn-54 | 4.E – 07 | 3.E – 07 | – | 1.E + 04 | 1.E + 04 | – | St/St/ |
| Mn-56 | 6.E – 06 | 9.E – 06 | – | 2.E + 05 | 3.E + 05 | – | St/St/ |
| Fe-52 | 1.E – 06 | 1.E – 06 | – | 5.E + 04 | 4.E + 04 | – | St/St/ |
| Fe-55 | 8.E – 07 | 2.E – 06 | – | 3.E + 04 | 6.E + 04 | – | St/St/ |
| Fe-59 | 1.E – 07 | 2.E – 07 | – | 5.E + 03 | 8.E + 03 | – | St/St/ |
| Fe-60 | 3.E – 09 | 8.E – 09 | – | 1.E + 02 | 3.E + 02 | – | St/St/ |
| Co-55 | – | 1.E – 06 | 1.E – 06 | – | 4.E + 04 | 4.E + 04 | /St/St |
| Co-56 | – | 1.E – 07 | 8.E – 08 | – | 5.E + 03 | 3.E + 03 | /St/St |
| Co-57 | – | 1.E – 06 | 3.E – 07 | – | 4.E + 04 | 1.E + 04 | /St/St |
| Co-58m | – | 4.E – 05 | 3.E – 05 | – | 1.E + 06 | 1.E + 06 | /St/St |
| Co-58 | – | 5.E – 07 | 3.E – 07 | – | 2.E + 04 | 1.E + 04 | /St/St |
| Co-60m | – | 2.E – 03 | 1.E – 03 | – | 6.E + 07 | 4.E + 07 | /St/St |
| Co-60 | – | 7.E – 08 | 1.E – 08 | – | 3.E + 03 | 5.E + 02 | /St/St |
| Co-61 | – | 3.E – 05 | 2.E – 05 | – | 1.E + 06 | 9.E + 05 | /St/St |
| Co-62m | – | 7.E – 05 | 7.E – 05 | – | 3.E + 06 | 2.E + 06 | /St/St |
| Ni-56 (Inorg) | 8.E – 07 | 5.E – 07 | – | 3.E + 04 | 2.E + 04 | – | St/St/ |
| Ni-56 (Vapor) | – | 5.E – 07 | – | – | 2.E + 04 | – | /St/ |
| Ni-57 (Inorg) | 2.E – 06 | 1.E – 06 | – | 7.E + 04 | 5.E + 04 | – | St/St/ |
| Ni-57 (Vapor) | – | 3.E – 06 | – | – | 1.E + 05 | – | /St/ |
| Ni-59 (Inorg) | 2.E – 06 | 3.E – 06 | – | 6.E + 04 | 1.E + 05 | – | St/St/ |
| Ni-59 (Vapor) | – | 8.E – 07 | – | – | 3.E + 04 | – | /St/ |
| Ni-63 (Inorg) | 7.E – 07 | 1.E – 06 | – | 3.E + 04 | 4.E + 04 | – | St/St/ |
| Ni-63 (Vapor) | – | 3.E – 07 | – | – | 1.E + 04 | – | /St/ |
| Ni-65 (Inorg) | 1.E – 05 | 1.E – 05 | – | 4.E + 05 | 5.E + 05 | – | St/St/ |
| Ni-65 (Vapor) | – | 7.E – 06 | – | – | 3.E + 05 | – | /St/ |
| Ni-66 (Inorg) | 7.E – 07 | 3.E – 07 | – | 3.E + 04 | 1.E + 04 | – | St/St/ |
| Ni-66 (Vapor) | – | 1.E – 06 | – | – | 5.E + 04 | – | /St/ |
| Cu-60 | 4.E – 05 | 5.E – 05 | 4.E – 05 | 1.E + 06 | 2.E + 06 | 2.E + 06 | St/St/St |
| Cu-61 | 1.E – 05 | 2.E – 05 | 1.E – 05 | 5.E + 05 | 6.E + 05 | 5.E + 05 | St/St/St |
| Cu-64 | 1.E – 05 | 1.E – 05 | 9.E – 06 | 5.E + 05 | 4.E + 05 | 3.E + 05 | St/St/St |
| Cu-67 | 3.E – 06 | 2.E – 06 | 2.E – 06 | 1.E + 05 | 8.E + 04 | 7.E + 04 | St/St/St |
| Zn-62 | – | – | 1.E – 06 | – | – | 4.E + 04 | / /St |
| Zn-63 | – | – | 3.E – 05 | – | – | 1.E + 06 | / /St |
| Zn-65 | – | – | 1.E – 07 | – | – | 4.E + 03 | / /St |
| Zn-69m | – | – | 3.E – 06 | – | – | 1.E + 05 | / /St |
| Zn-69 | – | – | 6.E – 05 | – | – | 2.E + 06 | / /St |
| Zn-71m | – | – | 7.E – 06 | – | – | 3.E + 05 | / /St |
| Zn-72 | – | – | 5.E – 07 | – | – | 2.E + 04 | / /St |
| Ga-65 | 7.E – 05 | 8.E – 05 | – | 3.E + 06 | 3.E + 06 | – | St/St/ |
| Ga-66 | 1.E – 06 | 1.E – 06 | – | 5.E + 04 | 5.E + 04 | – | St/St/ |
| Ga-67 | 6.E – 06 | 4.E – 06 | – | 2.E + 05 | 2.E + 05 | – | St/St/ |
| Ga-68 | 2.E – 05 | 2.E – 05 | – | 6.E + 05 | 8.E + 05 | – | St/St/ |
| Ga-70 | 7.E – 05 | 8.E – 05 | – | 3.E + 06 | 3.E + 06 | – | St/St/ |
| Ga-72 | 2.E – 06 | 1.E – 06 | – | 6.E + 04 | 5.E + 04 | – | St/St/ |
| Ga-73 | 6.E – 06 | 6.E – 06 | – | 2.E + 05 | 2.E + 05 | – | St/St/ |
| Ge-66 | 1.E – 05 | 8.E – 06 | – | 4.E + 05 | 3.E + 05 | – | St/St/ |
| Ge-67 | 4.E – 05 | 4.E – 05 | – | 1.E + 06 | 2.E + 06 | – | St/St/ |
| Ge-68 | 2.E – 06 | 4.E – 08 | – | 6.E + 04 | 2.E + 03 | – | St/St/ |
| Ge-69 | 6.E – 06 | 3.E – 06 | – | 2.E + 05 | 1.E + 05 | – | St/St/ |
| Ge-71 | 2.E – 04 | 2.E – 05 | – | 7.E + 06 | 6.E + 05 | – | St/St/ |
| Ge-75 | 3.E – 05 | 3.E – 05 | – | 1.E + 06 | 1.E + 06 | – | St/St/ |

| Radionuclide | Inhaled air-lung retention class [3] | | | Inhaled air-lung retention class [3] | | | Stochastic or organ [1] |
|---|---|---|---|---|---|---|---|
| | μCi/ml | | | Bq/m³ | | | |
| | D | W | Y | D | W | Y | ( D/ W/ Y) |
| Ge-77 | 4.E-06 | 2.E-06 | – | 2.E+05 | 9.E+04 | – | St/St/ |
| Ge-78 | 9.E-06 | 9.E-06 | – | 4.E+05 | 3.E+05 | – | St/St/ |
| As-69 | – | 5.E-05 | – | – | 2.E+06 | – | /St/ |
| As-70 | – | 2.E-05 | – | – | 8.E+05 | – | /St/ |
| As-71 | – | 2.E-06 | – | – | 7.E+04 | – | /St/ |
| As-72 | – | 6.E-07 | – | – | 2.E+04 | – | /St/ |
| As-73 | – | 7.E-07 | – | – | 3.E+04 | – | /St/ |
| As-74 | – | 3.E-07 | – | – | 1.E+04 | – | /St/ |
| As-76 | – | 6.E-07 | – | – | 2.E+04 | – | /St/ |
| As-77 | – | 2.E-06 | – | – | 8.E+04 | – | /St/ |
| As-78 | – | 9.E-06 | – | – | 3.E+05 | – | /St/ |
| Se-70 | 1.E-05 | 2.E-05 | – | 6.E+05 | 7.E+05 | – | St/St/ |
| Se-73m | 6.E-05 | 6.E-05 | – | 2.E+06 | 2.E+06 | – | St/St/ |
| Se-73 | 6.E-06 | 7.E-06 | – | 2.E+05 | 2.E+05 | – | St/St/ |
| Se-75 | 3.E-07 | 3.E-07 | – | 1.E+04 | 9.E+03 | – | St/St/ |
| Se-79 | 3.E-07 | 2.E-07 | – | 1.E+04 | 9.E+03 | – | St/St/ |
| Se-81m | 3.E-05 | 3.E-05 | – | 1.E+06 | 1.E+06 | – | St/St/ |
| Se-81 | 9.E-05 | 1.E-04 | – | 3.E+06 | 4.E+06 | – | St/St/ |
| Se-83 | 5.E-05 | 5.E-05 | – | 2.E+06 | 2.E+06 | – | St/St/ |
| Br-74m | 1.E-05 | 2.E-05 | – | 6.E+05 | 6.E+05 | – | St/St/ |
| Br-74 | 3.E-05 | 3.E-05 | – | 1.E+06 | 1.E+06 | – | St/St/ |
| Br-75 | 2.E-05 | 2.E-05 | – | 7.E+05 | 8.E+05 | – | St/St/ |
| Br-76 | 2.E-06 | 2.E-06 | – | 7.E+04 | 7.E+04 | – | St/St/ |
| Br-77 | 1.E-05 | 8.E-06 | – | 4.E+05 | 3.E+05 | – | St/St/ |
| Br-80m | 7.E-06 | 6.E-06 | – | 3.E+05 | 2.E+05 | – | St/St/ |
| Br-80 | 8.E-05 | 9.E-05 | – | 3.E+06 | 3.E+06 | – | St/St/ |
| Br-82 | 2.E-06 | 2.E-06 | – | 6.E+04 | 6.E+04 | – | St/St/ |
| Br-83 | 3.E-05 | 3.E-05 | – | 1.E+06 | 1.E+06 | – | St/St/ |
| Br-84 | 2.E-05 | 3.E-05 | – | 9.E+05 | 1.E+06 | – | St/St/ |
| Rb-79 | 5.E-05 | – | – | 2.E+06 | – | – | St/ / |
| Rb-81m | 1.E-04 | – | – | 5.E+06 | – | – | St/ / |
| Rb-81 | 2.E-05 | – | – | 8.E+05 | – | – | St/ / |
| Rb-82m | 7.E-06 | – | – | 3.E+05 | – | – | St/ / |
| Rb-83 | 4.E-07 | – | – | 2.E+04 | – | – | St/ / |
| Rb-84 | 3.E-07 | – | – | 1.E+04 | – | – | St/ / |
| Rb-86 | 3.E-07 | – | – | 1.E+04 | – | – | St/ / |
| Rb-87 | 6.E-07 | – | – | 2.E+04 | – | – | St/ / |
| Rb-88 | 3.E-05 | – | – | 1.E+06 | – | – | St/ / |
| Rb-89 | 6.E-05 | – | – | 2.E+06 | – | – | St/ / |
| Sr-80 | 5.E-06 | – | 5.E-06 | 2.E+05 | – | 2.E+05 | St/ /St |
| Sr-81 | 3.E-05 | – | 3.E-05 | 1.E+06 | – | 1.E+06 | St/ /St |
| Sr-83 | 3.E-06 | – | 2.E-06 | 1.E+05 | – | 5.E+04 | St/ /St |
| Sr-85m | 3.E-04 | – | 3.E-04 | 9.E+06 | – | 1.E+07 | St/ /St |
| Sr-85 | 1.E-06 | – | 7.E-07 | 4.E+04 | – | 2.E+04 | St/ /St |
| Sr-87m | 5.E-05 | – | 6.E-05 | 2.E+06 | – | 2.E+06 | St/ /St |
| Sr-89 | 3.E-07 | – | 6.E-08 | 1.E+04 | – | 2.E+03 | St/ /St |
| Sr-90 | 8.E-09 | – | 2.E-09 | 3.E+02 | – | 6.E+01 | BS/ /St |
| Sr-91 | 2.E-06 | – | 1.E-06 | 9.E+04 | – | 5.E+04 | St/ /St |
| Sr-92 | 4.E-06 | – | 3.E-06 | 1.E+05 | – | 1.E+05 | St/ /St |
| Y-86m | – | 2.E-05 | 2.E-05 | – | 9.E+05 | 9.E+05 | /St/St |
| Y-86 | – | 1.E-06 | 1.E-06 | – | 5.E+04 | 5.E+04 | /St/St |
| Y-87 | – | 1.E-06 | 1.E-06 | – | 5.E+04 | 5.E+04 | /St/St |
| Y-88 | – | 1.E-07 | 1.E-07 | – | 4.E+03 | 4.E+03 | /St/St |
| Y-90m | – | 5.E-06 | 5.E-06 | – | 2.E+05 | 2.E+05 | /St/St |
| Y-90 | – | 3.E-07 | 2.E-07 | – | 1.E+04 | 9.E+03 | /St/St |
| Y-91m | – | 1.E-04 | 7.E-05 | – | 4.E+06 | 3.E+06 | /St/St |
| Y-91 | – | 7.E-08 | 5.E-08 | – | 3.E+03 | 2.E+03 | /St/St |
| Y-92 | – | 3.E-06 | 3.E-06 | – | 1.E+05 | 1.E+05 | /St/St |
| Y-93 | – | 1.E-06 | 1.E-06 | – | 4.E+04 | 4.E+04 | /St/St |
| Y-94 | – | 3.E-05 | 3.E-05 | – | 1.E+06 | 1.E+06 | /St/St |
| Y-95 | – | 6.E-05 | 6.E-05 | – | 2.E+06 | 2.E+06 | /St/St |
| Zr-86 | 2.E-06 | 1.E-06 | 1.E-06 | 6.E+04 | 4.E+04 | 4.E+04 | St/St/St |
| Zr-88 | 9.E-08 | 2.E-07 | 1.E-07 | 3.E+03 | 7.E+03 | 5.E+03 | St/St/St |
| Zr-89 | 2.E-06 | 1.E-06 | 1.E-06 | 5.E+04 | 4.E+04 | 4.E+04 | St/St/St |
| Zr-93 | 3.E-09 | 1.E-08 | 2.E-08 | 1.E+02 | 4.E+02 | 9.E+02 | BS/BS/BS |
| Zr-95 | 6.E-08 | 2.E-07 | 1.E-07 | 2.E+03 | 6.E+03 | 4.E+03 | BS/St/St |
| Zr-97 | 8.E-07 | 6.E-07 | 5.E-07 | 3.E+04 | 2.E+04 | 2.E+04 | St/St/St |
| Nb-88 | – | 1.E-04 | 9.E-05 | – | 4.E+06 | 3.E+06 | /St/St |
| Nb-89 (66 min) | – | 2.E-05 | 2.E-05 | – | 6.E+05 | 6.E+05 | /St/St |
| Nb-89 (122 min) | – | 8.E-06 | 7.E-06 | – | 3.E+05 | 2.E+05 | /St/St |
| Nb-90 | – | 1.E-06 | 1.E-06 | – | 4.E+04 | 4.E+04 | /St/St |

| Radionuclide | Inhaled air-lung retention class[3] | | | Inhaled air-lung retention class[3] | | | Stochastic or organ[1] |
|---|---|---|---|---|---|---|---|
| | μCi/ml | | | Bq/m[3] | | | |
| | D | W | Y | D | W | Y | ( D/ W/ Y) |
| Nb-93m | – | 5.E-07 | 7.E-08 | – | 2.E+04 | 3.E+03 | /St/St |
| Nb-94 | – | 8.E-08 | 6.E-09 | – | 3.E+03 | 2.E+02 | /St/St |
| Nb-95m | – | 1.E-06 | 9.E-07 | – | 4.E+04 | 4.E+04 | /St/St |
| Nb-95 | – | 5.E-07 | 5.E-07 | – | 2.E+04 | 2.E+04 | /St/St |
| Nb-96 | – | 1.E-06 | 1.E-06 | – | 4.E+04 | 4.E+04 | /St/St |
| Nb-97 | – | 3.E-05 | 3.E-05 | – | 1.E+06 | 1.E+06 | /St/St |
| Nb-98 | – | 2.E-05 | 2.E-05 | – | 8.E+05 | 8.E+05 | /St/St |
| Mo-90 | 3.E-06 | – | 2.E-06 | 1.E+05 | – | 7.E+04 | St/ /St |
| Mo-93m | 7.E-06 | – | 6.E-06 | 3.E+05 | – | 2.E+05 | St/ /St |
| Mo-93 | 2.E-06 | – | 7.E-08 | 8.E+04 | – | 3.E+03 | St/ /St |
| Mo-99 | 1.E-06 | – | 6.E-07 | 4.E+04 | – | 2.E+04 | St/ /St |
| Mo-101 | 6.E-05 | – | 6.E-05 | 2.E+06 | – | 2.E+06 | St/ /St |
| Tc-93m | 7.E-05 | 1.E-04 | – | 2.E+06 | 5.E+06 | – | St/St/ |
| Tc-93 | 3.E-05 | 4.E-05 | – | 1.E+06 | 2.E+06 | – | St/St/ |
| Tc-94m | 2.E-05 | 2.E-05 | – | 7.E+05 | 9.E+05 | – | St/St/ |
| Tc-94 | 8.E-06 | 1.E-05 | – | 3.E+05 | 4.E+05 | – | St/St/ |
| Tc-96m | 1.E-04 | 1.E-04 | – | 4.E+06 | 4.E+06 | – | St/St/ |
| Tc-96 | 1.E-06 | 9.E-07 | – | 5.E+04 | 3.E+04 | – | St/St/ |
| Tc-97m | 3.E-06 | 5.E-07 | – | 1.E+05 | 2.E+04 | – | SW/St/ |
| Tc-97 | 2.E-05 | 2.E-06 | – | 8.E+05 | 9.E+04 | – | St/St/ |
| Tc-98 | 7.E-07 | 1.E-07 | – | 3.E+04 | 5.E+03 | – | St/St/ |
| Tc-99m | 6.E-05 | 1.E-04 | – | 2.E+06 | 4.E+06 | – | St/St/ |
| Tc-99 | 2.E-06 | 3.E-07 | – | 8.E+04 | 1.E+04 | – | SW/St/ |
| Tc-101 | 1.E-04 | 2.E-04 | – | 5.E+06 | 6.E+06 | – | St/St/ |
| Tc-104 | 3.E-05 | 4.E-05 | – | 1.E+06 | 1.E+06 | – | St/St/ |
| Ru-94 | 2.E-05 | 3.E-05 | 2.E-05 | 7.E+05 | 1.E+06 | 9.E+05 | St/St/St |
| Ru-97 | 8.E-06 | 5.E-06 | 5.E-06 | 3.E+05 | 2.E+05 | 2.E+05 | St/St/St |
| Ru-103 | 7.E-07 | 4.E-07 | 3.E-07 | 3.E+04 | 2.E+04 | 1.E+04 | St/St/St |
| Ru-105 | 6.E-06 | 6.E-06 | 5.E-06 | 2.E+05 | 2.E+05 | 2.E+05 | St/St/St |
| Ru-106 | 4.E-08 | 2.E-08 | 5.E-09 | 1.E+03 | 8.E+02 | 2.E+02 | St/St/St |
| Rh-99m | 2.E-05 | 3.E-05 | 3.E-05 | 9.E+05 | 1.E+06 | 1.E+06 | St/St/St |
| Rh-99 | 1.E-06 | 9.E-07 | 8.E-07 | 5.E+04 | 3.E+04 | 3.E+04 | St/St/St |
| Rh-100 | 2.E-06 | 2.E-06 | 2.E-06 | 8.E+04 | 6.E+04 | 6.E+04 | St/St/St |
| Rh-101m | 5.E-06 | 3.E-06 | 3.E-06 | 2.E+05 | 1.E+05 | 1.E+05 | St/St/St |
| Rh-101 | 2.E-07 | 3.E-07 | 7.E-08 | 8.E+03 | 1.E+04 | 2.E+03 | St/St/St |
| Rh-102m | 2.E-07 | 2.E-07 | 5.E-08 | 8.E+03 | 6.E+03 | 2.E+03 | St/St/St |
| Rh-102 | 4.E-08 | 7.E-08 | 2.E-08 | 1.E+03 | 3.E+03 | 9.E+02 | St/St/St |
| Rh-103m | 4.E-04 | 5.E-04 | 5.E-04 | 2.E+07 | 2.E+07 | 2.E+07 | St/St/St |
| Rh-105 | 5.E-06 | 3.E-06 | 2.E-06 | 2.E+05 | 1.E+05 | 9.E+04 | St/St/St |
| Rh-106m | 1.E-05 | 1.E-05 | 1.E-05 | 4.E+05 | 6.E+05 | 5.E+05 | St/St/St |
| Rh-107 | 1.E-04 | 1.E-04 | 1.E-04 | 4.E+06 | 4.E+06 | 4.E+06 | St/St/St |
| Pd-100 | 6.E-07 | 5.E-07 | 6.E-07 | 2.E+04 | 2.E+04 | 2.E+04 | St/St/St |
| Pd-101 | 1.E-05 | 1.E-05 | 1.E-05 | 5.E+05 | 5.E+05 | 5.E+05 | St/St/St |
| Pd-103 | 3.E-06 | 2.E-06 | 1.E-06 | 1.E+05 | 7.E+04 | 5.E+04 | St/St/St |
| Pd-107 | 9.E-06 | 3.E-06 | 2.E-07 | 3.E+05 | 1.E+05 | 6.E+03 | K /St/St |
| Pd-109 | 3.E-06 | 2.E-06 | 2.E-06 | 1.E+05 | 8.E+04 | 7.E+04 | St/St/St |
| Ag-102 | 8.E-05 | 9.E-05 | 8.E-05 | 3.E+06 | 3.E+06 | 3.E+06 | St/St/St |
| Ag-103 | 4.E-05 | 6.E-05 | 5.E-05 | 2.E+06 | 2.E+06 | 2.E+06 | St/St/St |
| Ag-104m | 4.E-05 | 5.E-05 | 5.E-05 | 2.E+06 | 2.E+06 | 2.E+06 | St/St/St |
| Ag-104 | 3.E-05 | 6.E-05 | 6.E-05 | 1.E+06 | 2.E+06 | 2.E+06 | St/St/St |
| Ag-105 | 4.E-07 | 7.E-07 | 7.E-07 | 2.E+04 | 3.E+04 | 3.E+04 | St/St/St |
| Ag-106m | 3.E-07 | 4.E-07 | 4.E-07 | 1.E+04 | 1.E+04 | 1.E+04 | St/St/St |
| Ag-106 | 7.E-05 | 8.E-05 | 8.E-05 | 3.E+06 | 3.E+06 | 3.E+06 | St/St/St |
| Ag-108m | 8.E-08 | 1.E-07 | 1.E-08 | 3.E+03 | 4.E+03 | 4.E+02 | St/St/St |
| Ag-110m | 6.E-08 | 8.E-08 | 4.E-08 | 2.E+03 | 3.E+03 | 1.E+03 | St/St/St |
| Ag-111 | 7.E-07 | 4.E-07 | 4.E-07 | 2.E+04 | 1.E+04 | 1.E+04 | L /St/St |
| Ag-112 | 3.E-06 | 4.E-06 | 4.E-06 | 1.E+05 | 2.E+05 | 1.E+05 | St/St/St |
| Ag-115 | 4.E-05 | 4.E-05 | 3.E-05 | 1.E+06 | 1.E+06 | 1.E+06 | St/St/St |
| Cd-104 | 3.E-05 | 5.E-05 | 5.E-05 | 1.E+06 | 2.E+06 | 2.E+06 | St/St/St |
| Cd-107 | 2.E-05 | 2.E-05 | 2.E-05 | 8.E+05 | 9.E+05 | 8.E+05 | St/St/St |
| Cd-109 | 1.E-08 | 5.E-08 | 5.E-08 | 5.E+02 | 2.E+03 | 2.E+03 | K /K /St |
| Cd-113m | 1.E-09 | 4.E-09 | 5.E-09 | 4.E+01 | 1.E+02 | 2.E+02 | K /K /St |
| Cd-113 | 9.E-10 | 3.E-09 | 6.E-09 | 4.E+01 | 1.E+02 | 2.E+02 | K /K /St |
| Cd-115m | 2.E-08 | 5.E-08 | 6.E-08 | 8.E+02 | 2.E+03 | 2.E+03 | K /St/St |
| Cd-115 | 6.E-07 | 5.E-07 | 6.E-07 | 2.E+04 | 2.E+04 | 2.E+04 | St/St/St |
| Cd-117m | 5.E-06 | 7.E-06 | 6.E-06 | 2.E+05 | 3.E+05 | 2.E+05 | St/St/St |
| Cd-117 | 5.E-06 | 7.E-06 | 6.E-06 | 2.E+05 | 3.E+05 | 2.E+05 | St/St/St |
| In-109 | 2.E-05 | 3.E-05 | – | 7.E+05 | 1.E+06 | – | St/St/ |
| In-110 (69 min) | 2.E-05 | 2.E-05 | – | 7.E+05 | 9.E+05 | – | St/St/ |
| In-110 (5 h) | 7.E-06 | 8.E-06 | – | 3.E+05 | 3.E+05 | – | St/St/ |
| In-111 | 3.E-06 | 3.E-06 | – | 1.E+05 | 1.E+05 | – | St/St/ |

| Radionuclide | Inhaled air-lung retention class [3] | | | Inhaled air-lung retention class [3] | | | Stochastic or organ [1] |
|---|---|---|---|---|---|---|---|
| | μCi/ml | | | Bq/m³ | | | |
| | D | W | Y | D | W | Y | ( D/ W/ Y) |
| In-112 | 3.E-04 | 3.E-04 | – | 1.E+07 | 1.E+07 | – | St/St/ |
| In-113m | 6.E-05 | 8.E-05 | – | 2.E+06 | 3.E+06 | – | St/St/ |
| In-114m | 3.E-08 | 4.E-08 | – | 1.E+03 | 2.E+03 | – | St/St/ |
| In-115m | 2.E-05 | 2.E-05 | – | 7.E+05 | 7.E+05 | – | St/St/ |
| In-115 | 6.E-10 | 2.E-09 | – | 2.E+01 | 8.E+01 | – | St/St/ |
| In-116m | 3.E-05 | 5.E-05 | – | 1.E+06 | 2.E+06 | – | St/St/ |
| In-117m | 1.E-05 | 2.E-05 | – | 5.E+05 | 7.E+05 | – | St/St/ |
| In-117 | 7.E-05 | 9.E-05 | – | 3.E+06 | 3.E+06 | – | St/St/ |
| In-119m | 5.E-05 | 6.E-05 | – | 2.E+06 | 2.E+06 | – | St/St/ |
| Sn-110 | 5.E-06 | 5.E-06 | – | 2.E+05 | 2.E+05 | – | St/St/ |
| Sn-111 | 9.E-05 | 1.E-04 | – | 4.E+06 | 4.E+06 | – | St/St/ |
| Sn-113 | 5.E-07 | 2.E-07 | – | 2.E+04 | 9.E+03 | – | St/St/ |
| Sn-117m | 5.E-07 | 6.E-07 | – | 2.E+04 | 2.E+04 | – | BS/St/ |
| Sn-119m | 1.E-06 | 4.E-07 | – | 4.E+04 | 1.E+04 | – | St/St/ |
| Sn-121m | 4.E-07 | 2.E-07 | – | 1.E+04 | 9.E+03 | – | St/St/ |
| Sn-121 | 6.E-06 | 5.E-06 | – | 2.E+05 | 2.E+05 | – | St/St/ |
| Sn-123m | 5.E-05 | 6.E-05 | – | 2.E+06 | 2.E+06 | – | St/St/ |
| Sn-123 | 3.E-07 | 7.E-08 | – | 1.E+04 | 3.E+03 | – | St/St/ |
| Sn-125 | 4.E-07 | 2.E-07 | – | 1.E+04 | 5.E+03 | – | St/St/ |
| Sn-126 | 2.E-08 | 3.E-08 | – | 9.E+02 | 1.E+03 | – | St/St/ |
| Sn-127 | 8.E-06 | 8.E-06 | – | 3.E+05 | 3.E+05 | – | St/St/ |
| Sn-128 | 1.E-05 | 1.E-05 | – | 4.E+05 | 6.E+05 | – | St/St/ |
| Sb-115 | 1.E-04 | 1.E-04 | – | 4.E+06 | 5.E+06 | – | St/St/ |
| Sb-116m | 3.E-05 | 6.E-05 | – | 1.E+06 | 2.E+06 | – | St/St/ |
| Sb-116 | 1.E-04 | 1.E-04 | – | 4.E+06 | 5.E+06 | – | St/St/ |
| Sb-117 | 9.E-05 | 1.E-04 | – | 3.E+06 | 4.E+06 | – | St/St/ |
| Sb-118m | 8.E-06 | 9.E-06 | – | 3.E+05 | 3.E+05 | – | St/St/ |
| Sb-119 | 2.E-05 | 1.E-05 | – | 7.E+05 | 4.E+05 | – | St/St/ |
| Sb-120 (16 min) | 2.E-04 | 2.E-04 | – | 7.E+06 | 8.E+06 | – | St/St/ |
| Sb-120 (6 d) | 9.E-07 | 6.E-07 | – | 3.E+04 | 2.E+04 | – | St/St/ |
| Sb-122 | 1.E-06 | 4.E-07 | – | 4.E+04 | 2.E+04 | – | St/St/ |
| Sb-124m | 3.E-04 | 3.E-04 | – | 1.E+07 | 9.E+06 | – | St/St/ |
| Sb-124 | 4.E-07 | 1.E-07 | – | 1.E+04 | 4.E+03 | – | St/St/ |
| Sb-125 | 1.E-06 | 2.E-07 | – | 4.E+04 | 8.E+03 | – | St/St/ |
| Sb-126m | 8.E-05 | 8.E-05 | – | 3.E+06 | 3.E+06 | – | St/St/ |
| Sb-126 | 4.E-07 | 2.E-07 | – | 2.E+04 | 8.E+03 | – | St/St/ |
| Sb-127 | 9.E-07 | 4.E-07 | – | 3.E+04 | 1.E+04 | – | St/St/ |
| Sb-128 (9 h) | 2.E-06 | 1.E-06 | – | 6.E+04 | 5.E+04 | – | St/St/ |
| Sb-128 (10 min) | 2.E-04 | 2.E-04 | – | 6.E+06 | 7.E+06 | – | St/St/ |
| Sb-129 | 4.E-06 | 4.E-06 | – | 1.E+05 | 1.E+05 | – | St/St/ |
| Sb-130 | 3.E-05 | 3.E-05 | – | 1.E+06 | 1.E+06 | – | St/St/ |
| Sb-131 | 1.E-05 | 1.E-05 | – | 4.E+05 | 4.E+05 | – | T /T / |
| Te-116 | 9.E-06 | 1.E-05 | – | 3.E+05 | 5.E+05 | – | St/St/ |
| Te-121m | 8.E-08 | 2.E-07 | – | 3.E+03 | 6.E+03 | – | BS/St/ |
| Te-121 | 2.E-06 | 1.E-06 | – | 7.E+04 | 5.E+04 | – | St/St/ |
| Te-123m | 9.E-08 | 2.E-07 | – | 3.E+03 | 8.E+03 | – | BS/St/ |
| Te-123 | 8.E-08 | 2.E-07 | – | 3.E+03 | 7.E+03 | – | BS/BS/ |
| Te-125m | 2.E-07 | 3.E-07 | – | 7.E+03 | 1.E+04 | – | BS/St/ |
| Te-127m | 1.E-07 | 1.E-07 | – | 4.E+03 | 4.E+03 | – | BS/St/ |
| Te-127 | 9.E-06 | 7.E-06 | – | 4.E+05 | 3.E+05 | – | St/St/ |
| Te-129m | 3.E-07 | 1.E-07 | – | 1.E+04 | 4.E+03 | – | St/St/ |
| Te-129 | 3.E-05 | 3.E-05 | – | 1.E+06 | 1.E+06 | – | St/St/ |
| Te-131m | 2.E-07 | 2.E-07 | – | 6.E+03 | 6.E+03 | – | T /T / |
| Te-131 | 2.E-06 | 2.E-06 | – | 8.E+04 | 8.E+04 | – | T /T / |
| Te-132 | 9.E-08 | 9.E-08 | – | 4.E+03 | 3.E+03 | – | T /T / |
| Te-133m | 2.E-06 | 2.E-06 | – | 8.E+04 | 8.E+04 | – | T /T / |
| Te-133 | 9.E-06 | 9.E-06 | – | 4.E+05 | 4.E+05 | – | T /T / |
| Te-134 | 1.E-05 | 1.E-05 | – | 4.E+05 | 4.E+05 | – | T /T / |
| I-120m | 9.E-06 | – | – | 3.E+05 | – | – | St/ / |
| I-120 | 4.E-06 | – | – | 1.E+05 | – | – | T / / |
| I-121 | 7.E-06 | – | – | 3.E+05 | – | – | T / / |
| I-123 | 3.E-06 | – | – | 1.E+05 | – | – | T / / |
| I-124 | 3.E-08 | – | – | 1.E+03 | – | – | T / / |
| I-125 | 3.E-08 | – | – | 1.E+03 | – | – | T / / |
| I-126 | 1.E-08 | – | – | 5.E+02 | – | – | T / / |
| I-128 | 5.E-05 | – | – | 2.E+06 | – | – | St/ / |
| I-129 | 4.E-09 | – | – | 1.E+02 | – | – | T / / |
| I-130 | 3.E-07 | – | – | 1.E+04 | – | – | T / / |
| I-131 | 2.E-08 | – | – | 7.E+02 | – | – | T / / |
| I-132m | 4.E-06 | – | – | 1.E+05 | – | – | T / / |
| I-132 | 3.E-06 | – | – | 1.E+05 | – | – | T / / |

| Radionuclide | Inhaled air-lung retention class [3] µCi/ml | | | Inhaled air-lung retention class [3] Bq/m [3] | | | Stochastic or organ [1] |
|---|---|---|---|---|---|---|---|
| | D | W | Y | D | W | Y | ( D/ W/ Y) |
| I-133 | 1.E-07 | – | – | 4.E+03 | – | – | T / / |
| I-134 | 2.E-05 | – | – | 7.E+05 | – | – | E / / |
| I-135 | 7.E-07 | – | – | 2.E+04 | – | – | T / / |
| Cs-125 | 6.E-05 | – | – | 2.E+06 | – | – | St/ / |
| Cs-127 | 4.E-05 | – | – | 2.E+06 | – | – | St/ / |
| Cs-129 | 1.E-05 | – | – | 5.E+05 | – | – | St/ / |
| Cs-130 | 8.E-05 | – | – | 3.E+06 | – | – | St/ / |
| Cs-131 | 1.E-05 | – | – | 5.E+05 | – | – | St/ / |
| Cs-132 | 2.E-06 | – | – | 6.E+04 | – | – | St/ / |
| Cs-134m | 6.E-05 | – | – | 2.E+06 | – | – | St/ / |
| Cs-134 | 4.E-08 | – | – | 2.E+03 | – | – | St/ / |
| Cs-135m | 8.E-05 | – | – | 3.E+06 | – | – | St/ / |
| Cs-135 | 5.E-07 | – | – | 2.E+04 | – | – | St/ / |
| Cs-136 | 3.E-07 | – | – | 1.E+04 | – | – | St/ / |
| Cs-137 | 7.E-08 | – | – | 2.E+03 | – | – | St/ / |
| Cs-138 | 2.E-05 | – | – | 9.E+05 | – | – | St/ / |
| Ba-126 | 6.E-06 | – | – | 2.E+05 | – | – | St/ / |
| Ba-128 | 7.E-07 | – | – | 3.E+04 | – | – | St/ / |
| Ba-131m | 6.E-04 | – | – | 2.E+07 | – | – | St/ / |
| Ba-131 | 3.E-06 | – | – | 1.E+05 | – | – | St/ / |
| Ba-133m | 4.E-06 | – | – | 1.E+05 | – | – | St/ / |
| Ba-133 | 3.E-07 | – | – | 1.E+04 | – | – | St/ / |
| Ba-135m | 5.E-06 | – | – | 2.E+05 | – | – | St/ / |
| Ba-139 | 1.E-05 | – | – | 5.E+05 | – | – | St/ / |
| Ba-140 | 6.E-07 | – | – | 2.E+04 | – | – | St/ / |
| Ba-141 | 3.E-05 | – | – | 1.E+06 | – | – | St/ / |
| Ba-142 | 6.E-05 | – | – | 2.E+06 | – | – | St/ / |
| La-131 | 5.E-05 | 7.E-05 | – | 2.E+06 | 3.E+06 | – | St/St/ |
| La-132 | 4.E-06 | 5.E-06 | – | 2.E+05 | 2.E+05 | – | St/St/ |
| La-135 | 4.E-05 | 4.E-05 | – | 2.E+06 | 2.E+06 | – | St/St/ |
| La-137 | 3.E-08 | 1.E-07 | – | 1.E+03 | 4.E+03 | – | L /E / |
| La-138 | 2.E-09 | 6.E-09 | – | 5.E+01 | 2.E+02 | – | St/St/ |
| La-140 | 6.E-07 | 5.E-07 | – | 2.E+04 | 2.E+04 | – | St/St/ |
| La-141 | 4.E-06 | 5.E-06 | – | 1.E+05 | 2.E+05 | – | St/St/ |
| La-142 | 9.E-06 | 1.E-05 | – | 4.E+05 | 5.E+05 | – | St/St/ |
| La-143 | 4.E-05 | 4.E-05 | – | 2.E+06 | 1.E+06 | – | St/St/ |
| Ce-134 | – | 3.E-07 | 3.E-07 | – | 1.E+04 | 1.E+04 | /St/St |
| Ce-135 | – | 2.E-06 | 2.E-06 | – | 6.E+04 | 5.E+04 | /St/St |
| Ce-137m | – | 2.E-06 | 2.E-06 | – | 7.E+04 | 6.E+04 | /St/St |
| Ce-137 | – | 6.E-05 | 5.E-05 | – | 2.E+06 | 2.E+06 | /St/St |
| Ce-139 | – | 3.E-07 | 3.E-07 | – | 1.E+04 | 1.E+04 | /St/St |
| Ce-141 | – | 3.E-07 | 2.E-07 | – | 1.E+04 | 9.E+03 | /St/St |
| Ce-143 | – | 8.E-07 | 7.E-07 | – | 3.E+04 | 2.E+04 | /St/St |
| Ce-144 | – | 1.E-08 | 6.E-09 | – | 4.E+02 | 2.E+02 | /St/St |
| Pr-136 | – | 1.E-04 | 9.E-05 | – | 4.E+06 | 4.E+06 | /St/St |
| Pr-137 | – | 6.E-05 | 6.E-05 | – | 2.E+06 | 2.E+06 | /St/St |
| Pr-138m | – | 2.E-05 | 2.E-05 | – | 8.E+05 | 7.E+05 | /St/St |
| Pr-139 | – | 5.E-05 | 5.E-05 | – | 2.E+06 | 2.E+06 | /St/St |
| Pr-142m | – | 7.E-05 | 6.E-05 | – | 3.E+06 | 2.E+06 | /St/St |
| Pr-142 | – | 8.E-07 | 8.E-07 | – | 3.E+04 | 3.E+04 | /St/St |
| Pr-143 | – | 3.E-07 | 3.E-07 | – | 1.E+04 | 1.E+04 | /St/St |
| Pr-144 | – | 5.E-05 | 5.E-05 | – | 2.E+06 | 2.E+06 | /St/St |
| Pr-145 | – | 4.E-06 | 3.E-06 | – | 1.E+05 | 1.E+05 | /St/St |
| Pr-147 | – | 8.E-05 | 8.E-05 | – | 3.E+06 | 3.E+06 | /St/St |
| Nd-136 | – | 2.E-05 | 2.E-05 | – | 9.E+05 | 8.E+05 | /St/St |
| Nd-138 | – | 3.E-06 | 2.E-06 | – | 1.E+05 | 8.E+04 | /St/St |
| Nd-139m | – | 7.E-06 | 6.E-06 | – | 3.E+05 | 2.E+05 | /St/St |
| Nd-139 | – | 1.E-04 | 1.E-04 | – | 5.E+06 | 4.E+06 | /St/St |
| Nd-141 | – | 3.E-04 | 3.E-04 | – | 1.E+07 | 9.E+06 | /St/St |
| Nd-147 | – | 4.E-07 | 3.E-07 | – | 2.E+04 | 1.E+04 | /St/St |
| Nd-149 | – | 1.E-05 | 1.E-05 | – | 4.E+05 | 4.E+05 | /St/St |
| Nd-151 | – | 8.E-05 | 8.E-05 | – | 3.E+06 | 3.E+06 | /St/St |
| Pm-141 | – | 8.E-05 | 7.E-05 | – | 3.E+06 | 3.E+06 | /St/St |
| Pm-143 | – | 3.E-07 | 3.E-07 | – | 9.E+03 | 1.E+04 | /St/St |
| Pm-144 | – | 5.E-08 | 5.E-08 | – | 2.E+03 | 2.E+03 | /St/St |
| Pm-145 | – | 7.E-08 | 8.E-08 | – | 3.E+03 | 3.E+03 | /BS/St |
| Pm-146 | – | 2.E-08 | 2.E-08 | – | 8.E+02 | 7.E+02 | /St/St |
| Pm-147 | – | 6.E-08 | 6.E-08 | – | 2.E+03 | 2.E+03 | /BS/St |
| Pm-148m | – | 1.E-07 | 1.E-07 | – | 5.E+03 | 5.E+03 | /St/St |
| Pm-148 | – | 2.E-07 | 2.E-07 | – | 8.E+03 | 8.E+03 | /St/St |
| Pm-149 | – | 8.E-07 | 8.E-07 | – | 3.E+04 | 3.E+04 | /St/St |

| Radionuclide | Inhaled air-lung retention class [3] | | | Inhaled air-lung retention class [3] | | | Stochastic or organ [1] |
|---|---|---|---|---|---|---|---|
| | μCi/ml | | | Bq/m [3] | | | |
| | D | W | Y | D | W | Y | ( D/ W/ Y) |
| Pm-150 | – | 8.E-06 | 7.E-06 | – | 3.E+05 | 3.E+05 | /St/St |
| Pm-151 | – | 2.E-06 | 1.E-06 | – | 6.E+04 | 5.E+04 | /St/St |
| Sm-141m | – | 4.E-05 | – | – | 2.E+06 | – | /St/ |
| Sm-141 | – | 7.E-05 | – | – | 3.E+06 | – | /St/ |
| Sm-142 | – | 1.E-05 | – | – | 4.E+05 | – | /St/ |
| Sm-145 | – | 2.E-07 | – | – | 8.E+03 | – | /St/ |
| Sm-146 | – | 1.E-11 | – | – | 6.E-01 | – | /BS/ |
| Sm-147 | – | 2.E-11 | – | – | 6.E-01 | – | /BS/ |
| Sm-151 | – | 4.E-08 | – | – | 2.E+03 | – | /BS/ |
| Sm-153 | – | 1.E-06 | – | – | 4.E+04 | – | /St/ |
| Sm-155 | – | 9.E-05 | – | – | 3.E+06 | – | /St/ |
| Sm-156 | – | 4.E-06 | – | – | 1.E+05 | – | /St/ |
| Eu-145 | – | 8.E-07 | – | – | 3.E+04 | – | /St/ |
| Eu-146 | – | 5.E-07 | – | – | 2.E+04 | – | /St/ |
| Eu-147 | – | 7.E-07 | – | – | 3.E+04 | – | /St/ |
| Eu-148 | – | 2.E-07 | – | – | 6.E+03 | – | /St/ |
| Eu-149 | – | 1.E-06 | – | – | 5.E+04 | – | /St/ |
| Eu-150 (12 h) | – | 3.E-06 | – | – | 1.E+05 | – | /St/ |
| Eu-150 (34 yr) | – | 8.E-09 | – | – | 3.E+02 | – | /St/ |
| Eu-152m | – | 3.E-06 | – | – | 1.E+05 | – | /St/ |
| Eu-152 | – | 1.E-08 | – | – | 4.E+02 | – | /St/ |
| Eu-154 | – | 8.E-09 | – | – | 3.E+02 | – | /St/ |
| Eu-155 | – | 4.E-08 | – | – | 1.E+03 | – | /BS/ |
| Eu-156 | – | 2.E-07 | – | – | 7.E+03 | – | /St/ |
| Eu-157 | – | 2.E-06 | – | – | 7.E+04 | – | /St/ |
| Eu-158 | – | 2.E-05 | – | – | 9.E+05 | – | /St/ |
| Gd-145 | 7.E-05 | 7.E-05 | – | 2.E+06 | 3.E+06 | – | St/St/ |
| Gd-146 | 5.E-08 | 1.E-07 | – | 2.E+03 | 4.E+03 | – | St/St/ |
| Gd-147 | 2.E-06 | 2.E-06 | – | 6.E+04 | 5.E+04 | – | St/St/ |
| Gd-148 | 3.E-12 | 1.E-11 | – | 1.E-01 | 5.E-01 | – | BS/BS/ |
| Gd-149 | 9.E-07 | 1.E-06 | – | 3.E+04 | 4.E+04 | – | St/St/ |
| Gd-151 | 2.E-07 | 5.E-07 | – | 6.E+03 | 2.E+04 | – | BS/St/ |
| Gd-152 | 4.E-12 | 2.E-11 | – | 2.E-01 | 6.E-01 | – | BS/BS/ |
| Gd-153 | 6.E-08 | 3.E-07 | – | 2.E+03 | 9.E+03 | – | BS/St/ |
| Gd-159 | 3.E-06 | 2.E-06 | – | 1.E+05 | 9.E+04 | – | St/St/ |
| Tb-147 | – | 1.E-05 | – | – | 5.E+05 | – | /St/ |
| Tb-149 | – | 3.E-07 | – | – | 1.E+04 | – | /St/ |
| Tb-150 | – | 9.E-06 | – | – | 3.E+05 | – | /St/ |
| Tb-151 | – | 4.E-06 | – | – | 1.E+05 | – | /St/ |
| Tb-153 | – | 3.E-06 | – | – | 1.E+05 | – | /St/ |
| Tb-154 | – | 2.E-06 | – | – | 7.E+04 | – | /St/ |
| Tb-155 | – | 3.E-06 | – | – | 1.E+05 | – | /St/ |
| Tb-156m (24 h) | – | 3.E-06 | – | – | 1.E+05 | – | /St/ |
| Tb-156m (5 h) | – | 1.E-05 | – | – | 4.E+05 | – | /St/ |
| Tb-156 | – | 6.E-07 | – | – | 2.E+04 | – | /St/ |
| Tb-157 | – | 1.E-07 | – | – | 5.E+03 | – | /BS/ |
| Tb-158 | – | 8.E-09 | – | – | 3.E+02 | – | /St/ |
| Tb-160 | – | 1.E-07 | – | – | 4.E+03 | – | /St/ |
| Tb-161 | – | 7.E-07 | – | – | 2.E+04 | – | /St/ |
| Dy-155 | – | 1.E-05 | – | – | 4.E+05 | – | /St/ |
| Dy-157 | – | 3.E-05 | – | – | 1.E+06 | – | /St/ |
| Dy-159 | – | 1.E-06 | – | – | 4.E+04 | – | /St/ |
| Dy-165 | – | 2.E-05 | – | – | 7.E+05 | – | /St/ |
| Dy-166 | – | 3.E-07 | – | – | 1.E+04 | – | /St/ |
| Ho-155 | – | 7.E-05 | – | – | 2.E+06 | – | /St/ |
| Ho-157 | – | 6.E-04 | – | – | 2.E+07 | – | /St/ |
| Ho-159 | – | 4.E-04 | – | – | 2.E+07 | – | /St/ |
| Ho-161 | – | 2.E-04 | – | – | 7.E+06 | – | /St/ |
| Ho-162m | – | 1.E-04 | – | – | 4.E+06 | – | /St/ |
| Ho-162 | – | 1.E-03 | – | – | 4.E+07 | – | /St/ |
| Ho-164m | – | 1.E-04 | – | – | 5.E+06 | – | /St/ |
| Ho-164 | – | 3.E-04 | – | – | 1.E+07 | – | /St/ |
| Ho-166m | – | 3.E-09 | – | – | 1.E+02 | – | /St/ |
| Ho-166 | – | 7.E-07 | – | – | 3.E+04 | – | /St/ |
| Ho-167 | – | 2.E-05 | – | – | 9.E+05 | – | /St/ |
| Er-161 | – | 3.E-05 | – | – | 1.E+06 | – | /St/ |
| Er-165 | – | 8.E-05 | – | – | 3.E+06 | – | /St/ |
| Er-169 | – | 1.E-06 | – | – | 4.E+04 | – | /St/ |
| Er-171 | – | 4.E-06 | – | – | 2.E+05 | – | /St/ |
| Er-172 | – | 6.E-07 | – | – | 2.E+04 | – | /St/ |
| Tm-162 | – | 1.E-04 | – | – | 4.E+06 | – | /St/ |

| Radionuclide | Inhaled air-lung retention class[3] µCi/ml | | | Inhaled air-lung retention class[3] Bq/m[3] | | | Stochastic or organ[1] |
|---|---|---|---|---|---|---|---|
| | D | W | Y | D | W | Y | ( D/ W/ Y) |
| Tm-166 | – | 6.E−06 | – | – | 2.E+05 | – | /St/ |
| Tm-167 | – | 8.E−07 | – | – | 3.E+04 | – | /St/ |
| Tm-170 | – | 9.E−08 | – | – | 3.E+03 | – | /St/ |
| Tm-171 | – | 1.E−07 | – | – | 5.E+03 | – | /BS/ |
| Tm-172 | – | 5.E−07 | – | – | 2.E+04 | – | /St/ |
| Tm-173 | – | 5.E−06 | – | – | 2.E+05 | – | /St/ |
| Tm-175 | – | 1.E−04 | – | – | 4.E+06 | – | /St/ |
| Yb-162 | – | 1.E−04 | 1.E−04 | – | 5.E+06 | 4.E+06 | /St/St |
| Yb-166 | – | 8.E−07 | 8.E−07 | – | 3.E+04 | 3.E+04 | /St/St |
| Yb-167 | – | 3.E−04 | 3.E−04 | – | 1.E+07 | 1.E+07 | /St/St |
| Yb-169 | – | 3.E−07 | 3.E−07 | – | 1.E+04 | 1.E+04 | /St/St |
| Yb-175 | – | 1.E−06 | 1.E−06 | – | 5.E+04 | 5.E+04 | /St/St |
| Yb-177 | – | 2.E−05 | 2.E−05 | – | 8.E+05 | 7.E+05 | /St/St |
| Yb-178 | – | 2.E−05 | 1.E−05 | – | 6.E+05 | 6.E+05 | /St/St |
| Lu-169 | – | 2.E−06 | 2.E−06 | – | 7.E+04 | 7.E+04 | /St/St |
| Lu-170 | – | 9.E−07 | 8.E−07 | – | 3.E+04 | 3.E+04 | /St/St |
| Lu-171 | – | 8.E−07 | 8.E−07 | – | 3.E+04 | 3.E+04 | /St/St |
| Lu-172 | – | 5.E−07 | 5.E−07 | – | 2.E+04 | 2.E+04 | /St/St |
| Lu-173 | – | 1.E−07 | 1.E−07 | – | 4.E+03 | 4.E+03 | /BS/St |
| Lu-174m | – | 1.E−07 | 9.E−08 | – | 4.E+03 | 3.E+03 | /BS/St |
| Lu-174 | – | 5.E−08 | 7.E−08 | – | 2.E+03 | 2.E+03 | /BS/St |
| Lu-176m | – | 1.E−05 | 1.E−05 | – | 4.E+05 | 4.E+05 | /St/St |
| Lu-176 | – | 2.E−09 | 3.E−09 | – | 7.E+01 | 1.E+02 | /BS/St |
| Lu-177m | – | 5.E−08 | 3.E−08 | – | 2.E+03 | 1.E+03 | /BS/St |
| Lu-177 | – | 9.E−07 | 9.E−07 | – | 3.E+04 | 3.E+04 | /St/St |
| Lu-178m | – | 8.E−05 | 7.E−05 | – | 3.E+06 | 3.E+06 | /St/St |
| Lu-178 | – | 5.E−05 | 5.E−05 | – | 2.E+06 | 2.E+06 | /St/St |
| Lu-179 | – | 8.E−06 | 6.E−06 | – | 3.E+05 | 2.E+05 | /St/St |
| Hf-170 | 2.E−06 | 2.E−06 | – | 9.E+04 | 7.E+04 | – | St/St/ |
| Hf-172 | 4.E−09 | 2.E−08 | – | 1.E+02 | 6.E+02 | – | BS/BS/ |
| Hf-173 | 5.E−06 | 5.E−06 | – | 2.E+05 | 2.E+05 | – | St/St/ |
| Hf-175 | 4.E−07 | 5.E−07 | – | 2.E+04 | 2.E+04 | – | BS/St/ |
| Hf-177m | 2.E−05 | 4.E−05 | – | 9.E+05 | 1.E+06 | – | St/St/ |
| Hf-178m | 6.E−10 | 2.E−09 | – | 2.E+01 | 8.E+01 | – | BS/BS/ |
| Hf-179m | 1.E−07 | 3.E−07 | – | 5.E+03 | 9.E+03 | – | BS/St/ |
| Hf-180m | 9.E−06 | 1.E−05 | – | 3.E+05 | 4.E+05 | – | St/St/ |
| Hf-181 | 7.E−08 | 2.E−07 | – | 3.E+03 | 7.E+03 | – | BS/St/ |
| Hf-182m | 4.E−05 | 6.E−05 | – | 1.E+06 | 2.E+06 | – | St/St/ |
| Hf-182 | 3.E−10 | 1.E−09 | – | 1.E+01 | 5.E+01 | – | BS/BS/ |
| Hf-183 | 2.E−05 | 2.E−05 | – | 7.E+05 | 8.E+05 | – | St/St/ |
| Hf-184 | 3.E−06 | 3.E−06 | – | 1.E+05 | 1.E+05 | – | St/St/ |
| Ta-172 | – | 5.E−05 | 4.E−05 | – | 2.E+06 | 2.E+06 | /St/St |
| Ta-173 | – | 8.E−06 | 7.E−06 | – | 3.E+05 | 3.E+05 | /St/St |
| Ta-174 | – | 4.E−05 | 4.E−05 | – | 1.E+06 | 1.E+06 | /St/St |
| Ta-175 | – | 7.E−06 | 6.E−06 | – | 3.E+05 | 2.E+05 | /St/St |
| Ta-176 | – | 5.E−06 | 5.E−06 | – | 2.E+05 | 2.E+05 | /St/St |
| Ta-177 | – | 8.E−06 | 7.E−06 | – | 3.E+05 | 3.E+05 | /St/St |
| Ta-178 | – | 4.E−05 | 3.E−05 | – | 1.E+06 | 1.E+06 | /St/St |
| Ta-179 | – | 2.E−06 | 4.E−07 | – | 8.E+04 | 1.E+04 | /St/St |
| Ta-180m | – | 3.E−05 | 2.E−05 | – | 1.E+06 | 9.E+05 | /St/St |
| Ta-180 | – | 2.E−07 | 1.E−08 | – | 7.E+03 | 4.E+02 | /St/St |
| Ta-182m | – | 2.E−04 | 2.E−04 | – | 8.E+06 | 6.E+06 | /St/St |
| Ta-182 | – | 1.E−07 | 6.E−08 | – | 5.E+03 | 2.E+03 | /St/St |
| Ta-183 | – | 5.E−07 | 4.E−07 | – | 2.E+04 | 2.E+04 | /St/St |
| Ta-184 | – | 2.E−06 | 2.E−06 | – | 8.E+04 | 7.E+04 | /St/St |
| Ta-185 | – | 3.E−05 | 3.E−05 | – | 1.E+06 | 1.E+06 | /St/St |
| Ta-186 | – | 1.E−04 | 9.E−05 | – | 4.E+06 | 3.E+06 | /St/St |
| W-176 | 2.E−05 | – | – | 8.E+05 | – | – | St/ / |
| W-177 | 4.E−05 | – | – | 1.E+06 | – | – | St/ / |
| W-178 | 8.E−06 | – | – | 3.E+05 | – | – | St/ / |
| W-179 | 7.E−04 | – | – | 3.E+07 | – | – | St/ / |
| W-181 | 1.E−05 | – | – | 5.E+05 | – | – | St/ / |
| W-185 | 3.E−06 | – | – | 1.E+05 | – | – | St/ / |
| W-187 | 4.E−06 | – | – | 2.E+05 | – | – | St/ / |
| W-188 | 5.E−07 | – | – | 2.E+04 | – | – | St/ / |
| Re-177 | 1.E−04 | 2.E−04 | – | 4.E+06 | 5.E+06 | – | St/St/ |
| Re-178 | 1.E−04 | 1.E−04 | – | 4.E+06 | 4.E+06 | – | St/St/ |
| Re-181 | 4.E−06 | 4.E−06 | – | 1.E+05 | 1.E+05 | – | St/St/ |
| Re-182 (64 h) | 1.E−06 | 9.E−07 | – | 4.E+04 | 3.E+04 | – | St/St/ |
| Re-182 (12 h) | 5.E−06 | 6.E−06 | – | 2.E+05 | 2.E+05 | – | St/St/ |
| Re-184m | 1.E−06 | 2.E−07 | – | 5.E+04 | 7.E+03 | – | St/St/ |

| Radionuclide | Inhaled air-lung retention class [3] | | | Inhaled air-lung retention class [3] | | | Stochastic or organ [1] |
|---|---|---|---|---|---|---|---|
| | μCi/ml | | | Bq/m³ | | | |
| | D | W | Y | D | W | Y | ( D/ W/ Y) |
| Re-184 | 2.E-06 | 6.E-07 | – | 6.E+04 | 2.E+04 | – | St/St/ |
| Re-186m | 7.E-07 | 6.E-08 | – | 3.E+04 | 2.E+03 | – | SW/St/ |
| Re-186 | 1.E-06 | 7.E-07 | – | 5.E+04 | 3.E+04 | – | St/St/ |
| Re-187 | 3.E-04 | 4.E-05 | – | 1.E+07 | 2.E+06 | – | SW/St/ |
| Re-188m | 6.E-05 | 6.E-05 | – | 2.E+06 | 2.E+06 | – | St/St/ |
| Re-188 | 1.E-06 | 1.E-06 | – | 4.E+04 | 4.E+04 | – | St/St/ |
| Re-189 | 2.E-06 | 2.E-06 | – | 8.E+04 | 7.E+04 | – | St/St/ |
| Os-180 | 2.E-04 | 2.E-04 | 2.E-04 | 6.E+06 | 8.E+06 | 7.E+06 | St/St/St |
| Os-181 | 2.E-05 | 2.E-05 | 2.E-05 | 7.E+05 | 7.E+05 | 7.E+05 | St/St/St |
| Os-182 | 2.E-06 | 2.E-06 | 2.E-06 | 9.E+04 | 7.E+04 | 6.E+04 | St/St/St |
| Os-185 | 2.E-07 | 3.E-07 | 3.E-07 | 8.E+03 | 1.E+04 | 1.E+04 | St/St/St |
| Os-189m | 1.E-04 | 9.E-05 | 7.E-05 | 4.E+06 | 3.E+06 | 3.E+06 | St/St/St |
| Os-191m | 1.E-05 | 9.E-06 | 7.E-06 | 4.E+05 | 3.E+05 | 3.E+05 | St/St/St |
| Os-191 | 9.E-07 | 7.E-07 | 6.E-07 | 3.E+04 | 3.E+04 | 2.E+04 | St/St/St |
| Os-193 | 2.E-06 | 1.E-06 | 1.E-06 | 7.E+04 | 5.E+04 | 4.E+04 | St/St/St |
| Os-194 | 2.E-08 | 2.E-08 | 3.E-09 | 7.E+02 | 9.E+02 | 1.E+02 | St/St/St |
| Ir-182 | 6.E-05 | 6.E-05 | 5.E-05 | 2.E+06 | 2.E+06 | 2.E+06 | St/St/St |
| Ir-184 | 1.E-05 | 1.E-05 | 1.E-05 | 4.E+05 | 5.E+05 | 4.E+05 | St/St/St |
| Ir-185 | 5.E-06 | 5.E-06 | 4.E-06 | 2.E+05 | 2.E+05 | 2.E+05 | St/St/St |
| Ir-186 | 3.E-06 | 3.E-06 | 2.E-06 | 1.E+05 | 1.E+05 | 9.E+04 | St/St/St |
| Ir-187 | 1.E-05 | 1.E-05 | 1.E-05 | 5.E+05 | 5.E+05 | 4.E+05 | St/St/St |
| Ir-188 | 2.E-06 | 2.E-06 | 1.E-06 | 7.E+04 | 6.E+04 | 5.E+04 | St/St/St |
| Ir-189 | 2.E-06 | 2.E-06 | 2.E-06 | 7.E+04 | 6.E+04 | 6.E+04 | St/St/St |
| Ir-190m | 8.E-05 | 9.E-05 | 8.E-05 | 3.E+06 | 3.E+06 | 3.E+06 | St/St/St |
| Ir-190 | 4.E-07 | 4.E-07 | 4.E-07 | 1.E+04 | 2.E+04 | 1.E+04 | St/St/St |
| Ir-192m | 4.E-08 | 9.E-08 | 6.E-09 | 1.E+03 | 3.E+03 | 2.E+02 | St/St/St |
| Ir-192 | 1.E-07 | 2.E-07 | 9.E-08 | 4.E+03 | 6.E+03 | 3.E+03 | St/St/St |
| Ir-194m | 4.E-08 | 7.E-08 | 4.E-08 | 2.E+03 | 3.E+03 | 2.E+03 | St/St/St |
| Ir-194 | 1.E-06 | 8.E-07 | 8.E-07 | 5.E+04 | 3.E+04 | 3.E+04 | St/St/St |
| Ir-195m | 1.E-05 | 1.E-05 | 9.E-06 | 4.E+05 | 4.E+05 | 3.E+05 | St/St/St |
| Ir-195 | 2.E-05 | 2.E-05 | 2.E-05 | 6.E+05 | 8.E+05 | 7.E+05 | St/St/St |
| Pt-186 | 2.E-05 | – | – | 6.E+05 | – | – | St/ / |
| Pt-188 | 7.E-07 | – | – | 3.E+04 | – | – | St/ / |
| Pt-189 | 1.E-05 | – | – | 4.E+05 | – | – | St/ / |
| Pt-191 | 3.E-06 | – | – | 1.E+05 | – | – | St/ / |
| Pt-193m | 2.E-06 | – | – | 9.E+04 | – | – | St/ / |
| Pt-193 | 1.E-05 | – | – | 4.E+05 | – | – | St/ / |
| Pt-195m | 2.E-06 | – | – | 7.E+04 | – | – | St/ / |
| Pt-197m | 2.E-05 | – | – | 7.E+05 | – | – | St/ / |
| Pt-197 | 4.E-06 | – | – | 2.E+05 | – | – | St/ / |
| Pt-199 | 6.E-05 | – | – | 2.E+06 | – | – | St/ / |
| Pt-200 | 1.E-06 | – | – | 5.E+04 | – | – | St/ / |
| Au-193 | 1.E-05 | 8.E-06 | 8.E-06 | 4.E+05 | 3.E+05 | 3.E+05 | St/St/St |
| Au-194 | 3.E-06 | 2.E-06 | 2.E-06 | 1.E+05 | 9.E+04 | 8.E+04 | St/St/St |
| Au-195 | 5.E-06 | 6.E-07 | 2.E-07 | 2.E+05 | 2.E+04 | 6.E+03 | St/St/St |
| Au-198m | 1.E-06 | 5.E-07 | 5.E-07 | 4.E+04 | 2.E+04 | 2.E+04 | St/St/St |
| Au-198 | 2.E-06 | 7.E-07 | 7.E-07 | 6.E+04 | 3.E+04 | 3.E+04 | St/St/St |
| Au-199 | 4.E-06 | 2.E-06 | 2.E-06 | 1.E+05 | 6.E+04 | 6.E+04 | St/St/St |
| Au-200m | 1.E-06 | 1.E-06 | 1.E-06 | 5.E+04 | 4.E+04 | 4.E+04 | St/St/St |
| Au-200 | 3.E-05 | 3.E-05 | 3.E-05 | 1.E+06 | 1.E+06 | 1.E+06 | St/St/St |
| Au-201 | 9.E-05 | 1.E-04 | 9.E-05 | 3.E+06 | 4.E+06 | 4.E+06 | St/St/St |
| Hg-193m (Org) | 6.E-06 | – | – | 2.E+05 | – | – | St/ / |
| Hg-193m (Inorg) | 4.E-06 | 3.E-06 | – | 1.E+05 | 1.E+05 | – | St/St/ |
| Hg-193m (Vapor) | – | 4.E-06 | – | – | 1.E+05 | – | /St/ |
| Hg-193 (Org) | 3.E-05 | – | – | 1.E+06 | – | – | St/ / |
| Hg-193 (Inorg) | 2.E-05 | 2.E-05 | – | 7.E+05 | 6.E+05 | – | St/St/ |
| Hg-193 (Vapor) | – | 1.E-05 | – | – | 5.E+05 | – | /St/ |
| Hg-194 (Org) | 1.E-08 | – | – | 4.E+02 | – | – | St/ / |
| Hg-194 (Inorg) | 2.E-08 | 5.E-08 | – | 7.E+02 | 2.E+03 | – | St/St/ |
| Hg-194 (Vapor) | – | 1.E-08 | – | – | 5.E+02 | – | /St/ |
| Hg-195m (Org) | 3.E-06 | – | – | 9.E+04 | – | – | St/ / |
| Hg-195m (Inorg) | 2.E-06 | 2.E-06 | – | 8.E+04 | 6.E+04 | – | St/St/ |
| Hg-195m (Vapor) | – | –2.E-06 | – | – | 6.E+04 | – | /St/ |
| Hg-195 (Org) | 2.E-05 | – | – | 7.E+05 | – | – | St/ / |
| Hg-195 (Inorg) | 1.E-05 | 1.E-05 | – | 5.E+05 | 5.E+05 | – | St/St/ |
| Hg-195 (Vapor) | – | 1.E-05 | – | – | 5.E+05 | – | /St/ |
| Hg-197m (Org) | 4.E-06 | – | – | 1.E+05 | – | – | St/ / |
| Hg-197m (Inorg) | 3.E-06 | 2.E-06 | – | 1.E+05 | 8.E+04 | – | St/St/ |
| Hg-197m (Vapor) | – | 2.E-06 | – | – | 8.E+04 | – | /St/ |
| Hg-197 (Org) | 6.E-06 | – | – | 2.E+05 | – | – | St/ / |
| Hg-197 (Inorg) | 5.E-06 | 4.E-06 | – | 2.E+05 | 1.E+05 | – | St/St/ |

| Radionuclide | Inhaled air-lung retention class[3] | | | Inhaled air-lung retention class[3] | | | Stochastic or organ[1] |
|---|---|---|---|---|---|---|---|
| | μCi/ml | | | Bq/m[3] | | | |
| | D | W | Y | D | W | Y | ( D/ W/ Y) |
| Hg-197 (Vapor) ... | – | 3.E – 05 | – | – | 1.E + 05 | – | /St/ |
| Hg-199m (Org) ... | 7.E – 05 | – | – | 3.E + 06 | – | – | St/ / |
| Hg-199m (Inorg) | 6.E – 05 | 7.E – 05 | – | 2.E + 06 | 3.E + 06 | – | St/St/ |
| Hg-199m (Vapor) | – | 3.E – 05 | – | – | 1.E + 06 | – | /St/ |
| Hg-203 (Org) ..... | 3.E – 07 | – | – | 1.E + 04 | – | – | St/ / |
| Hg-203 (Inorg) .... | 5.E – 07 | 5.E – 07 | – | 2.E + 04 | 2.E + 04 | – | St/St/ |
| Hg-203 (Vapor) ... | – | 3.E – 07 | – | – | 1.E + 04 | – | /St/ |
| Tl-194m ..... | 6.E – 05 | – | – | 2.E + 06 | – | – | St/ / |
| Tl-194 ..... | 3.E – 04 | – | – | 9.E + 06 | – | – | St/ / |
| Tl-195 ..... | 5.E – 05 | – | – | 2.E + 06 | – | – | St/ / |
| Tl-197 ..... | 5.E – 05 | – | – | 2.E + 06 | – | – | St/ / |
| Tl-198m ..... | 2.E – 05 | – | – | 9.E + 05 | – | – | St/ / |
| Tl-198 ..... | 1.E – 05 | – | – | 5.E + 05 | – | – | St/ / |
| Tl-199 ..... | 3.E – 05 | – | – | 1.E + 06 | – | – | St/ / |
| Tl-200 ..... | 5.E – 06 | – | – | 2.E + 05 | – | – | St/ / |
| Tl-201 ..... | 9.E – 06 | – | – | 3.E + 05 | – | – | St/ / |
| Tl-202 ..... | 2.E – 06 | – | – | 8.E + 04 | – | – | St/ / |
| Tl-204 ..... | 9.E – 07 | – | – | 3.E + 04 | – | – | St/ / |
| Pb-195m ..... | 8.E – 05 | – | – | 3.E + 06 | – | – | St/ / |
| Pb-198 ..... | 3.E – 05 | – | – | 1.E + 06 | – | – | St/ / |
| Pb-199 ..... | 3.E – 05 | – | – | 1.E + 06 | – | – | St/ / |
| Pb-200 ..... | 3.E – 06 | – | – | 1.E + 05 | – | – | St/ / |
| Pb-201 ..... | 9.E – 06 | – | – | 3.E + 05 | – | – | St/ / |
| Pb-202m ..... | 1.E – 05 | – | – | 4.E + 05 | – | – | St/ / |
| Pb-202 ..... | 2.E – 08 | – | – | 8.E + 02 | – | – | St/ / |
| Pb-203 ..... | 4.E – 06 | – | – | 2.E + 05 | – | – | St/ / |
| Pb-205 ..... | 6.E – 07 | – | – | 2.E + 04 | – | – | St/ / |
| Pb-209 ..... | 2.E – 05 | – | – | 9.E + 05 | – | – | St/ / |
| Pb-210 ..... | 1.E – 10 | – | – | 4.E + 00 | – | – | BS/ / |
| Pb-211 ..... | 3.E – 07 | – | – | 1.E + 04 | – | – | St/ / |
| Pb-212 ..... | 1.E – 08 | – | – | 5.E + 02 | – | – | St/ / |
| Pb-214 ..... | 3.E – 07 | – | – | 1.E + 04 | – | – | St/ / |
| Bi-200 ..... | 3.E – 05 | 4.E – 05 | – | 1.E + 06 | 2.E + 06 | – | St/St/ |
| Bi-201 ..... | 1.E – 05 | 2.E – 05 | – | 4.E + 05 | 6.E + 05 | – | St/St/ |
| Bi-202 ..... | 2.E – 05 | 3.E – 05 | – | 6.E + 05 | 1.E + 06 | – | St/St/ |
| Bi-203 ..... | 3.E – 06 | 2.E – 06 | – | 1.E + 05 | 9.E + 04 | – | St/St/ |
| Bi-205 ..... | 1.E – 06 | 5.E – 07 | – | 4.E + 04 | 2.E + 04 | – | St/St/ |
| Bi-206 ..... | 6.E – 07 | 4.E – 07 | – | 2.E + 04 | 1.E + 04 | – | St/St/ |
| Bi-207 ..... | 7.E – 07 | 2.E – 07 | – | 3.E + 04 | 5.E + 03 | – | St/St/ |
| Bi-210m ..... | 2.E – 09 | 3.E – 10 | – | 7.E + 01 | 1.E + 01 | – | K /St/ |
| Bi-210 ..... | 1.E – 07 | 1.E – 08 | – | 4.E + 03 | 4.E + 02 | – | K /St/ |
| Bi-212 ..... | 1.E – 07 | 1.E – 07 | – | 4.E + 03 | 4.E + 03 | – | St/St/ |
| Bi-213 ..... | 1.E – 07 | 2.E – 07 | – | 5.E + 03 | 5.E + 03 | – | St/St/ |
| Bi-214 ..... | 3.E – 07 | 4.E – 07 | – | 1.E + 04 | 1.E + 04 | – | St/St/ |
| Po-203 ..... | 3.E – 05 | 4.E – 05 | – | 1.E + 06 | 1.E + 06 | – | St/St/ |
| Po-205 ..... | 2.E – 05 | 3.E – 05 | – | 6.E + 05 | 1.E + 06 | – | St/St/ |
| Po-207 ..... | 1.E – 05 | 1.E – 05 | – | 4.E + 05 | 4.E + 05 | – | St/St/ |
| Po-210 ..... | 3.E – 10 | 3.E – 10 | – | 1.E + 01 | 1.E + 01 | – | E /St/ |
| At-207 ..... | 1.E – 06 | 9.E – 07 | – | 4.E + 04 | 3.E + 04 | – | St/St/ |
| At-211 ..... | 3.E – 08 | 2.E – 08 | – | 1.E + 03 | 8.E + 02 | – | St/St/ |
| Rn-220 ..... | 8.E – 09[4] | —[4] | —[4] | 3.E + 02[4] | —[4] | —[4] | —[4] |
| Rn-222 ..... | 3.E – 08[4] | —[4] | —[4] | 1.E + 03[4] | —[4] | —[4] | —[4] |
| Fr-222 ..... | 2.E – 07 | – | – | 7.E + 03 | – | – | St/ / |
| Fr-223 ..... | 3.E – 07 | – | – | 1.E + 04 | – | – | St/ / |
| Ra-223 ..... | – | 3.E – 10 | – | – | 1.E + 01 | – | /St/ |
| Ra-224 ..... | – | 7.E – 10 | – | – | 3.E + 01 | – | /St/ |
| Ra-225 ..... | – | 3.E – 10 | – | – | 1.E + 01 | – | /St/ |
| Ra-226 ..... | – | 3.E – 10 | – | – | 1.E + 01 | – | /St/ |
| Ra-227 ..... | – | 6.E – 06 | – | – | 2.E + 05 | – | /BS/ |
| Ra-228 ..... | – | 5.E – 10 | – | – | 2.E + 01 | – | /St/ |
| Ac-224 ..... | 1.E – 08 | 2.E – 08 | 2.E – 08 | 4.E + 02 | 8.E + 02 | 7.E + 02 | BS/St/St |
| Ac-225 ..... | 1.E – 10 | 3.E – 10 | 3.E – 10 | 4.E + 00 | 1.E + 01 | 1.E + 01 | BS/St/St |
| Ac-226 ..... | 1.E – 09 | 2.E – 09 | 2.E – 09 | 5.E + 01 | 8.E + 01 | 7.E + 01 | BS/St/St |
| Ac-227 ..... | 2.E – 13 | 7.E – 13 | 2.E – 12 | 7.E – 03 | 3.E – 02 | 6.E – 02 | BS/BS/St |
| Ac-228 ..... | 4.E – 09 | 2.E – 08 | 2.E – 08 | 2.E + 02 | 6.E + 02 | 7.E + 02 | BS/BS/St |
| Th-226 ..... | – | 7.E – 08 | 6.E – 08 | – | 2.E + 03 | 2.E + 03 | /St/St |
| Th-227 ..... | – | 1.E – 10 | 1.E – 10 | – | 5.E + 00 | 5.E + 00 | /St/St |
| Th-228 ..... | – | 4.E – 12 | 7.E – 12 | – | 2.E – 01 | 3.E – 01 | /BS/St |
| Th-229 ..... | – | 4.E – 13 | 1.E – 12 | – | 1.E – 02 | 4.E – 02 | /BS/BS |
| Th-230 ..... | – | 3.E – 12 | 7.E – 12 | – | 9.E – 02 | 2.E – 01 | /BS/BS |
| Th-231 ..... | – | 3.E – 06 | 3.E – 06 | – | 1.E + 05 | 1.E + 05 | /St/St |

| Radionuclide | Inhaled air-lung retention class [3] | | | Inhaled air-lung retention class [3] | | | Stochastic or organ [1] |
|---|---|---|---|---|---|---|---|
| | μCi/ml | | | Bq/m³ | | | |
| | D | W | Y | D | W | Y | ( D/ W/ Y) |
| Th-232 | – | 5.E−13 | 1.E−12 | – | 2.E−02 | 4.E−02 | /BS/BS |
| Th-234 | – | 9.E−08 | 6.E−08 | – | 3.E+03 | 2.E+03 | /St/St |
| Pa-227 | – | 5.E−08 | 4.E−08 | – | 2.E+03 | 2.E+03 | /St/St |
| Pa-228 | – | 5.E−09 | 5.E−09 | – | 2.E+02 | 2.E+02 | /BS/St |
| Pa-230 | – | 2.E−09 | 1.E−09 | – | 7.E+01 | 5.E+01 | /St/St |
| Pa-231 | – | 7.E−13 | 2.E−12 | – | 2.E−02 | 6.E−02 | /BS/BS |
| Pa-232 | – | 9.E−09 | 2.E−08 | – | 3.E+02 | 9.E+02 | /BS/BS |
| Pa-233 | – | 3.E−07 | 2.E−07 | – | 1.E+04 | 9.E+03 | /St/St |
| Pa-234 | – | 3.E−06 | 3.E−06 | – | 1.E+05 | 1.E+05 | /St/St |
| U-230 | 2.E−10 | 1.E−10 | 1.E−10 | 6.E+00 | 5.E+00 | 4.E+00 | BS/St/St |
| U-231 | 3.E−06 | 2.E−06 | 2.E−06 | 1.E+05 | 9.E+04 | 7.E+04 | St/St/St |
| U-232 | 9.E−11 | 2.E−10 | 3.E−12 | 3.E+00 | 6.E+00 | 1.E−01 | BS/St/St |
| U-233 | 5.E−10 | 3.E−10 | 2.E−11 | 2.E+01 | 1.E+01 | 6.E−01 | BS/St/St |
| U-234 | 5.E−10 | 3.E−10 | 2.E−11 | 2.E+01 | 1.E+01 | 6.E−01 | BS/St/St |
| U-235 | 6.E−10 | 3.E−10 | 2.E−11 | 2.E+01 | 1.E+01 | 6.E−01 | BS/St/St |
| U-236 | 6.E−10 | 3.E−10 | 2.E−11 | 2.E+01 | 1.E+01 | 6.E−01 | BS/St/St |
| U-237 | 1.E−06 | 7.E−07 | 6.E−07 | 4.E+04 | 3.E+04 | 2.E+04 | St/St/St |
| U-238 | 6.E−10 | 3.E−10 | 2.E−11 | 2.E+01 | 1.E+01 | 6.E−01 | BS/St/St |
| U-239 | 8.E−05 | 7.E−05 | 6.E−05 | 3.E+06 | 3.E+06 | 2.E+06 | St/St/St |
| U-240 | 2.E−06 | 1.E−06 | 1.E−06 | 6.E+04 | 4.E+04 | 4.E+04 | St/St/St |
| Np-232 | – | 1.E−06 | – | – | 4.E+04 | – | /BS/ |
| Np-233 | – | 1.E−03 | – | – | 5.E+07 | – | /St/ |
| Np-234 | – | 1.E−06 | – | – | 4.E+04 | – | /St/ |
| Np-235 | – | 5.E−07 | – | – | 2.E+04 | – | /BS/ |
| Np-236 (1.E+05 yr). | – | 1.E−11 | – | – | 4.E−01 | – | /BS/ |
| Np-236 (22 h) | – | 2.E−08 | – | – | 6.E+02 | – | /BS/ |
| Np-237 | – | 2.E−12 | – | – | 9.E−02 | – | /BS/ |
| Np-238 | – | 4.E−08 | – | – | 1.E+03 | – | /BS/ |
| Np-239 | – | 1.E−06 | – | – | 4.E+04 | – | /St/ |
| Np-240 | – | 3.E−05 | – | – | 1.E+06 | – | /St/ |
| Pu-234 | – | 9.E−08 | 8.E−08 | – | 3.E+03 | 3.E+03 | /St/St |
| Pu-235 | – | 1.E−03 | 1.E−03 | – | 5.E+07 | 4.E+07 | /St/St |
| Pu-236 | – | 7.E−12 | 1.E−11 | – | 3.E−01 | 6.E−01 | /BS/St |
| Pu-237 | – | 1.E−06 | 1.E−06 | – | 5.E+04 | 5.E+04 | /St/St |
| Pu-238 | – | 3.E−12 | 7.E−12 | – | 9.E−02 | 3.E−01 | /BS/BS |
| Pu-239 | – | 2.E−12 | 6.E−12 | – | 8.E−02 | 2.E−01 | /BS/BS |
| Pu-240 | – | 2.E−12 | 6.E−12 | – | 8.E−02 | 2.E−01 | /BS/BS |
| Pu-241 | – | 1.E−10 | 3.E−10 | – | 4.E+00 | 1.E+01 | /BS/BS |
| Pu-242 | – | 2.E−12 | 6.E−12 | – | 9.E−02 | 2.E−01 | /BS/BS |
| Pu-243 | – | 1.E−05 | 1.E−05 | – | 5.E+05 | 6.E+05 | /St/St |
| Pu-244 | – | 2.E−12 | 6.E−12 | – | 9.E−02 | 2.E−01 | /BS/BS |
| Pu-245 | – | 2.E−06 | 2.E−06 | – | 7.E+04 | 6.E+04 | /St/St |
| Am-237 | – | 1.E−04 | – | – | 4.E+06 | – | /St/ |
| Am-238 | – | 1.E−06 | – | – | 4.E+04 | – | /BS/ |
| Am-239 | – | 5.E−06 | – | – | 2.E+05 | – | /St/ |
| Am-240 | – | 1.E−06 | – | – | 4.E+04 | – | /St/ |
| Am-241 | – | 2.E−12 | – | – | 8.E−02 | – | /BS/ |
| Am-242m | – | 2.E−12 | – | – | 8.E−02 | – | /BS/ |
| Am-242 | – | 3.E−08 | – | – | 1.E+03 | – | /BS/ |
| Am-243 | – | 2.E−12 | – | – | 8.E−02 | – | /BS/ |
| Am-244m | – | 2.E−06 | – | – | 6.E+04 | – | /BS/ |
| Am-244 | – | 7.E−08 | – | – | 3.E+03 | – | /BS/ |
| Am-245 | – | 3.E−05 | – | – | 1.E+06 | – | /St/ |
| Am-246m | – | 7.E−05 | – | – | 3.E+06 | – | /St/ |
| Am-246 | – | 4.E−05 | – | – | 2.E+06 | – | /St/ |
| Cm-238 | – | 4.E−07 | – | – | 2.E+04 | – | /St/ |
| Cm-240 | – | 2.E−10 | – | – | 8.E+00 | – | /BS/ |
| Cm-241 | – | 9.E−09 | – | – | 4.E+02 | – | /BS/ |
| Cm-242 | – | 1.E−10 | – | – | 4.E+00 | – | /BS/ |
| Cm-243 | – | 3.E−12 | – | – | 1.E−01 | – | /BS/ |
| Cm-244 | – | 4.E−12 | – | – | 2.E−01 | – | /BS/ |
| Cm-245 | – | 2.E−12 | – | – | 8.E−02 | – | /BS/ |
| Cm-246 | – | 2.E−12 | – | – | 8.E−02 | – | /BS/ |
| Cm-247 | – | 2.E−12 | – | – | 9.E−02 | – | /BS/ |
| Cm-248 | – | 6.E−13 | – | – | 2.E−02 | – | /BS/ |
| Cm-249 | – | 6.E−06 | – | – | 2.E+05 | – | /BS/ |
| Bk-245 | – | 5.E−07 | – | – | 2.E+04 | – | /St/ |
| Bk-246 | – | 1.E−06 | – | – | 5.E+04 | – | /St/ |
| Bk-247 | – | 2.E−12 | – | – | 8.E−02 | – | /BS/ |
| Bk-249 | – | 9.E−10 | – | – | 3.E+01 | – | /BS/ |

| Radionuclide | Inhaled air-lung retention class[3] | | | Inhaled air-lung retention class[3] | | | Stochastic or organ[1] |
|---|---|---|---|---|---|---|---|
| | μCi/ml | | | Bq/m[3] | | | |
| | D | W | Y | D | W | Y | ( D/ W/ Y) |
| Bk-250 | – | 2.E-07 | – | – | 7.E+03 | – | /BS/ |
| Cf-244 | – | 2.E-07 | 2.E-07 | – | 9.E+03 | 9.E+03 | /St/St |
| Cf-246 | – | 4.E-09 | 4.E-09 | – | 2.E+02 | 1.E+02 | /St/St |
| Cf-248 | – | 4.E-11 | 5.E-11 | – | 1.E+00 | 2.E+00 | /BS/St |
| Cf-249 | – | 2.E-12 | 6.E-12 | – | 8.E-02 | 2.E-01 | /BS/BS |
| Cf-250 | – | 5.E-12 | 1.E-11 | – | 2.E-01 | 4.E-01 | /BS/St |
| Cf-251 | – | 2.E-12 | 5.E-12 | – | 8.E-02 | 2.E-01 | /BS/BS |
| Cf-252 | – | 1.E-11 | 2.E-11 | – | 4.E-01 | 6.E-01 | /BS/St |
| Cf-253 | – | 8.E-10 | 7.E-10 | – | 3.E+01 | 3.E+01 | /St/St |
| Cf-254 | – | 9.E-12 | 7.E-12 | – | 3.E-01 | 3.E-01 | /St/St |
| Es-250 | – | 3.E-07 | – | – | 1.E+04 | – | /BS/ |
| Es-251 | – | 4.E-07 | – | – | 2.E+04 | – | /BS/ |
| Es-253 | – | 6.E-10 | – | – | 2.E+01 | – | /St/ |
| Es-254m | – | 4.E-09 | – | – | 2.E+02 | – | /St/ |
| Es-254 | – | 4.E-11 | – | – | 2.E+00 | – | /BS/ |
| Fm-252 | – | 6.E-09 | – | – | 2.E+02 | – | /St/ |
| Fm-253 | – | 4.E-09 | – | – | 2.E+02 | – | /St/ |
| Fm-254 | – | 4.E-08 | – | – | 2.E+03 | – | /St/ |
| Fm-255 | – | 9.E-09 | – | – | 3.E+02 | – | /St/ |
| Fm-257 | – | 1.E-10 | – | – | 4.E+00 | – | /E / |
| Md-257 | – | 4.E-08 | – | – | 2.E+03 | – | /St/ |
| Md-258 | – | 1.E-10 | – | – | 4.E+00 | – | /BS/ |

Footnotes for Appendix A

[1] A determination of whether the DACs are controlled by stochastic (St) or nonstochastic (organ) dose, or if they both give the same result (E), for each lung retention class, is given in this column. The key to the organ notation for nonstochastic dose is: BS= Bone surface, K= Kidney, L= Liver, SW= Stomach wall, and T= Thyroid. A blank indicates that no calculations were performed for the lung retention class shown.

[2] The ICRP identifies tritiated water and carbon as having immediate uptake and distribution; therefore no solubility classes are designated. For the purposes of this table, the DAC values are shown as being constant, independent of solubility class. For tritiated water, the inhalation DAC values allow for an additional 50% absorption through the skin, as described in ICRP Publication No. 30: Limits for Intakes of Radionuclides by Workers. For elemental tritium, the DAC values are based solely on consideration of the dose-equivalent rate to the tissues of the lung from inhaled tritium gas contained within the lung, without absorption in the tissues.

[3] A dash indicates no values given for this data category.

[4] These values are appropriate for protection from radon combined with its short-lived daughters and are based on information given in ICRP Publication 32: Limits for Inhalation of Radon Daughters by Workers and Federal Guidance Report No. 11: Limiting Values of Radionuclide Intake and Air Concentrations, and Dose Conversion Factors for Inhalation, Submersion, and Ingestion (EPA 520/1-88-020). The values given are for 100% equilibrium concentration conditions of the radon daughters with the parent. To allow for an actual measured equilibrium concentration or a demonstrated equilibrium concentration, the values given in this table should be multiplied by the ratio (100%/actual %) or (100%/demonstrated %), respectively. Alternatively, the DAC values for Rn-220 and Rn-222 may be replaced by 1 WL* and 1/3 WL*, respectively, for appropriate limiting of daughter concentrations. Because of the dosimetric considerations for radon, no $f_1$ or lung clearance values are listed.

*A "Working Level" (WL) is any combination of short-lived radon daughters, in one liter of air without regard to the degree of equilibrium, that will result in the ultimate emission of 1.3 E+05 MeV of alpha energy.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59687, Nov. 4, 1998]

## APPENDIX B TO PART 835 [RESERVED]

## APPENDIX C TO PART 835—DERIVED AIR CONCENTRATIONS (DAC) FOR WORKERS FROM EXTERNAL EXPOSURE DURING IMMERSION IN A CONTAMINATED ATMOSPHERIC CLOUD

a. The data presented in appendix C are to be used for controlling occupational exposures in accordance with §835.209, identifying the need for air monitoring in accordance with §835.403, and identifying the need for posting of airborne radioactivity areas in accordance with §835.603(d).

b. The air immersion DAC values shown in this appendix are based on a stochastic dose limit of 5 rems (0.05 Sv) per year or a nonstochastic (organ) dose limit of 50 rems (0.5 Sv) per year. Four columns of information are presented: (1) Radionuclide; (2) half-life in units of seconds (s), minutes (min), hours (h), days (d), or years (yr); (3) air immersion DAC in units of μCi/ml; and (4) air immersion DAC in units of Bq/m³. The data are listed by radionuclide in order of increasing atomic mass. The air immersion DACs were calculated for a continuous, nonshielded exposure via immersion in a semi-infinite atmospheric cloud. The DACs listed in this appendix may be modified to allow for submersion in a cloud of finite dimensions.

c. The DAC value for air immersion listed for a given radionuclide is determined either by a yearly limit on effective dose equivalent, which provides a limit on stochastic radiation effects, or by a limit on yearly dose equivalent to any organ, which provides a limit on nonstochastic radiation effects. For most of the radionuclides listed, the DAC value is determined by the yearly limit on

effective dose equivalent. Thus, the few cases where the DAC value is determined by the yearly limit on shallow dose equivalent to the skin are indicated in the table by an appropriate footnote. Again, the DACs listed in this appendix account only for immersion in a semi-infinite cloud and do not account for inhalation or ingestion exposures.

d. Three classes of radionuclides are included in the air immersion DACs as described below.

(1) *Class 1.* The first class of radionuclides includes selected noble gases and short-lived activation products that occur in gaseous form. For these radionuclides, inhalation doses are negligible compared to the external dose from immersion in an atmospheric cloud.

(2) *Class 2.* The second class of radionuclides includes those for which a DAC value for inhalation has been calculated, but for which the DAC value for external exposure to a contaminated atmospheric cloud is more restrictive (i.e., results in a lower DAC value). These radionuclides generally have half-lives of a few hours or less, or are eliminated from the body following inhalation sufficiently rapidly to limit the inhalation dose.

(3) *Class 3.* The third class of radionuclides includes selected isotopes with relatively short half-lives. These radionuclides typically have half-lives that are less than 10 minutes, they do not occur as a decay product of a longer lived radionuclide, or they lack sufficient decay data to permit internal dose calculations. These radionuclides are also typified by a radioactive emission of highly intense, high-energy photons and rapid removal from the body following inhalation.

e. The DAC values are given for individual radionuclides. For known mixtures of radionuclides, determine the sum of the ratio of the observed concentration of a particular radionuclide and its corresponding DAC for all radionuclides in the mixture. If this sum exceeds unity (1), then the DAC has been exceeded. For unknown radionuclides, the most restrictive DAC (lowest value) for those isotopes not known to be absent shall be used.

| Radionuclide | Half-Life | Air Immersion DAC | |
|---|---|---|---|
| | | (μCi/ml) | (Bq/m³) |
| C-11 | 20.48 min | 4.E-06 | 1.E+05 |
| N-13 | 9.97 min | 4.E-06 | 1.E+05 |
| N-16 | 7.13 s | 7.E-07 | 3.E+04 |
| O-15 | 122.24 s | 4.E-06 | 1.E+05 |
| F-18[1] | 109.74 min | 4.E-06 | 1.E+05 |
| Na-24[1] | 15.00 h | 9.E-07 | 3.E+04 |
| Mg-27[2] | 9.458 min | 5.E-06 | 2.E+05 |
| Al-28[2] | 2.240 min | 2.E-06 | 7.E+04 |
| Cl-38[1] | 37.21 min | 3.E-06 | 1.E+05 |
| Ar-37 | 35.02 d | 3.E+00 | 1.E+11 |
| Ar-39 | 269 yr | 2.E-04[3] | 7.E+06[3] |
| Ar-41 | 1.827 h | 3.E-06 | 1.E+05 |
| K-43[1] | 22.6 h | 5.E-06 | 2.E+05 |
| Ca-492 | 8.719 min | 1.E-06 | 4.E+04 |
| Sc-44[1] | 3.927 h | 2.E-06 | 7.E+04 |
| Sc-46m[2] | 18.72 s | 5.E-05 | 2.E+06 |
| Ti-45[1] | 3.08 h | 5.E-06 | 2.E+05 |
| Ti-51[2] | 5.752 min | 1.E-05 | 4.E+05 |
| V-52[2] | 3.75 min | 3.E-06 | 1.E+05 |
| Cr-49[1] | 42.09 min | 5.E-06 | 2.E+05 |
| Mn-52m[1] | 21.4 min | 2.E-06 | 7.E+04 |
| Mn-56[1] | 2.5785 h | 2.E-06 | 7.E+04 |
| Mn-57[2] | 1.47 min | 6.E-05 | 2.E+06 |
| Co-60m[1] | 10.47 min | 1.E-03 | 4.E+07 |
| Ni-57[1,4] | 36.08 h | 2.E-06 | 7.E+04 |
| Ni-65[1,5] | 2.520 h | 8.E-06 | 3.E+05 |
| Cu-61[1] | 3.408 h | 5.E-06 | 2.E+05 |
| Cu-62[2] | 9.74 min | 5.E-06 | 2.E+05 |
| Ga-66[1] | 9.40 h | 2.E-06 | 7.E+04 |
| Ga-68[1] | 68.0 min | 5.E-06 | 2.E+05 |
| Ga-72[1] | 14.1 h | 1.E-06 | 4.E+04 |
| Se-73[1] | 7.15 h | 4.E-06 | 1.E+05 |
| Br-77[1] | 57.04 h | 1.E-05[6] | 4.E+05[6] |
| Br-80[1] | 17.4 min | 5.E-05 | 2.E+06 |
| Br-82[1] | 35.30 h | 1.E-06 | 4.E+04 |
| Br-84[1] | 31.80 min | 2.E-06 | 7.E+04 |
| Br-85[2] | 172 s | 5.E-05 | 2.E+06 |
| Kr-79 | 35.04 h | 2.E-05 | 7.E+05 |
| Kr-81 | 2.1E+05 yr | 5.E-04 | 2.E+07 |
| Kr-83m | 1.83 h | 5.E-02 | 2.E+09 |
| Kr-85 | 10.72 yr | 1.E-04[3] | 4.E+06[3] |
| Kr-85m | 4.48 h | 3.E-05 | 1.E+06 |

| Radionuclide | Half-Life | Air Immersion DAC | |
|---|---|---|---|
| | | (μCi/ml) | (Bq/m³) |
| Kr–87 | 76.3 min | 5.E–06 | 2.E+05 |
| Kr–88 | 2.84 h | 2.E–06 | 7.E+04 |
| Kr–89 | 3.16 min | 2.E–06 | 7.E+04 |
| Kr–90 | 32.32 s | 3.E–06 | 1.E+05 |
| Rb–81[1] | 4.58 h | 8.E–06 | 3.E+05 |
| Rb–82[2] | 1.25 min | 2.E–06 | 7.E+04 |
| Rb–88[1] | 17.8 min | 7.E–06 | 3.E+05 |
| Rb–89[1] | 15.44 min | 2.E–06 | 7.E+04 |
| Rb–90[2] | 157 s | 2.E–06 | 7.E+04 |
| Rb–90m[2] | 258 s | 1.E–06 | 4.E+04 |
| Sr–85m[1] | 67.66 min | 2.E–05 | 7.E+04 |
| Sr–87m[1] | 2.805 h | 6.E–05 | 2.E+06 |
| Sr–92[1] | 2.71 h | 3.E–06 | 1.E+05 |
| Sr–93[2] | 7.3 min | 2.E–06 | 7.E+04 |
| Y–86[1] | 14.74 h | 1.E–06 | 4.E+04 |
| Y–90m[1] | 3.19 h | 5.E–06[6] | 2.E+05[6] |
| Y–91m[1] | 49.71 min | 9.E–06 | 3.E+05 |
| Nb–90[1] | 14.60 h | 1.E–07 | 4.E+03 |
| Nb–94m[2] | 6.26 min | 9.E–04 | 3.E+07 |
| Nb–97[1] | 72.1 min | 7.E–06 | 3.E+05 |
| Nb–97m[1] | 60 s | 6.E–06 | 2.E+05 |
| Mo–91[2] | 15.9 min | 4.E–06 | 1.E+05 |
| Mo–101[1] | 14.61 min | 3.E–06 | 1.E+05 |
| Tc–95[1] | 20.0 h | 5.E–06 | 2.E+05 |
| Tc–96m[1] | 51.5 min | 1.E–04 | 4.E+06 |
| Tc–99m[1] | 6.02 h | 3.E–05 | 1.E+06 |
| Tc–101[1] | 14.2 min | 1.E–05 | 4.E+05 |
| Ru–105[1] | 4.44 h | 5.E–06 | 2.E+05 |
| Rh–105m[2] | 45 s | 1.E–04 | 4.E+06 |
| Rh–106[2] | 29.92 s | 2.E–05 | 7.E+05 |
| Ag–108[2] | 2.37 min | 2.E–04 | 7.E+06 |
| Ag–109m[2] | 39.6 s | 1.E–03 | 4.E+07 |
| Ag–110[2] | 24.57 s | 9.E–05 | 3.E+06 |
| Cd–111m[2] | 48.7 min | 1.E–05 | 4.E+05 |
| Cd–117[1] | 2.49 h | 4.E–06 | 1.E+05 |
| Cd–117m[1] | 3.36 h | 2.E–06 | 7.E+04 |
| In–113m[1] | 1.658 h | 2.E–05 | 7.E+05 |
| In–114[2] | 71.9 s | 1.E–04 | 4.E+06 |
| In–116m[1] | 54.15 min | 2.E–06 | 7.E+04 |
| In–117[1] | 43.8 min | 7.E–06 | 3.E+05 |
| Sb–117[1] | 2.80 h | 3.E–05 | 1.E+06 |
| Sb–126m[1] | 19.0 min | 3.E–06 | 1.E+05 |
| Sb–129[1] | 4.40 h | 3.E–06 | 1.E+05 |
| Te–133[1] | 12.45 min | 5.E–06 | 2.E+05 |
| Te–133m[1] | 55.4 min | 2.E–06 | 7.E+04 |
| Te–134[1] | 41.8 min | 5.E–06 | 2.E+05 |
| I–122[2] | 3.62 min | 5.E–06 | 2.E+05 |
| I–128[1] | 24.99 min | 5.E–05 | 2.E+06 |
| I–132[1] | 2.30 h | 2.E–06 | 7.E+04 |
| I–134[1] | 52.6 min | 1.E–06 | 4.E+04 |
| I–135[1] | 6.61 h | 7.E–07[6] | 3.E+04[6] |
| I–136[2] | 83 s | 1.E–06 | 4.E+04 |
| Xe–122 | 20.1 h | 8.E–05 | 3.E+06 |
| Xe–123 | 2.14 h | 7.E–06 | 3.E+05 |
| Xe–125 | 16.8 h | 2.E–05 | 7.E+05 |
| Xe–127 | 36.406 d | 1.E–05 | 4.E+05 |
| Xe–129m | 8.89 d | 2.E–04 | 7.E+06 |
| Xe–131m | 11.84 d | 5.E–04 | 2.E+07 |
| Xe–133 | 5.245 d | 1.E–04 | 4.E+06 |
| Xe–133m | 2.19 d | 1.E–04 | 4.E+06 |
| Xe–135 | 9.11 h | 2.E–05 | 7.E+05 |
| Xe–135m | 15.36 min | 1.E–05 | 4.E+05 |
| Xe–137 | 3.83 min | 2.E–05 | 7.E+05 |
| Xe–138 | 14.13 min | 4.E–06 | 1.E+05 |
| Cs–126[2] | 1.64 min | 4.E–06 | 1.E+05 |
| Cs–129[1] | 32.06 h | 1.E–05[6] | 4.E+05[6] |
| Cs–138[1] | 32.2 min | 2.E–06 | 7.E+04 |
| Cs–139[2] | 9.40 min | 1.E–05 | 4.E+05 |
| Ba–137m[2] | 2.552 min | 7.E–06 | 3.E+05 |
| Ba–141[1] | 18.27 min | 5.E–06 | 2.E+05 |
| Ba–142[1] | 10.70 min | 5.E–06 | 2.E+05 |
| La–142[1] | 95.4 min | 1.E–06 | 4.E+04 |

| Radionuclide | Half-Life | Air Immersion DAC | |
|---|---|---|---|
| | | (μCi/ml) | (Bq/m³) |
| Pr-144m[2] | 7.2 min | 9.E-04 | 3.E+07 |
| Nd-149[1] | 1.73 h | 1.E-05 | 4.E+05 |
| Gd-162[2] | 9.7 min | 1.E-05 | 4.E+05 |
| Td-162[2] | 7.76 min | 4.E-06 | 1.E+05 |
| Dy-157[1] | 8.06 h | 1.E-05 | 4.E+05 |
| Re-182m[1] | 12.7 h | 4.E-06 | 1.E+05 |
| Os-190m[2] | 9.9 min | 3.E-06 | 1.E+05 |
| Ir-190m[1] | 3.2 h | 8.E-05[6] | 3.E+06[6] |
| Au-195m[2] | 30.6 s | 2.E-05 | 7.E+05 |
| Tl-200[1] | 26.1 h | 3.E-06 | 1.E+05 |
| Tl-207[2] | 4.77 min | 4.E-05[3] | 1.E+06[3] |
| Tl-208[2] | 3.053 min | 1.E-06 | 4.E+04 |
| Tl-209[2] | 2.20 min | 2.E-06 | 7.E+04 |
| Tl-210[2] | 1.30 min | 1.E-06 | 4.E+04 |
| Pb-204m[2] | 66.9 min | 2.E-06 | 7.E+04 |
| Bi-211[2] | 2.13 min | 1.E-04 | 4.E+06 |
| Po-211[2] | 0.516 s | 5.E-04 | 2.E+07 |
| Th-233[2] | 22.3 min | 1.E-04 | 4.E+06 |
| Pa-234[1] | 6.70 h | 2.E-06 | 7.E+04 |
| Pa-234m[2] | 1.17 min | 4.E-05[3] | 1.E+06[3] |
| U-239[1] | 23.40 min | 8.E-05[6] | 3.E+06[6] |
| Np-240[1] | 65 min | 4.E-06 | 1.E+05 |
| Np-240m[2] | 7.4 min | 1.E-05 | 4.E+05 |
| Am-246[1] | 25.0 min | 4.E-06 | 1.E+05 |

[1] Committed effective dose equivalent from inhalation is calculated in ICRP Publication 30, but the DAC value for external exposure to a contaminated atmospheric cloud is more restrictive than the DAC value for inhalation.

[2] Committed effective dose equivalent from inhalation is not calculated in ICRP Publication 30, but DAC value for external exposure to contaminated cloud should be more restrictive than DAC value for inhalation due to relatively short half-life of radionuclide.

[3] DAC value is determined by limit on annual shallow dose equivalent to skin, rather than yearly limit on effective dose equivalent.

[4] DAC value applies to radionuclide in vapor form only; DAC value for inhalation is more restrictive for radionuclide in inorganic form.

[5] DAC value applies to radionuclide in inorganic or vapor form.

[6] DAC value for exposure to contaminated atmospheric cloud is the same as DAC value for inhalation.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59687, Nov. 4, 1998]

## APPENDIX D TO PART 835—SURFACE CONTAMINATION VALUES

The data presented in appendix D are to be used in identifying the need for posting of contamination and high contamination areas in accordance with §835.603(e) and (f) and identifying the need for surface contamination monitoring and control in accordance with §§835.1101 and 835.1102.

SURFACE CONTAMINATION VALUES[1] IN DPM/100 CM[2]

| Radionuclide | Removable[2,4] | Total (Fixed + Removable)[2,3] |
|---|---|---|
| U-nat, U-235, U-238, and associated decay products | [7] 1,000 | [7] 5,000 |
| Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 | 20 | 500 |
| Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 | 200 | 1,000 |
| Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above[5] | 1,000 | 5,000 |
| Tritium and tritiated compounds[6] | 10,000 | N/A |

[1] The values in this appendix, with the exception noted in footnote 5, apply to radioactive contamination deposited on, but not incorporated into the interior or matrix of, the contaminated item. Where surface contamination by both alpha-and beta-gamma-emitting nuclides exists, the limits established for alpha-and beta-gamma-emitting nuclides apply independently.

[2] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[3] The levels may be averaged over one square meter provided the maximum surface activity in any area of 100 cm² is less than three times the value specified. For purposes of averaging, any square meter of surface shall be considered to be above the surface contamination value if: (1) From measurements of a representative number of sections it is determined that the average contamination level exceeds the applicable value; or (2) it is determined that the sum of the activity of all isolated spots or particles in any 100 cm² area exceeds three times the applicable value.

[4] The amount of removable radioactive material per 100 $cm^2$ of surface area should be determined by swiping the area with dry filter or soft absorbent paper, applying moderate pressure, and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. (Note—The use of dry material may not be appropriate for tritium.) When removable contamination on objects of surface area less than 100 $cm^2$ is determined, the activity per unit area shall be based on the actual area and the entire surface shall be wiped. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

[5] This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.

[6] Tritium contamination may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may migrate to the surface in order to ensure the surface contamination value provided in this appendix is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a "Total" value does not apply.

[7] (alpha)

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59688, Nov. 4, 1998]

## APPENDIX E TO PART 835—VALUES FOR ESTABLISHING SEALED RADIOACTIVE SOURCE ACCOUNTABILITY AND RADIOACTIVE MATERIAL POSTING AND LABELING REQUIREMENTS

The data presented in this appendix E are to be used for identifying accountable sealed radioactive sources as defined at §835.2(a), establishing the need for radioactive material area posting in accordance with §835.603(g), and establishing the need for radioactive material labeling in accordance with §835.605.

NOTE: The data are listed in alphabetical order by nuclide.

| Nuclide | Activity (μCi) | Nuclide | Activity (μCi) | Nuclide | Activity (μCi) |
|---|---|---|---|---|---|
| Ac-227 | 1.5E+00 | H-3 | 1.6E+08 | Re-184m | 1.5E+02 |
| Ag-105 | 2.1E+06 | Hf-172 | 3.1E+04 | Re-186m | 2.8E+05 |
| Ag-108m | 1.8E+01 | Hf-175 | 1.8E+06 | Rh-101 | 2.5E+05 |
| Ag-110m | 2.2E+01 | Hf-178m | 4.1E+03 | Rh-102 | 8.3E+04 |
| Al-26 | 1.6E+01 | Hf-181 | 3.5E+02 | Rh-102m | 2.1E+05 |
| Am-241 | 2.3E+01 | Hf-182 | 3.0E+03 | Ru-103 | 4.4E+02 |
| Am-242m | 2.4E+01 | Hg-194 | 3.5E+04 | Ru-106 | 2.1E+04 |
| Am-243 | 2.3E+01 | Hg-203 | 4.9E+02 | S-35 | 4.0E+06 |
| As-73 | 5.4E+02 | Ho-166m | 2.2E+01 | Sb-124 | 9.1E+01 |
| Au-195 | 4.8E+02 | I-125 | 3.5E+02 | Sb-125 | 6.8E+01 |
| Ba-133 | 5.2E+01 | I-129 | 1.8E+02 | Sc-46 | 6.2E+01 |
| Be-10 | 2.8E+04 | In-114m | 7.8E+02 | Se-75 | 6.4E+01 |
| Be-7 | 3.2E+03 | Ir-192 | 1.4E+02 | Se-79 | 1.0E+06 |
| Bi-207 | 1.7E+01 | Ir-192m | 2.6E+04 | Si-32 | 9.9E+03 |
| Bi-208 | 1.5E+01 | Ir-194m | 2.7E+01 | Sm-145 | 9.1E+05 |
| Bi-210m | 1.3E+03 | K-40 | 2.8E+02 | Sm-146 | 1.2E+02 |
| Bk-247 | 1.7E+01 | La-137 | 1.1E+05 | Sm-151 | 2.5E+05 |
| Bk-249 | 7.2E+03 | Lu-173 | 4.4E+05 | Sn-113 | 3.1E+02 |
| C-14 | 4.8E+06 | Lu-174 | 2.5E+05 | Sn-119m | 3.3E+02 |
| Ca-41 | 7.4E+06 | Lu-174m | 3.9E+05 | Sn-121m | 8.7E+05 |
| Ca-45 | 1.5E+06 | Lu-177m | 5.8E+01 | Sn-123 | 1.3E+04 |
| Cd-109 | 1.6E+02 | Md-258 | 6.0E+02 | Sn-126 | 1.8E+02 |
| Cd-113m | 6.5E+03 | Mn-53 | 2.0E+07 | Sr-85 | 1.2E+02 |
| Cd-115m | 1.0E+04 | Mn-54 | 6.5E+01 | Sr-89 | 2.4E+05 |
| Ce-139 | 2.4E+02 | Mo-93 | 7.7E+01 | Sr-90 | 7.7E+03 |
| Ce-141 | 2.4E+03 | Na-22 | 1.9E+01 | Ta-179 | 1.5E+06 |
| Ce-144 | 1.5E+03 | Nb-91 | 7.0E+01 | Ta-182 | 7.3E+01 |
| Cf-248 | 2.0E+02 | Nb-91m | 3.6E+02 | Tb-157 | 2.5E+03 |
| Cf-249 | 1.7E+01 | Nb-92 | 1.8E+01 | Tb-158 | 3.9E+04 |
| Cf-250 | 3.8E+01 | Nb-93m | 4.4E+02 | Tb-160 | 1.2E+02 |
| Cf-251 | 1.7E+01 | Nb-94 | 2.3E+01 | Tc-95m | 1.3E+02 |
| Cf-252 | 6.4E+01 | Nb-95 | 3.4E+02 | Tc-97 | 8.1E+01 |
| Cf-254 | 3.4E+01 | Ni-59 | 7.5E+06 | Tc-97m | 3.6E+02 |
| Cl-36 | 4.6E+05 | Ni-63 | 3.2E+06 | Tc-98 | 2.5E+01 |
| Cm-241 | 6.8E+04 | Np-235 | 1.2E+02 | Tc-99 | 6.8E+06 |
| Cm-242 | 5.8E+02 | Np-236 | 2.2E+01 | Te-121m | 1.9E+02 |
| Cm-243 | 3.3E+01 | Np-237 | 1.9E+01 | Te-123m | 2.8E+02 |
| Cm-244 | 4.0E+01 | Os-185 | 1.4E+02 | Te-125m | 4.4E+02 |
| Cm-245 | 2.2E+01 | Os-194 | 1.5E+04 | Te-127m | 8.0E+02 |
| Cm-246 | 2.2E+01 | Pa-231 | 7.8E+00 | Te-129m | 2.3E+03 |
| Cm-247 | 2.4E+01 | Pb-202 | 1.0E+05 | Th-228 | 2.9E+01 |
| Cm-248 | 6.0E+00 | Pb-205 | 9.1E+01 | Th-229 | 4.7E+00 |
| Cm-250 | 1.1E+00 | Pb-210 | 9.2E+01 | Th-230 | 3.1E+01 |
| Co-56 | 4.0E+01 | Pd-107 | 7.8E+05 | Th-232 | 6.1E+00 |
| Co-57 | 2.3E+02 | Pm-143 | 1.3E+02 | Ti-44 | 1.6E+02 |
| Co-58 | 1.4E+02 | Pm-144 | 2.9E+01 | Tl-204 | 2.2E+04 |
| Co-60 | 1.8E+01 | Pm-145 | 2.6E+02 | Tm-170 | 8.4E+03 |

| Nuclide | Activity (μCi) | Nuclide | Activity (μCi) | Nuclide | Activity (μCi) |
|---|---|---|---|---|---|
| Cs-134 | 2.7E+01 | Pm-146 | 4.5E+01 | Tm-171 | 2.8E+04 |
| Cs-135 | 2.2E+06 | Pm-147 | 2.5E+05 | U-232 | 1.5E+01 |
| Cs-137 | 6.0E+01 | Pm-148m | 1.1E+02 | U-233 | 7.4E+01 |
| Dy-159 | 4.1E+06 | Po-209 | 6.3E+03 | U-234 | 7.5E+01 |
| Es-254 | 6.3E+01 | Po-210 | 1.1E+03 | U-235 | 6.7E+01 |
| Es-255 | 4.6E+04 | Pt-193 | 4.4E+07 | U-236 | 8.0E+01 |
| Eu-148 | 7.0E+05 | Pu-236 | 6.9E+01 | U-238 | 8.4E+01 |
| Eu-149 | 5.3E+06 | Pu-237 | 3.3E+02 | V-49 | 2.9E+07 |
| Eu-152 | 3.1E+01 | Pu-238 | 2.5E+01 | W-181 | 1.1E+03 |
| Eu-154 | 3.1E+01 | Pu-239 | 2.3E+01 | W-185 | 3.9E+06 |
| Eu-155 | 3.7E+02 | Pu-240 | 2.3E+01 | W-188 | 6.4E+04 |
| Fe-55 | 3.7E+06 | Pu-241 | 1.2E+03 | Y-88 | 3.4E+01 |
| Fe-59 | 2.0E+02 | Pu-242 | 2.4E+01 | Y-91 | 5.0E+04 |
| Fe-60 | 1.3E+04 | Pu-244 | 2.5E+01 | Yb-169 | 5.5E+02 |
| Fm-257 | 4.3E+02 | Ra-226 | 1.2E+03 | Zn-65 | 1.1E+02 |
| Gd-146 | 2.6E+05 | Ra-228 | 2.1E+03 | Zr-88 | 1.2E+02 |
| Gd-148 | 3.0E+01 | Rb-83 | 9.2E+01 | Zr-93 | 3.1E+04 |
| Gd-151 | 1.1E+06 | Rb-84 | 2.0E+02 | Zr-95 | 2.0E+02 |
| Gd-153 | 2.1E+02 | Re-183 | 5.4E+02 | | |
| Ge-68 | 5.7E+02 | Re-184 | 2.6E+02 | | |

Any alpha emitting radionuclide not listed above and mixtures of alpha emitters of unknown composition have a value of 10 microcuries.

Any radionuclide other than alpha emitting radionuclides not listed above and mixtures of beta emitters of unknown composition have a value of 100 microcuries.

NOTE: Where there is involved a combination of radionuclides in known amounts, derive the value for the combination as follows: determine, for each radionuclide in the combination, the ratio between the quantity present in the combination and the value otherwise established for the specific radionuclide when not in combination. If the sum of such ratios for all radionuclides in the combination exceeds unity (1), then the accountability criterion has been exceeded.

[63 FR 59688, Nov. 4, 1998]

# PART 840—EXTRAORDINARY NUCLEAR OCCURRENCES

Sec.

840.1 Scope and purpose.
840.2 Procedures.
840.3 Determination of extraordinary nuclear occurrence.
840.4 Criterion I—Substantial discharge of radioactive material or substantial radiation levels offsite.
840.5 Criterion II—Substantial damages to persons offsite or property offsite.

AUTHORITY: Sec. 161 of the Atomic Energy Act of 1954, Pub. L. 83-703, 68 Stat. 919 (42 U.S.C. 2201); sec. 170 of the Atomic Energy Act of 1954, Pub. L. 85-256, 71 Stat. 576, as amended by Pub. L. 89-645, 80 Stat. 891 (42 U.S.C. 2210); Department of Energy Organization Act, Pub. L. 95-91, 91 Stat. 565-613 (42 U.S.C. 7101-7352).

SOURCE: 49 FR 21473, May 21, 1984, unless otherwise noted.

## § 840.1 Scope and purpose.

(a) *Scope.* This subpart applies to those DOE contractor activities to which the nuclear hazards indemnity provisions in 41 CFR 9-50.704-6 apply, and to other persons indemnified with respect to such activities.

(b) *Purpose.* One purpose of this subpart is to set forth the criteria which the DOE proposes to follow in order to determine whether there has been an "extraordinary nuclear occurrence." The other purpose is to establish the conditions of the waivers of defenses proposed for incorporation in indemnity agreements.

(1) The system is to come into effect only where the discharge or dispersal constitutes a substantial amount of source, special nuclear or byproduct material, or has caused substantial radiation levels offsite. The various limits in present DOE regulations are not appropriate for direct application in

# U.S. Department of Energy

Oakland Operations Office, Oakland, California

# FINAL RADIOLOGICAL PROCEDURES TO SUPPORT THE RADIOLOGICAL PROTECTION PROGRAM

For the:

LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH (LEHR)
UNIVERSITY OF CALIFORNIA AT DAVIS, CALIFORNIA

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DOE Oakland Operations Contract DE-AC03-96SF20686

Weiss Associates
Environmental Science, Engineering and Management

# RADIOLOGICAL PROTECTION PROGRAM SUPPORTING PROCEDURE TITLES

| Procedure [1)] ID | Procedure Title |
|---|---|
| SOP 24.1 | Radiological Areas and Posting |
| SOP 25.1 | Radiological Surveys and Instrumentation |
| SOP 25.2 | Radiological Survey Forms |
| SOP 32.1 | Contamination Control |
| SOP 37.1 | Tenelec Series 5 Low Background Counting System |
| SOP 37.2 | Liquid Scintillation Analyzer |
| SOP 38.1 | Check-In and Orientation for Radiological Workers, General Employees, and Members of the Public |
| SOP 38.2 | External Dosimetry Issuance |
| SOP 38.3 | Radiation Protection Records |
| SOP 38.4 | Radiological Protection Program Audits |
| SOP 38.5 | Occupational Exposure Reports |
| SOP 39.1 | LEHR Site Inspection |
| HSP 14.1 | Airborne Radioactivity Monitoring |
| HSP 15.1 | External Radiation Exposure Control |
| HSP 16.1 | Internal Dosimetry Procedure |
| HSP 17.1 | Hazardous Work Permits |
| HSP 18.1 | Personnel Contamination |
| HSP 19.1 | Embryo-Fetus Protection Program |
| HSP 20.1 | Employee and Subcontractor Training Requirements |

1) Standard Operating Procedures (SOPs) and Health and Safety Procedures (HSPs) may be revised or added in accordance with the provisions of the Quality Assurance Project Plan (QAPP) and Project Health and Safety Plan (PHSP) on the basis that the procedure maintains compliance with 10 CFR 835 and maintains equivalent effectiveness of the Radiological Protection Program (RPP). Updates to procedures will be maintained in "controlled" documents. Please refer to the latest revision or update of any consulted procedure. A list of current controlled SOPs and HSPs is contained within the SOP and HSP controlled procedures binder. However, SOPs and HSPs that are pivotal to the implementation of the RPP are contained within this binder and are presented in this section. In the event of a conflict among procedures, plans, or manuals, the least restrictive procedure, plan or manual maintaining compliance with 10 CFR 835 will apply. Content of procedures, plans, or manuals not specifically required for compliance with 10 CFR 835 nor contractually stipulated by DOE shall not be used as a basis for non-compliance.

# RADIOLOGICAL AREAS AND POSTING

STANDARD OPERATING PROCEDURE

## 1.0 PURPOSE

This procedure describes radiological areas and the posting and labeling requirements for environmental restoration and waste management activities at LEHR.

## 2.0 REFERENCES

### *2.1 10 CFR 835, "Radiation Protection for Occupational Workers"*

## 3.0 DEFINITIONS

### *3.1 Airborne Radioactivity Area*

Any area accessible to individuals, where:

(1) The concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed the derived air concentration (DAC) values listed in Appendix A or Appendix C of 10 CFR 835; or,

(2) An individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-hours in a week.

### *3.2 Contamination Area*

Any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in Appendix D of this part, but do not exceed 100 times those values.

### *3.3 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 10 CFR 835.

### *3.4 Fixed Contamination Area*

Any area that contains radioactive material that cannot be readily removed from surfaces by nondestructive means, such as casual contact, wiping, brushing, or laundering, in excess of levels in Appendix D of 10 CFR 835.

### *3.5 Controlled Area*

Any area to which access is managed by or for DOE to protect individuals from exposure to radiation and/or radioactive material.

### *3.6 Radiological Buffer Area*

An area established inside of the Controlled Area boundary surrounding Contamination Areas, Airborne Radioactivity Areas, and High Radiation Areas, to provide a secondary boundary to minimize the spread of contamination.

### *3.7 Derived Air Concentration (DAC)*

The values obtained by dividing the Annual Limit on Intake by the volume of air breathed by an average worker during a working year of 2000 hours (i.e., 2.4E3 $m^3$). These values are shown in Appendix A, 10 CFR 835 (Reference 2.1).

### *3.8 Very High Radiation Area*

Any area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in one hour at 1 meter from a radiation source or from any surface that the radiation penetrates.

### *3.9 High Radiation Area*

Any area where an individual can receive a dose equivalent of greater than 100 mrem in one hour at a distance of 30 cm from the radiation source or from any surface through which the radiation penetrates.

### *3.10 Radiation Area*

Any area where an individual can receive a dose equivalent greater than 5 mrem in one hour at a distance of 30 cm from the radiation source or from any surface through which the radiation penetrates.

### *3.11 Radioactive Material Area*

Any area to within a controlled area, accessible to individuals, in which items or containers of radioactive material exist and the total activity of radioactive material exceeds the applicable values provided in Appendix E of 10CFR835.

### *3.12 Underground Radioactive Material Areas*

Any underground items that contain radioactive materials (i.e., pipelines, radioactive cribs, covered ponds, covered ditches, catch tanks inactive burial grounds, and sites of known covered, unplanned releases (spills) etc.).

### *3.13 Radiological Areas*

Areas controlled for radiation protection purposes that are contained within a controlled area, specifically Airborne Radioactivity Areas, Radioactive Material Areas, Radiation Areas, High Radiation Areas, Very High Radiation Areas, Contamination Areas, or Very High Contamination Areas.

## 4.0 RESPONSIBILITIES

### *4.1 Project Manager (PM)*

The PM is responsible for the safe and effective implementation of this procedure.

### *4.2 Radiation Safety Officer (RSO)*

The RSO is responsible for ensuring that all Radiological Control Technicians and project personnel are trained on this procedure and understand its requirements. The RSO is responsible for implementing this procedure, direct supervision of the Radiation Control Technicians (RCTs), and auditing the work areas for compliance with this procedure.

### *4.3 Radiological Control Technicians (RCTs)*

The RCTs are responsible for assessing radiological areas and placing and removing postings.

# 5.0 SAFETY PRECAUTIONS/PREREQUISITES

- RCTs posting areas shall have approved signs, tags, and boundary tape available on-site.
- Written authorizations shall be required to control entry into and perform work within radiological areas. Therefore, Hazardous Work Permits (HWP's) shall be utilized when performing any work in radiological areas.

# 6.0 PROCEDURE

## *6.1 Posted Areas*

The following areas and each access point to a radiological area shall be posted with conspicuous signs bearing the wording and entry requirements in Section 6.2 and if not otherwise exempted in 10 CFR 835:

- Controlled Areas
- Radiological Buffer Areas
- Radiation Areas
- High Radiation Areas
- Very High Radiation Areas
- Airborne Radioactivity Areas
- Contamination Areas
- High Contamination Areas
- Fixed Contamination Areas
- Radioactive Material Areas
- Underground Radioactive Material Areas

## *6.2 Posting and Entry Requirements*

Personnel entry control shall be maintained for each radiological area.

6.2.1 Controlled Areas - Each access point to a Controlled Area shall be posted.

Minimum that shall be required:

- General Employee Radiological Training (GERT) - worker
- Radiological Orientation or Escort Required for Access – visitor

The sign should contain wording equivalent to "Controlled Area".

6.2.2 Radiological Buffer Areas - Should be established within a Controlled Area to provide secondary boundaries to minimize the spread of contamination in conjunction with work in Contamination Areas, High Contamination Areas, and Airborne Radioactivity Areas. Access to these areas should be posted with the words "Caution, Radiological Buffer Area."

Minimum that shall be required:

- General Employee Radiological Training (GERT) - worker
- Radiological Worker I (RW-I)

6.2.3 Radiation Areas - Any area accessible to individuals shall be posted with the words "Caution, Radiation Area."

Minimum that shall be required:

- General Employee Radiological Training (GERT) - worker
- Radiological Worker II (RW-II) Training, TLD, and HWP.

If more than one radiological condition exists in the same area, each condition shall be identified.

6.2.4 High Radiation Areas - Any area accessible to individuals shall be posted with the words "Danger, High Radiation Area." A HWP is required for entry.

Minimum that shall be required:

- General Employee Radiological Training (GERT) – worker (unless RW-II, or above, trained);
- Radiological Worker II (RW-II) Training;
- Entryways shall be locked;
- During periods when access is required, positive control (i.e., RCT's, alarming dosimetry, etc.) over each entrant shall be maintained;
- No control shall be established that would prevent rapid evacuation of personnel;
- Approval for entry obtained from the RCM;
- An As-Low-As-Reasonably-Achievable (ALARA) pre-job briefing shall be conducted prior to entry;
- Radiation survey and supplemental dosimeter shall be provided;
- Area shall be maintained as necessary during access to determine the exposure rates to which individuals are exposed;

- A control device that prevents entry to the area when high radiation levels exist or upon entry causes the radiation level to be reduced below that level defining a high radiation area;
- A device that functions automatically to prevent use or operation of the radiation source or field while personnel are in the area;
- 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;
- Entryways that are locked. During periods when access to the area is required, positive control over each entry is maintained;
- Continuous direct or electronic surveillance that is capable of preventing unauthorized entry; and,
- A control device that will automatically generate audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source.

6.2.5 Very High Radiation Areas - Any area accessible to individuals shall be posted with the words "Grave Danger, Very High Radiation Area." Currently, no such areas exist or are expected to be encountered at LEHR. If such conditions were to change, a specific procedure would be generated outlining requirements for posting and control.

6.2.6 Airborne Radioactivity Areas - Any area accessible to individuals shall be posted with the words "Caution, Airborne Radioactivity Area." A HWP is required for entry.

Minimum that shall be required:

- General Employee Radiological Training (GERT) – worker, or
- Radiological Worker II (RW-II) Training

6.2.7 Contamination Area - Any area accessible to individuals shall be posted with the words "Caution, Contamination Area." A HWP is required for entry.

Minimum that shall be required:

- General Employee Radiological Training (GERT) – worker (unless RW-II trained, or higher), or
- Radiological Worker II (RW-II) training

6.2.8 Fixed Contamination Area - Any area accessible to individuals should be posted with the words "Caution, Fixed Contamination Area."

Minimum that shall be required:

- General Employee Radiological Training (GERT) – worker, or
- Radiological Worker II (RW-II) training

Entry control and posting are not required for areas of fixed contamination meeting the conditions of Appendix D, 10 CFR 835 and this section.

Markings indicating the status of the area shall be applied to the surface (or at access points) to provide adequate warning. Markings and postings shall be maintained in a legible condition.

Appropriate written procedures shall be implemented to prevent planned or uncontrolled removal of the contamination.

6.2.9 High Contamination Area - Any area accessible to individuals shall be posted with the words "Danger, High Contamination Area." A HWP is required for entry.

Minimum that shall be required:

- General Employee Radiological Training (GERT) – worker, or,
- Radiological Worker II (RW-II)
- Approval for entry must be obtained from the RCM
- An ALARA pre-job briefing shall be conducted prior to entry

6.2.10 Radioactive Material Area - Areas where radioactive materials are used, handled or stored shall be posted with the words "Caution, Radioactive Material."

Minimum Training Required:

- General Employee Radiological Training (GERT) – worker, or,
- Radiological Worker II (RW-II) Training

Radioactive material areas shall be located within Controlled Areas.

Radioactive Material Areas need not be posted when:

- The area is posted as a radiological area in accordance 10 CFR 835;
- Each item or container of radioactive material in the area is clearly labeled to warn individuals of the hazards;
- The area contains only packages of radioactive material received from transportation while awaiting survey; and,

- For periods of eight continuous hours or less, the area is under the direct observation and control of an individual knowledgeable of and empowered to implement required access control measures.

6.2.11 Underground Radioactive Material Areas - should be posted with the words "Underground Radioactive Material."

6.2.12 When an escort is used in lieu of training in accordance with this procedure, the escort shall:

(1) Have completed radiation safety training, examinations, and performance demonstrations required for entry to the area and performance of the work; and,

(2) Ensure that all escorted individuals comply with the documented radiation protection program.

## *6.3 Posting and Labeling Guidelines*

6.3.1 All areas that contain radiological hazards and/or require exposure control shall be clearly designated and conspicuously posted by appropriate signs, tags or labels that may contain radiological protection instructions appropriate to the hazard. Signs, tags, and labels should have a similar design and be DOE approved. During transient radiological conditions of less than 8-hours continuous duration when posting is not practical, individuals who are knowledgeable of and empowered to implement required access and exposure control shall be stationed to provide line-of-sight surveillance and verbal warning. Areas containing only packages received from radioactive material transportation labeled and in non-degraded condition need not be posted in accordance with § 835.603 until the packages are monitored in accordance with § 835.405.

6.3.2 The radiation symbol (trefoil) and the color combination yellow background and magenta/black standard radiation trefoil symbol shall be used on all signs/labels to signify the actual or potential presence of ionizing radiation and to identify objects, devices, materials, or combinations of materials which emit ionizing radiation.

6.3.3 The symbols and color combination of yellow and magenta are not to be used for purposes other than to warn of the actual or potential presence of a radiation or contamination hazard or for training purposes when the signs, barriers, and symbols are clearly identified "For Training Purposes Only."

6.3.4 Each sign, tag or label shall be displayed prominently and must be recognizable from a safe distance. Signs should be placed intermittently along the boundaries of accessible areas, with at least one sign visible on each side of the boundary. Boundaries and barriers should be clearly visible, and established at an elevation that would prevent unintentional entry into radiological areas. The signs and symbols shall be approved by the Department of Energy and conform to ANSI N12.1-1971 and ANSI N2.1-1971.

6.3.5 Each posted area shall be defined and clearly marked with appropriate signs and may include a portion or all of a room, building, area, or vehicle. Areas without clearly defined existing

boundaries should be defined by the use of yellow and magenta radiation tape, ribbon, or rope. Postings at entrances to rooms shall be displayed in a manner which allows the posting to remain visible with the door open or closed. Postings shall be visible from each direction from which the area can be easily accessed.

6.3.6 Supplementary notices specifying the requirements for entry to and exit from areas, special precautions that are to be exercised, and the most recent radiological survey for each area should be posted in conjunction with radiation warning signs and tags to provide personnel with any required additional instructions or information not given by the signs and tags.

6.3.7 The information signs, tags, labels, and notices shall be kept current, reflecting any changes in radiological conditions.

6.3.8 Warning signs, tags, labels, notices and other radiation hazard identification markings will be removed when the conditions requiring their use no longer exist.

6.3.9 Each item containing radioactive material above the values listed in Appendix E of 10 CFR 835 shall be labeled with the trefoil and the words "Caution, Radioactive Material" or "Danger, Radioactive Material" if the item is not used, handled, or stored within a posted radiological area. When practical, the label should contain the contact radiation levels, the removable surface contamination levels, the date surveyed, the surveyor's name, and a description of the source.

6.3.10 In situations where more than one radiological condition exists, each condition shall be identified. Multiple radiological conditions should either be posted on individual signs or be combined on a single sign, with the headings listed in descending order of importance.

6.3.11 Radiological postings shall not block access to emergency exits.

6.3.12 Radioactive items or containers of radioactive materials shall be individually labeled if adequate warning is not provided by control measures and required posting.

6.3.13 Each access point to a controlled area shall be posted, identifying it as a controlled area, whenever radioactive material and/or radiation fields that would require posting under Section 10CFR835 may be present in the area. Signs used for this purpose may be selected by the contractor to avoid conflict with local security requirements. Individuals who enter only controlled areas without entering radiological areas or radioactive material areas are not expected to receive a total effective dose equivalent of more than 0.1 rem (0.001 sievert) in a year.

6.3.14 At a minimum, labels shall include the radiation symbol and the words "CAUTION" or "DANGER RADIOACTIVE MATERIAL" and provide information necessary to avoid or minimize exposure.

6.3.15 Radioactive material in quantities exceeding 10 times these listed in Attachment 2 quantities shall be stored in a Radioactive Material Area or other areas posted in accordance with 10 CFR 835.

# 7.0 DOCUMENTATION/RECORDS

None.

# 8.0 ATTACHMENTS

## *8.1 Surface Residual Radioactivity Guidelines*

## *8.2 Values for Establishing Sealed Radioactive Source Accountability With Radioactive Material Posting and Labeling Requirements*

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# ATTACHMENT 8.1

## SURFACE RESIDUAL RADIOACTIVITY GUIDELINES

Attachment1. Surface Contamination Values[1] in dpm/100 $cm^2$

| Radionuclide | Removable [2,4] | Total (Fixed + Removable)[2,3] |
|---|---|---|
| U-nat, U-235, U-238, and associated decay products | [7] 1,000 | [7] 5,000 |
| Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 | 20 | 500 |
| Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 | 200 | 1,000 |
| Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above[5] | 1,000 | 5,000 |
| Tritium and tritiated compounds[6] | 10,000 | N/A |

1 The values in this appendix, with the exception noted in footnote 5 below, apply to radioactive contamination deposited on, but not incorporated into the interior or matrix of, the contaminated item. Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides apply independently.
2 As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
3 The levels may be averaged over one square meter provided the maximum surface activity in any area of 100 $cm^2$ is less than three times the value specified. For purposes of averaging, any square meter of surface shall be considered to be above the surface contamination value if: (1) from measurements of a representative number of sections it is determined that the average contamination level exceeds the applicable value; or (2) it is determined that the sum of the activity of all isolated spots or particles in any 100 $cm^2$ area exceeds three times the applicable value.
4 The amount of removable radioactive material per 100 $cm^2$ of surface area should be determined by swiping the area with dry filter or soft absorbent paper, applying moderate pressure, and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. (Note - The use of dry material may not be appropriate for tritium.) When removable contamination on objects of surface area less than 100 $cm^2$ is determined, the activity per unit area shall be based on the actual area and the entire surface shall be wiped. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.
5 This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.
6 Tritium contamination may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may migrate to the surface in order to ensure the surface contamination value provided in this appendix is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a "Total" value does not apply.
7 **(alpha)** .

# ATTACHMENT 8.2

## VALUES FOR ESTABLISHING SEALED RADIOACTIVE SOURCE ACCOUNTABILITY WITH RADIOACTIVE MATERIAL POSTING AND LABELING REQUIREMENTS

## Appendix E to Part 835—Values for Establishing Sealed Radioactive Source Accountability and Radioactive Material Posting and Labeling Requirements

The data presented in this appendix E are to be used for identifying accountable sealed radioactive sources as defined at § 835.2(a), establishing the need for radioactive material area posting in accordance with § 835.603(g), and establishing the need for radioactive material labeling in accordance with § 835.605.

Note: The data are listed in alphabetical order by nuclide.

| Nuclide | Activity (μCi) | Nuclide | Activity (μCi) | Nuclide | Activity (μCi) |
|---|---|---|---|---|---|
| Ac-227 | 1.5E+00 | H-3 | 1.6E+08 | Re-184m | 1.5E+02 |
| Ag-105 | 2.1E+06 | Hf-172 | 3.1E+04 | Re-186m | 2.8E+05 |
| Ag-108m | 1.8E+01 | Hf-175 | 1.8E+06 | Rh-101 | 2.5E+05 |
| Ag-110m | 2.2E+01 | Hf-178m | 4.1E+03 | Rh-102 | 8.3E+04 |
| Al-26 | 1.6E+01 | Hf-181 | 3.5E+02 | Rh-102m | 2.1E+05 |
| Am-241 | 2.3E+01 | Hf-182 | 3.0E+03 | Ru-103 | 4.4E+02 |
| Am-242m | 2.4E+01 | Hg-194 | 3.5E+04 | Ru-106 | 2.1E+04 |
| Am-243 | 2.3E+01 | Hg-203 | 4.9E+02 | S-35 | 4.0E+06 |
| As-73 | 5.4E+02 | Ho-166m | 2.2E+01 | Sb-124 | 9.1E+01 |
| Au-195 | 4.8E+02 | I-125 | 3.5E+02 | Sb-125 | 6.8E+01 |
| Ba-133 | 5.2E+01 | I-129 | 1.8E+02 | Sc-46 | 6.2E+01 |
| Be-10 | 2.8E+04 | In-114m | 7.8E+02 | Se-75 | 6.4E+01 |
| Be-7 | 3.2E+03 | Ir-192 | 1.4E+02 | Se-79 | 1.0E+06 |
| Bi-207 | 1.7E+01 | Ir-192m | 2.6E+04 | Si-32 | 9.9E+03 |
| Bi-208 | 1.5E+01 | Ir-194m | 2.7E+01 | Sm-145 | 9.1E+05 |
| Bi-210m | 1.3E+03 | K-40 | 2.8E+02 | Sm-146 | 1.2E+02 |
| Bk-247 | 1.7E+01 | La-137 | 1.1E+05 | Sm-151 | 2.5E+05 |
| Bk-249 | 7.2E+03 | Lu-173 | 4.4E+05 | Sn-113 | 3.1E+02 |
| C-14 | 4.8E+06 | Lu-174 | 2.5E+05 | Sn-119m | 3.3E+02 |
| Ca-41 | 7.4E+06 | Lu-174m | 3.9E+05 | Sn-121m | 8.7E+05 |
| Ca-45 | 1.5E+06 | Lu-177m | 5.8E+01 | Sn-123 | 1.3E+04 |
| Cd-109 | 1.6E+02 | Md-258 | 6.0E+02 | Sn-126 | 1.8E+02 |
| Cd-113m | 6.5E+03 | Mn-53 | 2.0E+07 | Sr-85 | 1.2E+02 |
| Cd-115m | 1.0E+04 | Mn-54 | 6.5E+01 | Sr-89 | 2.4E+05 |
| Ce-139 | 2.4E+02 | Mo-93 | 7.7E+01 | Sr-90 | 7.7E+03 |
| Ce-141 | 2.4E+03 | Na-22 | 1.9E+01 | Ta-179 | 1.5E+06 |
| Ce-144 | 1.5E+03 | Nb-91 | 7.0E+01 | Ta-182 | 7.3E+01 |
| Cf-248 | 2.0E+02 | Nb-91m | 3.6E+02 | Tb-157 | 2.5E+03 |
| Cf-249 | 1.7E+01 | Nb-92 | 1.8E+01 | Tb-158 | 3.9E+04 |
| Cf-250 | 3.8E+01 | Nb-93m | 4.4E+02 | Tb-160 | 1.2E+02 |
| Cf-251 | 1.7E+01 | Nb-94 | 2.3E+01 | Tc-95m | 1.3E+02 |
| Cf-252 | 6.4E+01 | Nb-95 | 3.4E+02 | Tc-97 | 8.1E+01 |
| Cf-254 | 3.4E+01 | Ni-59 | 7.5E+06 | Tc-97m | 3.6E+02 |
| Cl-36 | 4.6E+05 | Ni-63 | 3.2E+06 | Tc-98 | 2.5E+01 |
| Cm-241 | 6.8E+04 | Np-235 | 1.2E+02 | Tc-99 | 6.8E+06 |
| Cm-242 | 5.8E+02 | Np-236 | 2.2E+01 | Te-121m | 1.9E+02 |
| Cm-243 | 3.3E+01 | Np-237 | 1.9E+01 | Te-123m | 2.8E+02 |
| Cm-244 | 4.0E+01 | Os-185 | 1.4E+02 | Te-125m | 4.4E+02 |
| Cm-245 | 2.2E+01 | Os-194 | 1.5E+04 | Te-127m | 8.0E+02 |
| Cm-246 | 2.2E+01 | Pa-231 | 7.8E+00 | Te-129m | 2.3E+03 |
| Cm-247 | 2.4E+01 | Pb-202 | 1.0E+05 | Th-228 | 2.9E+01 |
| Cm-248 | 6.0E+00 | Pb-205 | 9.1E+01 | Th-229 | 4.7E+00 |
| Cm-250 | 1.1E+00 | Pb-210 | 9.2E+01 | Th-230 | 3.1E+01 |
| Co-56 | 4.0E+01 | Pd-107 | 7.8E+05 | Th-232 | 6.1E+00 |
| Co-57 | 2.3E+02 | Pm-143 | 1.3E+02 | Tl-44 | 1.6E+02 |
| Co-58 | 1.4E+02 | Pm-144 | 2.9E+01 | Tl-204 | 2.2E+04 |
| Co-60 | 1.8E+01 | Pm-145 | 2.6E+02 | Tm-170 | 8.4E+03 |
| Cs-134 | 2.7E+01 | Pm-146 | 4.5E+01 | Tm-171 | 2.8E+04 |
| Cs-135 | 2.2E+06 | Pm-147 | 2.5E+05 | U-232 | 1.5E+01 |
| Cs-137 | 6.0E+01 | Pm-148m | 1.1E+02 | U-233 | 7.4E+01 |
| Dy-159 | 4.1E+06 | Po-209 | 6.3E+03 | U-234 | 7.5E+01 |
| Es-254 | 6.3E+01 | Po-210 | 1.1E+03 | U-235 | 6.7E+01 |
| Es-255 | 4.6E+04 | Pt-193 | 4.4E+07 | U-236 | 8.0E+01 |
| Eu-148 | 7.0E+05 | Pu-236 | 6.9E+01 | U-238 | 8.4E+01 |
| Eu-149 | 5.3E+06 | Pu-237 | 3.3E+02 | V-49 | 2.9E+07 |
| Eu-152 | 3.1E+01 | Pu-238 | 2.5E+01 | W-181 | 1.1E+03 |
| Eu-154 | 3.1E+01 | Pu-239 | 2.3E+01 | W-185 | 3.9E+06 |
| Eu-155 | 3.7E+02 | Pu-240 | 2.3E+01 | W-188 | 6.4E+04 |
| Fe-55 | 3.7E+06 | Pu-241 | 1.2E+03 | Y-88 | 3.4E+01 |
| Fe-59 | 2.0E+02 | Pu-242 | 2.4E+01 | Y-91 | 5.0E+04 |
| Fe-60 | 1.3E+04 | Pu-244 | 2.5E+01 | Yb-169 | 5.5E+02 |
| Fm-257 | 4.3E+02 | Ra-226 | 1.2E+03 | Zn-65 | 1.1E+02 |
| Gd-146 | 2.6E+05 | Ra-228 | 2.1E+03 | Zr-88 | 1.2E+02 |
| Gd-148 | 3.0E+01 | Rb-83 | 9.2E+01 | Zr-93 | 3.1E+04 |
| Gd-151 | 1.1E+06 | Rb-84 | 2.0E+02 | Zr-95 | 2.0E+02 |
| Gd-153 | 2.1E+02 | Re-183 | 5.4E+02 | | |
| Ge-68 | 5.7E+02 | Re-184 | 2.6E+02 | | |

Any alpha emitting radionuclide not listed above and mixtures of alpha emitters of unknown composition have a value of 10 microcuries.

Any radionuclide other than alpha emitting radionuclides not listed above and mixtures of beta emitters of unknown composition have a value of 100 microcuries.

Note: Where there is involved a combination of radionuclides in known amounts, derive the value for the combination as follows: determine, for each radionuclide in the combination, the ratio between the quantity present in the combination and the value otherwise established for the specific radionuclide when not in combination. If the sum of such ratios for all radionuclides in the combination exceeds unity (1), then the accountability criterion has been exceeded.

# RADIOLOGICAL SURVEYS AND INSTRUMENTATION

STANDARD OPERATING PROCEDURE

## 1.0 PURPOSE

This procedure describes the requirements for performing radiological surveys and the requirements for radiological survey instrumentation at LEHR.

## 2.0 REFERENCES

*2.1* *ANSI N323, "Radiation Protection Instrumentation Test and Calibration," 1978*

*2.2* *10 CFR 835, "Occupational Radiation Protection"*

*2.3* *SOP 24.1, "Radiological Areas and Posting"*

*2.4* *SOP 38.3, "Radiation Protection Records"*

*2.5* *SOP 25.2, "Radiological Survey Forms"*

## 3.0 DEFINITIONS

### *3.1 Air Monitoring*

Actions to detect and quantify airborne radiological conditions by the collection of an air sample and the subsequent analysis, either in real-time or offline laboratory analysis, of the amount and type of radioactive material present in the workplace atmosphere.

### *3.2 Airborne Radioactivity Area*

Means any area, accessible to individuals, where: (1) the concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed the derived air concentration (DAC) values listed in Appendix A or Appendix C of 10CFR835; or (2) an individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-hours in a week.

### *3.3 Calibration*

The process of adjusting or determining either:

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

### *3.4 Chi Square Test*

A statistical test used to check the stability of a counting system by comparing a given set of detector measurements against those theoretically expected from a Poisson distribution.

### *3.5 Contamination*

The presence of radioactivity in unwanted areas (i.e., surfaces of structures, objects, areas, or personnel).

### *3.6 Controlled Area*

Any area to which access is managed by or for DOE to protect individuals from exposure to radiation and/or radioactive materials.

### *3.7 Derived Air Concentration (DAC)*

For the radionuclides listed in Appendix A of 10 CFR 835, the airborne concentration that equals the Annual Limit on Intake (ALI) divided by the volume of air breathed by an average worker during a working year of 2000 hours (assuming a breathing volume of 2.4E3 $m^3$).

### *3.8 Instruments*

Measuring equipment, devices, or systems used to quantify, test, gage, inspect, or control in order to acquire data or determine compliance with project specifications.

### *3.9 Source Check*

Test of measuring equipment against a source of known intensity or concentration to measure functionality. Typically performed daily or prior to use. A source check is not a calibration.

### *3.10 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 herein, does not include non-ionizing radiation, such as radio or micro-waves, or visible, infrared, or ultraviolet light.

### *3.11 Removable Contamination*

The fraction of the total surface radioactive contamination that can be readily removed by non-destructive means, such as casual contact, wiping, brushing, or washing.

### *3.12 Total Surface Contamination*

The total activity of radioactive material on the surface of an object, where total surface contamination = removable contamination + fixed contamination.

## 4.0 RESPONSIBILITIES

### *4.1 Project Manager (PM)*

The PM is responsible for the safe and effective implementation of this procedure.

### *4.2 Radiological Control Manager (RCM)*

The RCM is responsible for ensuring all field activities are performed in compliance with this procedure.

### *4.3 Radiation Safety Officer (RSO)*

The RSO is responsible for ensuring that all Radiological Control Technicians (RCTs) are properly trained on this procedure, and that the posting(s) at each radiological area reflect the most current survey of that area.

### *4.4 Radiological Control Technicians (RCTs)*

The RCTs are responsible for the performance of the work described in this procedure.

## 5.0 SAFETY PRECAUTIONS/PREREQUISITES

Personnel conducting surveys shall be aware of the radiological and hazardous conditions of the areas/items to be surveyed.

Instruments used for release surveys should: (1) be appropriate for the type of contamination to be detected; (2) have an MDA less than the release limits shown in Appendix D of 10 CFR 835; and, (3) be in current calibration (at least annually).

All items that meet the criteria for uncontrolled release from a radiological area or Radiologically Controlled Area should be removed as soon as practical following the release survey.

Applicable Hazardous Work Permits (HWP) will be read, understood, and signed by all survey personnel prior to conducting surveys.

All survey personnel will wear the appropriate personal protective equipment listed in the HWP while conducting surveys.

All survey instruments shall have a current calibration, and be source and background checked on the day of use, and be visually inspected prior to use.

Personnel shall be trained on the proper operation, use, and application of the survey equipment.

# 6.0 PROCEDURE

## *6.1 Surveys*

The types of surveys required to ensure adequate identification, control, and documentation of radiological hazards during field investigation, waste packaging, and decommissioning and decontamination (D&D) activities at LEHR are described below. Radiological surveys shall be performed only by trained and qualified personnel.

The minimum detectable activity (MDA) with a 0.05 probability of Type I or Type II errors (95% confidence level) should be calculated for each instrument/counting system. This information can be used to determine if a system can detect contamination levels required to meet approved release criteria or contamination limits.

Counting room equipment shall be routinely tested for operability. Daily performance checks of background count rate and radiation response should be performed on the counting system. A Chi Square test should be performed monthly on the counting system to determine variations about the mean count rate to ensure that the system remains within calibration throughout the calibration interval.

### 6.1.1 Area Surveys

Area surveys are performed to identify and quantify radiation and contamination in areas and on items. Area surveys include radiation, contamination, and airborne surveys. The frequency of area surveys is discussed below.

## *6.2 Radiation Surveys*

6.2.1 Radiation surveys should include dose rates as follows:

- at contact with source;
- at 30 cm from source;
- in the general area of interest in work area; and,
- at identified area boundaries.

Routine radiation surveys should be performed in accordance with the following minimum frequencies:

- Daily, in office space located in Radiological Buffer Areas and other areas surrounding radiological areas where the potential exists for external radiation exposure.
- Weekly, in routinely occupied Radiological Buffer Areas and Radiation Areas.
- Weekly, for operating HEPA-filtered ventilation units.
- Weekly, for temporary Radiation Areas boundaries to ensure that radiation areas do not extend beyond posted boundaries.
- Monthly, or upon entry if entries are less frequent than monthly, for Radioactive Material Areas.
- Monthly, for potentially contaminated ducts, piping, and hoses in use outside radiological facilities.

The RSO or RCM should approve the frequency and extent of surveys not mandated by 10 CFR 835.

6.2.2 Radiation surveys are a means to verify effectiveness of engineering and process controls in containing radioactive material and reducing radiation exposure.

6.2.3 Radiation surveys on received radioactive material packages shall be performed:

- When the quantity of received radioactive material exceeds a Type A quantity (as defined in 10 CFR 71.4) and the packaged is labeled with a Radioactive White I or Yellow II or III label (as specified in 49 CFR 172.403 and 172.436-440).
- When the radioactive material has been transported as low specific activity material on an exclusive use vehicle (as defined in 10 CFR 71.4).

These surveys are used to ensure compliance with Department of Transportation regulations and applicable DOE Orders and to identify appropriate postings and access control measures. These measures should be established as soon as practicable after receipt.

Monitoring shall include:

- Measurements of removable contamination levels, unless the package contains only special form (as defined at 10 CFR 71.4) or gaseous radioactive material; and,
- Measurements of the radiation levels, unless the package contains less than a Type A quantity (as defined at 10 CFR 71.4) of radioactive material.

The monitoring required shall be completed as soon as practicable following receipt of the package, but not later than 8 hours after the beginning of the working day following receipt of the package.

6.2.4 Surveys shall also be performed when a received package shows evidence of damage, such as packages that are crushed or wet.

6.2.5 Surveys of received packages shall be performed within three hours of receipt, if received normal working hours, or within three hours from the beginning of the next working day, if received outside of normal working hours.

### *6.3 Contamination Surveys*

6.3.1 Contamination surveys should be conducted in Radiological Buffer Areas and other areas surrounding radiological areas established for the control of contamination and other areas with the potential for spread of contamination as follows:

- Prior to transfer of equipment and material from one Radiological Buffer Area to another.
- Prior to transfer of equipment and material from High Contamination Areas within Radiological Buffer Areas unless precautions such as bagging or wrapping are taken prior to transfer.
- Daily, at contamination areas control points, change areas, or step-off pads when in use, or per shift in high use situations.
- Daily, in office space located in Radiological Buffer Areas.
- Daily, in lunchrooms or eating areas near Radiological Buffer Areas.
- Weekly, in routinely occupied Radiological Buffer Areas.
- Weekly, or upon entry if entries are less frequent, in areas where radioactive materials are handled or stored.
- Weekly, or upon entry if entries are less frequent, where contamination area boundaries or postings are located.
- During initial entry into a known or suspected contamination area, periodically during work, at completion of job, or as specified in a Radiological Work Permit.

- Weekly, in and around areas of fixed contamination.
- After a leak or spill of radioactive materials.

The RSO or RCM should approve frequency and extent of surveys not mandated by 10 CFR 835.

6.3.2 Release of Material from Contaminated Areas to Controlled Areas

All material removed from Contaminated Areas shall be surveyed prior to release, and shall have contamination levels less than values shown in Appendix D, 10 CFR 835.

Radioactive material that exceeds the values shown in Appendix D, 10 CFR 835, that need to be removed to other areas shall be packaged, labeled, and escorted by RCTs. Items shall be controlled through use of postings, inventories, and frequent surveys.

6.3.3 Release of Material from Contaminated Areas to Uncontrolled Areas

All material removed from Contaminated Areas shall be surveyed prior to release, and shall have contamination levels less than values shown in Appendix D, 10 CFR 835.

DOE 5400.5 and NRC Regulation Guide 1.86 describe radiological criteria for releasing material to uncontrolled areas.

Material shall be evaluated for potential internal contamination or contamination under coating or paint. This often involves taking a material's history into consideration, as well as process knowledge.

All radiological labeling or marking shall be removed prior to release.

All released material shall be removed from applicable radioactive material inventories.

6.3.4 Contamination surveys shall be performed on received packages of normal form radioactive material (as specified in 10 CFR 71.4):

- When the package is labeled with a Radioactive White I, Yellow II, or Yellow III label (as specified at 49 CFR 172.403 and 172.436-440); and,
- When the radioactive material has been transported as low specific activity material on an exclusive use vehicle (as defined in 10 CFR 71.4).

These surveys are used to ensure compliance with Department of Transportation regulations and to identify appropriate postings and access control measures. These measures should be established as soon as practicable after receipt.

6.3.5 Surveys shall also be performed when a received package shows evidence of damage, such as packages that are crushed or wet.

6.3.6 Surveys of received packages shall be performed within three hours of receipt, if received during normal working hours, or within three hours from the beginning of the next working day, if received outside of normal working hours.

6.3.7 Items with inaccessible surfaces that were located in known or suspected contamination areas and had the potential to become contaminated at levels likely to exceed Appendix D, 10 CFR 835, values shall be treated as potentially contaminated and subject to administrative controls unless the items are dismantled and monitored or special survey techniques are used to survey all surfaces.

6.3.8 Total (direct) contamination surveys are performed at the following distances from the surface of items:

- scanning surveys: the bottom edge of the probe is held 0.6 cm (0.25 in) from the surface; and,
- static surveys: the probe is in contact with the surface, unless the surface is known or suspected of being contaminated.

## *6.4 Airborne Radioactivity Surveys*

6.4.1 Discussion

6.4.2 Airborne radioactivity monitoring is required when airborne radioactivity levels have the potential to increase because early detection can minimize internal exposure of radioactive material. Selection of the type of sampling equipment should be based on type of work being performed, job duration, and any limiting factors, (i.e., explosive atmosphere, structural limitations, worker mobility, etc.). Air monitoring equipment includes portable, fixed station sampling, and continuous air monitors (CAM) or combination thereof.

Airborne radioactivity surveys fall into three categories: area, personnel, and containment ventilation surveys. The requirements for each of these surveys are described below.

Airborne radioactivity area surveys are required in any room, enclosure, or operating area where work is being performed which has the potential to cause airborne radioactivity. The samplers should be run continuously during the work activities or during the periods when the highest levels of airborne activity are expected for that area during a work shift.

The minimum detectable activity (MDA) with a 0.05 probability of Type I or Type II errors (95 % confidence level) should be calculated for each sampling/counting system. This information can be used to determine if a system can detect the minimum air concentrations required to meet workplace air monitoring requirements given in 10CFR835.403.

Counting room equipment shall be routinely tested for operability. Daily performance checks of background count rate and radiation response should be performed on the counting system. A Chi Square test should be performed monthly on the counting system to determine variations about the mean count rate to ensure that the system remains within calibration throughout the calibration

interval. Periodic grab samples are collected outside contamination control enclosures. Initially these samples will be collected daily. The frequency may be reduced if experience shows minimal airborne radioactivity i.e., less than one percent of the DAC.

Personnel breathing zone (BZ) samples are collected as needed for individual workers when it is suspected that specific field activities may generate excessive amounts of airborne radioactivity (exposure is likely to exceed 40 DAC-hours in a year). BZ surveys require a lapel air sampler.

Sample flow rates may vary depending upon the specific application, but should always allow collection of a sample volume adequate to ensure the minimum detectable activity of the sampling and counting system is no greater than 2% of an ALI.

Continuous sampling of containment ventilation exhausts will be performed while field activities are being performed which could cause airborne radioactivity within a building or containment.

Note: When collecting air samples from exhaust ventilation systems, the sampling system should be designed and operated to obtain isokinetic samples. Hyperkinetic samples are acceptable because they will over-estimate the radioactivity in the containment ventilation exhaust. Sampler filters are to be changed at least weekly and are evaluated for compliance with the DACs. If containment ventilation exhaust sample results indicate levels that, on a weekly basis, exceed the DACs, operations shall be discontinued until engineering controls are implemented to reduce the airborne radioactivity to acceptable levels.

6.4.3 Air sampling equipment shall be staged such that the air concentrations being measured are representative to which personnel are being exposed.

6.4.4 All air monitoring equipment shall be maintained and calibrated at least once per year. Continuous Air Monitors (CAMs) shall be capable of measuring 1 DAC when averaged over eight hours, and an operational check shall be performed daily. Pocket and electronic dosimeters and area radiation monitors shall be calibrated at least every 12 months.

6.4.5 Air monitoring (in addition to surveys) in the workplace shall be routinely performed, as necessary, to identify and control potential sources of personnel exposure to radiation and/or radioactive material and to identify areas requiring postings in accordance to SOP 24.1, *Radiological Areas and Posting* (Reference 2.3).

## *6.5 General*

Radiation, contamination and airborne radioactivity surveys shall be performed only by RCTs.

All radiation, contamination and airborne radioactivity surveys shall be documented. Documentation shall be completed using the forms and instructions in Attachment 1, "Radiological Survey Log."

Radiation, contamination and airborne radioactivity surveys should include a map or drawing of the area or item being surveyed, indicating the locations of dose rate readings, smear samples, and air samplers.

Radiation, contamination and airborne radioactivity surveys shall be reviewed by the RSO for completeness and trending of area conditions.

## *6.6 Monitoring of Individuals and Areas*

Monitoring of individuals and areas shall be performed to:

- Demonstrate compliance with the regulations in 10 CFR 835;
- Document radiological conditions;
- Detect changes in radiological conditions;
- Detect the gradual buildup of radioactive material;
- Verify the effectiveness of engineering and process controls in containing radioactive material and reducing radiation exposure; and,
- Identify and control potential sources of individual exposure to radiation and/or radioactive material.

## *6.7 Radiation/Contamination Survey Instrumentation*

6.7.1 Instrumentation used for monitoring shall be readily available and of sufficient accuracy to determine the extent of radiological hazards to which employees are exposed, and shall be appropriate for the types, levels and energies of the radiation/contamination encountered or expected and for which their calibrations are valid. Instrumentation shall also be appropriate for existing environmental conditions and routinely tested for operability.

6.7.2 Prior to purchase, instruments shall be evaluated, tested, and calibrated by the manufacturer.

6.7.3 Instruments shall be evaluated and tested as applicable for:

- Physical construction;
- Effect of shock, sound, vibration, electric transients, radio frequency energy, magnetic fields and high humidity;
- Extent of switching transients, capacitance effects, geotropism and static charge effects;
- Power supply, including stability and battery life;
- Range, sensitivity, linearity, detection limit, and response to overload conditions;
- Accuracy and reproducibility (precision);
- Energy dependence;
- Angular dependence;

- Response to ionizing radiation other than that being measured; and,
- Temperature and pressure dependence on measurements.

6.7.4 Instrumentation shall be calibrated using the guidelines of ANSI N323, "Radiation Protection Instrumentation Test and Calibration," (Reference 2.1) with the following additional requirements/exceptions:

- On a case-by-case basis, the calibration of a high-range instrument at 80 percent of full scale on the high scale may be waived by the RSO;
- Instruments shall be calibrated annually; and,
- Calibrations shall use National Institute of Standards and Technology Traceable Sources.

6.7.5 Prior to each use or daily when kept in use each instrument shall have the following inspection conducted (as applicable):

- A battery check;
- A test of the reset button;
- A test of the audible response;
- A check of the zero;
- An examination for physical damage;
- A verification that the calibration sticker is on the instrument and the instrument is in calibration;
- A background check; and,
- A source response check on at least one scale.

6.7.6 In addition to 6.2.3, an instrument should be tested weekly against a reference standard source in a fixed geometry on at least one scale. The instrument reading, when corrected for efficiency and background and source units (dpm, pCi, mrem/hr, etc.), should be within 20 percent of the standard's value.

6.7.7 Instruments failing any of the activities in 6.2.3 and 6.2.4 shall be taken out of service, tagged as "out of service," evaluated for failure, and repaired or reset-up prior to use.

6.7.8 Each instrument shall be labeled with a unique identifier to enable traceability to surveys and records.

6.7.9 The instrument checks, as required, will be recorded on the instrument check sheet (SOP 25.2, Attachment 8.5).

# 7.0 DOCUMENTATION/RECORDS

7.1.1 A log shall be maintained of all surveys. All surveys need to be listed in numerical order on log, and filed in numerical order. Original copies should be maintained in a locked fireproof file cabinet. The log sheet is shown in Attachment 1.

7.1.2 A project file shall be maintained for each instrument documenting its inspection, calibration, and maintenance history.

7.1.3 Changes in equipment, techniques, and procedures used for monitoring in the workplace shall be documented.

7.1.4 Records are to be retained as per SOP 38.3, *Radiation Protection Records* (Reference 2.4).

# 8.0 ATTACHMENTS

## *8.1 Radiological Survey Log Sheet*

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# ATTACHMENT 8.1

## RADIOLOGICAL SURVEY LOG

# RADIOLOGICAL SURVEY LOG

| SURVEY NUMBER | SURVEY DATE | SURVEY BY | DESCRIPTION | RELEASED TO (Only if survey is conducted for release of material; otherwise check N/A) |
|---|---|---|---|---|
| | | | | N/A ☐ |
| | | | | N/A ☐ |
| | | | | N/A ☐ |
| | | | | N/A ☐ |
| | | | | N/A ☐ |
| | | | | N/A ☐ |
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| | | | | N/A ☐ |
| | | | | N/A ☐ |
| | | | | N/A ☐ |
| | | | | N/A ☐ |

**Abbreviation**

N/A not applicable

# RADIOLOGICAL SURVEY FORMS

STANDARD OPERATING PROCEDURE

## 1.0 PURPOSE

This procedure describes the requirements for documenting radiological surveys and equipment setup and performance checks at LEHR.

## 2.0 REFERENCES

*2.1 10 CFR 835, "Occupational Radiation Protection"*

*2.2 SOP 38.3, "Internal and External Dosimetry and Radiation Protection Records"*

*2.3 SOP 25.1, "Radiological Surveys And Instrumentation"*

## 3.0 DEFINITIONS

### *3.1 Calibration*

The process of adjusting or determining either:

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

### *3.2 Instruments*

Measuring equipment, devices, or systems used to quantify, test, gauge, inspect, or control in order to acquire data or determine compliance with project specifications.

### *3.3 Source Check*

Test of measuring equipment against a source of known intensity or concentration to measure functionality. Typically performed daily or prior to use. A source check is not a calibration.

# 4.0 RESPONSIBILITIES

## *4.1 Project Manager (PM)*

The PM is responsible for the safe and effective implementation of this procedure.

## *4.2 Radiation Safety Officer (RSO)*

RSO is responsible for ensuring that all Radiological Control Technicians (RCTs) are properly trained on this procedure, and that the attached forms are used as required.

## *4.3 Radiological Control Technicians (RCTs)*

The RCTs are responsible for the proper completion, legibility and documentation of the forms in this procedure.

# 5.0 SAFETY PRECAUTIONS/PREREQUISITES

## *5.1 RCTs*

RCTs shall be aware of the radiation hazards associated with instrument check sources and shall store radioactive sources in a secure, locked location that shall identify the presence of radioactive material through the application of postings or labels (stickers).

## *5.2 Personnel*

Personnel shall be trained on the proper operation, use, and application of the survey equipment.

# 6.0 PROCEDURE

## *6.1 Discussion*

6.1.1 All radiological surveys shall be performed in accordance with SOP 25.1 "Radiological Surveys And Instrumentation," (Reference 2.3).

## *6.2 Radiological Survey Form*

RCTs shall document surveys performed to identify and quantify radiation and contamination in areas and on items on a Radiological Survey Form (Attachment 1). When necessary, the continuation sheet will be used (Attachment 2).

6.2.1 The RSO shall review all completed survey forms.

6.2.2 The RSO shall maintain a Radiological Survey Log (Attachment 3) for all radiological surveys performed at the LEHR site.

6.2.3 All surveys shall be maintained in a project file for easy retrievability and reference.

## *6.3 Airborne Survey Form*

6.3.1 All airborne radioactive monitoring shall be conducted in accordance with SOP 25.1, "Radiological Surveys And Instrumentation," (Reference 2.3).

6.3.2 RCTs shall document calculations for airborne radioactivity on Radioactive Airborne Contamination Survey Report forms (Attachment 4).

6.3.3 The RSO shall review all completed Radioactive Airborne Contamination Survey Report forms (Attachment 4).

6.3.4 All airborne radioactive survey forms shall be maintained in a project file for easy retrievability and reference.

## *6.4 Radiation / Contamination Survey Instrumentation Setup*

6.4.1 Upon arrival at the LEHR site, all instrumentation shall:

- be verified against procurement purchase order;
- be inspected for damage;
- have calibration certificates inspected and entered into files;
- have background determined and be source response checked;
- have instrument efficiency determined (as applicable); and,
- have instrument minimum detectable activity (MDA) and lower limit of detection (LLD) determined (as applicable).

6.4.2 Instrument Data Forms:

- Background and source checks shall be documented on the "Scaler Daily Source Check" form, ( Attachment 5).
- Instrument efficiencies shall be documented on "Scaler Setup Sheet" form, (Attachment 6).

6.4.3 RCTs shall establish, on a monthly basis, average background and efficiency for all scaler instruments used at the LEHR site. "Scaler Setup Sheet" forms (Attachment 6), shall be used to document the values used, calculations, and the final average values for background and efficiency obtained for each instrument.

6.4.4 The RSO shall review all completed "Scaler Setup Sheet" forms.

6.4.5 RCTs shall document the performance of daily background and source checks on "Scaler Daily Source Check" form (Attachment 5).

6.4.6 The RSO shall review all survey forms, and instrument data forms upon completion. Forms shall be maintained in a project file for easy retrievability and reference.

## 7.0 DOCUMENTATION/RECORDS

The RSO shall retain all records generated by this procedure in compliance with SOP 38.3, "Internal and External Dosimetry and Radiation Protection Records," (Reference 2.2) and in compliance with 10 CFR 835, "Occupational Radiation Protection," (Reference 2.1).

## 8.0 ATTACHMENTS

*8.1 Radiological Survey Form*

*8.2 Radiological Survey Form Continuation Sheet*

*8.3 Radiological Survey Log*

*8.4 Radioactive Airborne Contamination Survey Report*

*8.5 Scaler Daily Source Check*

*8.6 Scaler Setup Sheet*

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# ATTACHMENT 8.1

## RADIOLOGICAL SURVEY FORM

# RADIOLOGICAL SURVEY FORM



Survey Number _____

Survey Description: _____
Drawing Attached: Yes No

Instrument (1)
Instrument Model: _____
Instrument Ser. #: _____
Calibration Due: _____
Efficiency: _____
MDA: CF: BKG:

Instrument (3)
Instrument Model: _____
Instrument Ser. #: _____
Calibration Due: _____
Efficiency: _____
MDA: CF: BKG:

Survey Date: _____
Survey By: _____ / _____
Signature Date
Print Name: _____
Review By: _____ / _____
Signature Date

Instrument (2)
Instrument Model: _____
Instrument Ser. #: _____
Calibration Due: _____
Efficiency: _____
MDA: CF: BKG:

Instrument (4)
Instrument Model: _____
Instrument Ser. #: _____
Calibration Due: _____
Efficiency: _____
MDA: CF: BKG:

| Survey Point | Smearable Contamination | | Fixed Contamination | | Radiation Level (μR/hr) | Instrument Used | Additional Comments |
|---|---|---|---|---|---|---|---|
| | beta/gamma dpm/100cm$^2$ | alpha dpm/100cm$^2$ | beta/gamma dpm/100cm$^2$ | alpha dpm/100cm$^2$ | | | |
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# ATTACHMENT 8.2

## RADIOLOGICAL SURVEY FORM CONTINUATION SHEET

# RADIOLOGICAL SURVEY FORM CONTINUATION SHEET

Survey Number _____

| Survey Point | Smearable Contamination | | Fixed Contamination | | Radiation Level (μR/hr) | Instrument Used | Additional Comments |
|---|---|---|---|---|---|---|---|
| | beta/gamma dpm/100cm$^2$ | alpha dpm/100cm$^2$ | beta/gamma dpm/100cm$^2$ | alpha dpm/100cm$^2$ | | | |
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# ATTACHMENT 8.3

## RADIOLOGICAL SURVEY LOG

# RADIOLOGICAL SURVEY LOG

| SURVEY NUMBER | SURVEY DATE | SURVEY BY | DESCRIPTION | RELEASED TO (Only if survey is conducted for release of material; otherwise check N/A) |
|---|---|---|---|---|
| | | | | N/A ☐ |
| | | | | N/A ☐ |
| | | | | N/A ☐ |
| | | | | N/A ☐ |
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| | | | | N/A ☐ |
| | | | | N/A ☐ |

**Abbreviation**

N/A not applicable

# ATTACHMENT 8.4

## RADIOACTIVE AIRBORNE CONTAMINATION SURVEY REPORT FORM

# RADIOACTIVE AIRBORNE CONTAMINATION SURVEY REPORT

SAMPLE IDENTIFICATION — AIR SAMPLE RECORD #

| SAMPLE LOCATION | REASON FOR SAMPLE | HWP NUMBER | SAMPLED BY |
|---|---|---|---|
| | | | |

SAMPLE TYPE (all collection effiencies 0.95): [ ] 47 mm (membrane) [ ] PAM (filter) [ ] 4" (filter)

| SAMPLER S/N | MODEL CAL DUE | ON | DATE TIME | OFF | DATE TIME | TOTAL TIME | FLOW ON | FLOW OFF | AVERAGE FLOW RATE | SAMPLE VOLUME |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | min | LPM | LPM | LPM | ml |

| | | | |
|---|---|---|---|
| AVERAGE FLOW = (FLOW ON + FLOW OFF) / 2 | VOL = (MIN)(CFM)(2.832E4) OR (MIN)(LPM)(1000) | CALCULATED BY | PRINT<br>SIGNATURE |

SAMPLE ANALYSIS COUNT NUMBER:

| COUNTER S/N | MODEL CAL DUE | EFF | COUNT | DATE TIME | TOTAL COUNTS | COUNT DURATION | GROSS CPM | BKGD CPM | NET CPM | ACTIVITY |
|---|---|---|---|---|---|---|---|---|---|---|
| Alpha | | | | | COUNTS | MIN | GCPM | BCPM | NCPM | DPM |
| Beta | | | | | COUNTS | MIN | GCPM | BCPM | NCPM | DPM |

GCPM = TOTAL COUNTS + COUNT LENGTH — NCPM = GCPM - BCPM — ACTIVITY = NCPM / EFF

CALCULATION OF MINIMUM DETECTABLE CONCENTRATION (MDC) AND AIR ACTIVITY CONCENTRATION (AC)

| MDC & ACTIVITY CONCENTRATION EQUATION | | AIR ACTIVITY CONCENTRATION AND MDC CALCULATIONS | CONCENTRATION |
|---|---|---|---|
| MDC = (MDA IN DPM A or B)(4.74E / arv | Alpha MDC | 4.74E-07 / 0.7 | uCi/ml |
| Ac = (ACTIVITY A or B)(4.74E-7) / arv | Beta MDC | | uCi/ml |
| a = 0.7 for filter paper alpha<br>= 1.0 for all others | Alpha Ac | 4.74E-07 / 0.7 | uCi/ml |
| r = fraction of sample counted<br>= 0.29 for 4" filter cut to 1 7/8"<br>= 1.0 for all others | Beta Ac | | uCi/ml |
| ume of sample in ml | | | |

CALCULATION OF MINIMUM DETECTABLE DAC FRACTION (MDDF) AND DAC FRACTION (DF)

| DAC VALUES | DAC FRACTION CALCULATION | | FRACTION | TOTAL |
|---|---|---|---|---|
| Alpha Isotope | Alpha MDC / DAC Value | | MDDF | |
| DAC Value | Beta MDC / DAC Value | | MDDF | |
| Beta Isotope | Alpha Ac / DAC Value | | DF | |
| DAC Value | Beta Ac / DAC Value | | DF | |

REMARKS: _____

SAMPLE ANALYSIS PERFROMED BY: _____ / _____ / _____

(PRINT) (SIGN) (DATE/TIME)

# ATTACHMENT 8.5

## SCALER DAILY SOURCE CHECK

# Scaler Daily Source Check

Instrument # _____ Setup Date _____
Cal Date _____ Source ID _____
Probe # _____ Project/# _____

Ranges:

BKG: _____ cpm to _____
Source _____ cpm to _____

| Date | Source Reading | Background Reading | Sat/ Unsat | Technician Initials | Additional Comments |
|---|---|---|---|---|---|
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Completed By: _____ Date _____
Reviewed By: _____ Date _____

# ATTACHMENT 8.6

## INSTRUMENT CHECK SHEET

# SCALER SETUP SHEET

Project Name/# _____
Instrument/# _____
Probe Type/# _____
Technician _____

Date/Time _____
Date Calibrated _____
Source Activity _____ dpm
Source Type _____
HV Check/Setting _____

1. Total Background Counts observed: record counts in 1 - 10

Count Time _____ minutes

| | | | |
|---|---|---|---|
| 1 | _____ | _____ | _____ |
| 2 | _____ | _____ | _____ |
| 3 | _____ | _____ | _____ |
| 4 | _____ | _____ | _____ |
| 5 | _____ | _____ | _____ |
| 6 | _____ | _____ | _____ |
| 7 | _____ | _____ | _____ |
| 8 | _____ | _____ | _____ |
| 9 | _____ | _____ | _____ |
| 10 | _____ | _____ | _____ |

Average Counts = _____ counts

Average count rate = _____ cpm

Standard Deviation Bkg _____ counts

Sum of Squares = _____

2. Total Source Counts observed: record in 1 - 10

| | | | |
|---|---|---|---|
| 1 | _____ | _____ | _____ |
| 2 | _____ | _____ | _____ |
| 3 | _____ | _____ | _____ |
| 4 | _____ | _____ | _____ |
| 5 | _____ | _____ | _____ |
| 6 | _____ | _____ | _____ |
| 7 | _____ | _____ | _____ |
| 8 | _____ | _____ | _____ |
| 9 | _____ | _____ | _____ |
| 10 | _____ | _____ | _____ |

Average source count= _____ counts

Avg Source Ct Rate = _____ cpm

Std Dev Source cts= _____ counts

Sum of Squares = _____

Net source cts = _____ counts

Efficiency = _____ cpm/dpm

Std. Dev. Net = _____ counts

Corr. Factor _____ dpm/cpm

Net Ct. Rate = _____ cpm

LLD= _____ counts

MDA= _____ dpm/100 cm^2

RSO REVIEW _____ Date _____

# CONTAMINATION CONTROL

STANDARD OPERATING PROCEDURE

## 1.0 PURPOSE

This procedure provides requirements and guidelines for the control of radioactive contamination.

## 2.0 REFERENCES

*2.1* *10 CFR 835, "Occupational Radiation Protection"*

*2.2* *HSP 17.1, "Hazardous Work Permits"*

*2.3* *HSP 18.1, "Personnel Contamination"*

*2.4* *SOP 24.1, "Radiological Areas and Posting"*

*2.5* *SOP 25.1, "Radiological Surveys and Instrumentation"*

*2.6* *SOP 38.3, "Radiation Protection Records"*

*2.7* *DOE Order 5400.5, "Radiation Protection of the Public and the Environment"*

## 3.0 DEFINITIONS

### *3.1 Controlled Area*

Any area to which access is managed by or for DOE to protect individuals from exposure to radiation and/or radioactive material.

### *3.2 Radiological Buffer Area*

An intermediate area established to prevent the spread of radioactive contamination and to protect personnel from radiation exposure.

### *3.3 Contamination*

The presence of radioactivity in unwanted areas (i.e., surfaces of structures, objects, areas, or personnel).

### *3.4 Contamination Area*

Any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in Attachment 8.1, but do not exceed 100 times those values.

### *3.5 Hazardous Work Permit (HWP)*

A document issued by the Radiological Control Manager (RCM) which establishes administrative and physical controls and limits for work performed in hazardous or controlled areas.

## 4.0 RESPONSIBILITIES

### *4.1 Project Manager (PM)*

The PM is responsible for the safe and effective implementation of this procedure.

### *4.2 Radiological Control Manager(RCM)*

The RCM is responsible for ensuring all field activities are performed in compliance with this procedure.

### *4.3 Radiation Safety Officer (RSO)*

The RSO is responsible for ensuring that all Radiological Control technicians are properly trained on this procedure.

### *4.4 Radiological Control Technicians (RCTs)*

RCTs are responsible for the implementation of this procedure.

### *4.5 Radiological Workers*

Radiological Workers are responsible for performing the work outlined in this procedure in accordance with its requirements and those of the applicable HWP.

# 5.0 SAFETY PRECAUTIONS/PREREQUISITES

- Personnel engaging in contamination control activities shall be aware of the radiological and hazardous conditions of the work area.
- Personnel will wear the appropriate personnel protective equipment.
- An HWP will be approved and understood by all personnel prior to engaging in contamination control activities.
- All survey instrumentation shall have a current calibration, and be source and background checked on the day of use, and be visually inspected prior to use.

# 6.0 PROCEDURE

## *6.1 Contamination Limits and Control*

6.1.1 Personnel, equipment, and facilities are considered contaminated if the amount of radioactive material exceeds the values specified in Appendix D of 10 CFR 835 (Reference 2.1).

6.1.2 Instruments and techniques used for radioactive contamination monitoring and control shall be adequate to ensure compliance with 10 CFR 835.

6.1.3 Appropriate controls shall be maintained and verified which prevent the inadvertent transfer of removable contamination to locations outside of radiological areas under normal operating conditions.

6.1.4 Any area in which contamination levels exceed the values specified in Appendix D of 10 CFR 835 shall be controlled in a manner commensurate with the physical and chemical characteristics of the contaminant, the radionuclides present, and the fixed and removable contamination levels.

6.1.5 Areas with fixed contamination exceeding the total radioactivity values specified in Appendix D of 10 CFR 835 may be located outside of radiological areas provided the following conditions are met:

- Removable contamination levels are below the levels specified in Appendix D of 10 CFR 835;
- Unrestricted access to the area is not likely to cause any individual to receive a total effective dose equivalent in excess of 0.1 rem in a year;
- The areas is routinely monitored;
- The areas is clearly marked to alert personnel of the contaminated status;

- Appropriate administrative procedures are established and exercised to maintain control of these areas; and,
- Dose rates do not exceed levels which would require posting in accordance with Section 835.603.

6.1.6 Appropriate monitoring (whole body frisking) to detect and prevent the spread of contamination shall be performed by individuals exiting radiological areas established to control removable contamination and/or airborne radioactivity.

6.1.7 Periodic surveys shall be conducted to ensure the removable surface contamination remains fixed to the surface and below limits set in Appendix D, 10 CFR 835.

## *6.2 Tagging and Posting*

6.2.1 Contaminated areas shall be posted in accordance with SOP 24.1, *Radiological Areas and Posting* (Reference 2.4) when contamination levels exceed the values specified in Appendix D of 10 CFR 835.

6.2.2 All contaminated items that are not in a posted contamination area shall be tagged. The tag shall contain information on extent and type of contamination. An example is shown as Attachment 2.

6.2.3 Only Radiological Control Technicians shall post and tag or remove postings and tags.

## *6.3 Protection of Personnel, Equipment, and Areas*

Administrative and engineering controls shall be used to minimize the potential for the spread of contamination. Administrative controls may consist of access restrictions and posting of contaminated areas. Engineering controls may consist of containment enclosures, HEPA filtered ventilation, and physical barriers. The checklist provided as Attachment 4 "Checklist for Reducing Occupational Radiation Exposure", may be used to aid in work planning.

6.3.1 Protection of Personnel

- Personnel shall wear personal protective equipment (PPE) whenever they are in contaminated areas. PPE may include shoe covers, boots, coveralls, hood, gloves, faceshield, etc.
- PPE shall be specified only by a Hazardous Work Permit (HWP) (Reference 2.3).
- Protective clothing shall be required for entry to areas in which removable contamination exists at levels exceeding those specified in Appendix D to 10 CFR 835.
- Personnel entry control shall be maintained for each radiological area.

- The degree of (personnel entry) control shall be commensurate with existing and potential radiological hazards within the area.
- One or more of the following methods shall be used to ensure (personnel entry) control:
  1. Signs and barricades;
  2. Control devices on entrances;
  3. Conspicuous visual and/or audible alarms;
  4. Locked entrance ways; or,
  5. Administrative controls.
- Administrative procedures shall be written as necessary to demonstrate compliance with the provisions of this section, if not covered in the available HSPs/SOPs.
- These administrative procedures shall include actions essential to ensure the effectiveness and operability of barricades, devices, alarms, and locks.
- Authorizations shall be required to perform specific work within the area and shall include specific radiation protection measures.
- No control(s) shall be installed at any radiological areas exit that would prevent rapid evacuation of personnel under emergency conditions.
- Guidelines for contamination control practices that include donning and removal of PPE (e.g. full set) are contained in Attachment 3.
- PPE used may have residual, fixed contamination present. The use of PPE having residual, fixed contamination will be reviewed and approved by the RSO on a case-by-case basis. The limits on contamination for reuse of PPE are:

  - 1000 dpm/100 $cm^2$ alpha
  - 15000 dpm/100 $cm^2$ beta-gamma.
- Physical barriers shall be set up such that they do not impede the intended use of emergency exits or evacuation routes.
- Physical access controls for high and very high radiation areas are provided as Attachment 5.
- Personnel shall wear protective clothing during work in Contamination and High Contamination Areas and should wear protective clothing during the following activities:
  - Handling of contaminated materials with removable contamination in excess of Appendix D, 10 CFR 835 levels;
  - Work in Airborne Radioactivity Areas;
  - As directed by the Radiological Control Organization or as required by the HWP; and,

- Written authorizations shall be required to control entry into and perform work within radiological areas. These authorizations shall specify radiation protection measures commensurate with the existing and potential hazards.

6.3.2 Protection of Equipment

- Material that is to enter a contaminated area shall be protected to minimize the potential for contamination. This may include bagging, taping, etc.
- Material that can not be protected from becoming contaminated shall be treated in a manner to facilitate decontamination whenever possible. These measures include painting, strip coating or polishing.

6.3.3 Protection of Areas

- Any equipment outside of a contamination area that has removable contamination on it shall be bagged, wrapped, taped, etc. to prevent contamination from spreading, and the equipment and bag shall be tagged.
- Contaminated equipment shall be stored in designated storage areas. These areas should be approved prior to use by RCTs.
- Storage areas shall be protected to prevent them from becoming contaminated. This includes use of floor coverings, other physical barriers, etc.
- Storage areas could also be treated to the extent practicable to allow decontamination. This includes painting, sealing concrete, etc.

## *6.4 Ingress/Egress of Contaminated Areas*

All ingress/egress points shall be maintained in compliance with this procedure.

6.4.1 Contamination areas shall be demarcated such that ingress/egress are through designated points.

6.4.2 Where possible, one way traffic flow in contamination areas should be encouraged.

6.4.3 Ingress/egress points should be located in low contamination areas.

6.4.4 Workers shall remove all PPE except inner gloves and shoe covers in the contamination area when leaving. PPE shall be placed in designated receptacles at the egress point.

6.4.5 Egress points should have a step-off pad or sticky pad outside the exit point, contiguous with the area boundary. Gloves and shoe covers are removed at this point prior to stepping onto the step-off pad.

6.4.6 Personnel shall frisk themselves for contamination immediately upon leaving a contaminated area. The frisking should cover the areas protected by PPE. If personnel are contaminated they shall

remain where they are and call the RCT for assistance. Frisking instructions, including required actions if contamination is detected, will be posted at each frisking station. Personnel decontamination and reporting shall be conducted in accordance with HSP-18.1, "Personnel Contamination,"( Reference 2.3). Guidelines for personnel contamination monitoring are provided as Attachment 6.

If an RCT is not present, the individual can isolate the contaminated area using tape, plastic bags, etc. and then proceed to the RSO office for assistance.

6.4.7 Friskers shall be located as close to egress points as background radiation levels allow.

6.4.8 Items shall be surveyed by RCTs when leaving the contaminated area.

6.4.9 The following practices are forbidden within a radiologically controlled (controlled) area:

- Smoking or other use of tobacco.
- Eating, drinking, or gum chewing.
- Wearing contact lenses.
- Entering a controlled area without having the required training.
- Entering a controlled area without having read and signed in on the HWP appropriate for the task.
- Entering a controlled area without proper protective clothing, improperly using PPE, or with faulty equipment.
- Exiting a controlled area without properly frisking.
- Performing tasks outside the scope of the HWP.
- Other practices identified in the HWP.

These restrictions shall be posted at the entrances to controlled areas or otherwise communicated to site workforce.

6.4.10 Entry control and posting are not required for areas with fixed contamination meeting the conditions of Appendix D, 10 CFR 835.

6.4.11 Physical controls for high and very high radiation areas are presented as Attachment 5.

## *6.5 Identification of Contaminated Areas and Equipment*

In addition to the tagging and posting requirements, contaminated areas and equipment are identified through association with the colors yellow and magenta. Contaminated equipment should be bagged or wrapped in materials that are yellow. All contamination area postings shall be in accordance with SOP-24.1, *Radiological Areas and Postings* (Reference 2.4).

## *6.6 Surveillance of Contaminated and Clean Areas*

6.6.1 A surveillance program shall be initiated to routinely survey controlled areas for contamination. Surveys shall be performed in accordance to the minimum frequency presented in SOP-25.1, "Radiological Surveys and Instrumentation," (Reference 2.5). However, changing conditions and operations may require increased frequencies as directed by the RSO or the judgement of the RCT.

6.6.2 The surveillance program shall be prescribed by the RCM.

## *6.7 Release of Materials and Equipment from Radiological Areas*

The following requirements apply for the release of materials and equipment from radiological areas for use in controlled areas.

6.7.1 In radiological areas established to control surface or airborne radioactive material, material and equipment shall be treated as radioactive material and shall not be released from radiological areas to controlled areas if either of the following conditions exist:

- Measurements of accessible surfaces from contamination, high contamination or airborne radioactivity areas show that either the total or removable contamination levels upon survey exceed the values specified in Appendix D, 10 CFR 835; or,
- Prior use suggests that the contamination levels on inaccessible surfaces are likely to exceed the values specified in Appendix D to this part.

6.7.2 Material and equipment exceeding the total or removable contamination levels specified in Appendix D to this part may be conditionally released for movement on-site from one radiological area for immediate placement in another radiological area only if appropriate monitoring and control procedures are established and exercised. These items shall be routinely monitored, labeled, and controlled in accordance with written procedures.

6.7.3 Material and equipment with fixed contamination levels that exceed the limits specified in Appendix D to this part may be released for use in controlled areas outside of the radiological areas with the following provisions:

- Removable contamination levels shall be below the level specified in Appendix D of this part;
- Materials shall be routinely monitored, clearly labeled, or tagged to alert personnel of the contaminated status;
- appropriate administrative procedures shall be established and exercised to maintain control of these items; and,
- Disassembly to the extent necessary shall be performed to do an adequate survey.

6.7.4 The records for release of material and equipment shall describe the property, date on which the release survey was performed, identity of the individual who performed the survey, type and identification number of the survey instrument used, and results of the survey.

6.7.5 Radiological labeling shall be removed from or defaced on non-radioactive materials prior to release from radiological areas.

## *6.8 Stop Radiological Work Authority*

Radiological Control Technicians and their supervisors, line supervision, and any worker through their supervisor shall have the authority and responsibility to stop radiological work activities for any of the following reasons [see DOE 440.1.7]:

- Inadequate radiological controls;
- Radiological controls not being implemented; or,
- Radiological Control Hold Point not being satisfied.

## *6.9 Transportation of Radioactive Material*

6.9.1 10 CFR 835.1 excludes radioactive material transportation activities that are performed in compliance with applicable DOE Orders from the requirements of 10 CFR 835. However, radioactive material transportation does not include preparation of materials for shipment, packaging and labeling, or performance of surveys required for occupational radiation protection. Therefore, these activities shall be conducted in accordance with 10 CFR 835.

6.9.2 On-site transfers over nonpublic thoroughfares or between facilities on the same site should be performed in accordance with written procedures utilizing pre-approved routes. The procedures or other measures shall include requirements to ensure appropriate monitoring and control of the radioactive material.

6.9.3 On-site transfers over public thoroughfares by non-DOE conveyance shall be performed in accordance with Department of Transportation, state, and local shipping requirements and pre-approved agreements. Onsite transfers over public thoroughfares by DOE conveyance shall be performed in accordance with applicable DOE Orders and should conform with state and local shipping requirements and pre-approved agreements.

6.9.4 Specific arrangements shall be made for receiving packages containing radioactive material, regardless of the means of conveyance, in excess of Type A quantities (as defined in 10 CFR 71.4). These arrangements shall include:

- Making arrangements to receive packages upon delivery or to receive notification of delivery which leads to expeditious receipt of the package;
- Receive notification as soon as practical after arrival of the package and to take possession of the package expeditiously after receiving such notification; and,

- Development and maintenance of written procedures for safely opening packages with due consideration of the type of package and potential hazards present.

## *6.10 Radioactive Source Controls*

Sealed radioactive sources having activities equal to or exceeding the values specified in SOP 24.1, Attachment 2, are considered accountable sealed sources and are subject to the controls established below and shall be used, handled, and stored in a manner commensurate with the hazards associated with operations involving the sources.

6.10.1 Written procedures shall be established and implemented to control accountable sealed radioactive sources. These procedures should establish requirements for source acquisition, receipt, storage, transfer, inventory, leak testing, and usage.

6.10.2 Accountable sealed sources, or their storage containers shall be labeled with the radiation symbol and "CAUTION" or "DANGER RADIOACTIVE MATERIAL". The label shall also provide sufficient information to minimize exposures, such as the radionuclide, the quantity of radioactive material, and the date of quantity estimate. However, such labels are exempt from the normal color scheme of magenta or black on yellow. If the size or configuration of the source precludes application of a suitable label, the label should be attached to the source container or mechanism.

6.10.3 Each accountable sealed radioactive source shall be inventoried at intervals not to exceed six months. This inventory shall:

1. Establish the physical location of each accountable sealed radioactive source;
2. Verify that the associated posting and labeling are adequate; and,
3. Establish that storage locations, containers, and devices are adequate.

6.10.4 Each accountable sealed radioactive source having an activity in excess of 0.005 μCi shall be subject to a source leak test upon receipt, when damage is suspected and at intervals not to exceed six months. Source leak tests shall be capable of detecting radioactive material leakage equal to or exceeding 0.005 μCi.

6.10.5 Periodic leak tests need not be performed if the source has been documented to have been removed from service. Such sources shall be stored in a controlled location and subject to periodic inventory and subject to leak testing prior to being returned to service.

6.10.6 If a source is located in an area that is unsafe for human entry (such as due to operational or environmental constraints), then periodic inventories and leak tests need not be performed. When the conditions that restrict access to the area have been terminated, the inventory and leak test should be performed before allowing uncontrolled access to the area.

6.10.7 If an accountable sealed radioactive source is found to be leaking radioactive material at a level exceeding 0.005 μCi, then controls shall be established to prevent the escape of radioactive

material to the workplace. These controls should include wrapping or containing the source, applying appropriate labels, and removing the source from service.

6.10.8 Procurement of radioactive sources should be coordinated with the RCM and RSO

6.10.9 Receipt surveys of radioactive material shipments should be performed by the RCTs.

6.10.10 Sealed radioactive sources, including radiography sources, should not be brought on-site by external organizations without the prior knowledge and approval of the RSO.

6.10.11 Items and containers may be excepted from the radioactive material labeling requirements of § 835.605 when:

- Used, handled, or stored in areas posted and controlled in accordance with this subpart and sufficient information is provided to permit individuals to take precautions to avoid or control exposures; or
- The quantity of radioactive material is less than one tenth of the values specified in appendix E of this part; or
- Packaged, labeled, and marked in accordance with the regulations of the Department of Transportation or DOE Orders governing radioactive material transportation; or
- Inaccessible, or accessible only to individuals authorized to handle or use them, or to work in the vicinity; or
- Installed in manufacturing, process, or other equipment, such as reactor components, piping, and tanks; or
- The radioactive material consists solely of nuclear weapons or their components.

Radioactive material labels applied to sealed radioactive sources may be excepted from the color specifications of § 835.601(a).

## *6.11 Solid Radioactive Waste Management*

6.11.1 Requirements

- DOE 5820.2A describes how solid radioactive waste is treated, packaged, stored, transported, and disposed;
- Radiological operations generating radioactive waste shall be designed and developed to promote minimization and permit segregation, monitoring, treatment, storage, and disposal; and,
- Radioactive waste minimization goals and practices shall be developed and implemented [DOE 5820.2A].

6.11.2 Waste Minimization

A radioactive waste minimization program shall be in effect to reduce the generation of radioactive waste and spread of contamination from Contamination, High Contamination, or Airborne Radioactivity Areas [see DOE 5820.2A].

## 7.0 RECORDS

Survey results are to be maintained as required by SOP 38.3 (Reference 6).

## 8.0 ATTACHMENTS

***8.1*** *Surface Residual Radioactivity Guidelines*

***8.2*** *Sample Contamination Tag*

***8.3*** *Guidelines for Contamination Control Practices*

***8.4*** *Checklist for Reducing Occupational Radiation Exposure*

***8.5*** *Physical Access Controls for High and Very High Radiation Areas*

***8.6*** *Guidelines for Personnel Contamination Monitoring with Hand Held Instruments*

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# ATTACHMENT 8.1

## SURFACE RESIDUAL RADIOACTIVE GUIDELINES

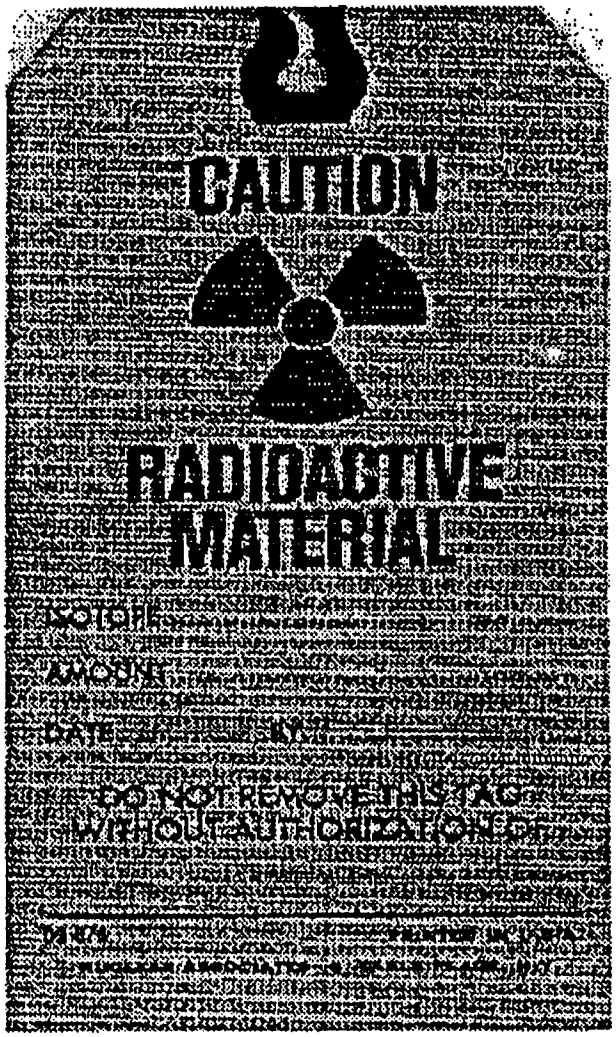
Attachment 8-1. Surface Contamination Values[1] in dpm/100 $cm^2$

| Radionuclide | Removable [2,4] | Total (Fixed + Removable)[2,3] |
|---|---|---|
| U-nat, U-235, U-238, and associated decay products | [7] 1,000 | [7] 5,000 |
| Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 | 20 | 500 |
| Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 | 200 | 1,000 |
| Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above[5] | 1,000 | 5,000 |
| Tritium and tritiated compounds[6] | 10,000 | N/A |

[1] The values in this appendix, with the exception noted in footnote 5 below, apply to radioactive contamination deposited on, but not incorporated into the interior or matrix of, the contaminated item. Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides apply independently.
[2] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
[3] The levels may be averaged over one square meter provided the maximum surface activity in any area of 100 $cm^2$ is less than three times the value specified. For purposes of averaging, any square meter of surface shall be considered to be above the surface contamination value if: (1) from measurements of a representative number of sections it is determined that the average contamination level exceeds the applicable value; or (2) it is determined that the sum of the activity of all isolated spots or particles in any 100 $cm^2$ area exceeds three times the applicable value.
[4] The amount of removable radioactive material per 100 $cm^2$ of surface area should be determined by swiping the area with dry filter or soft absorbent paper, applying moderate pressure, and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. (Note - The use of dry material may not be appropriate for tritium.) When removable contamination on objects of surface area less than 100 $cm^2$ is determined, the activity per unit area shall be based on the actual area and the entire surface shall be wiped. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.
[5] This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.
[6] Tritium contamination may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may migrate to the surface in order to ensure the surface contamination value provided in this appendix is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a "Total" value does not apply.
[7] **(alpha)**

# ATTACHMENT 8.2

## SAMPLE CONTAMINATION TAG


CAUTION
RADIOACTIVE
MATERIAL
ISOTOPE
AMOUNT
DATE
BY
DO NOT REMOVE THIS TAG
WITHOUT AUTHORIZATION OF

# ATTACHMENT 8.3

## GUIDELINES FOR CONTAMINATION CONTROL PRACTICES

# GUIDELINES FOR CONTAMINATION CONTROL PRACTICES

Selection of Protective Clothing (PC)

1. Workers should inspect protective clothing prior to use for tears, holes, or split seams that would diminish protection. Any defective items should be replaced with intact protective clothing.

2. Protective clothing as prescribed by Hazardous Work Permit should be selected based on the contamination level in the work area, the anticipated work activity, worker health considerations, and regard for nonradiological hazards that may be present. Table 8.3-1 provides general guidelines for selection. As referenced in the table, a full set and double set of protective clothing typically includes:

   Full Set of PCs

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

   Double Set of PCs

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

3. Cotton glove liners may be worn inside standard gloves for comfort, but should not be worn alone or considered as a layer of protection.

4. Shoecovers and gloves should be sufficiently durable for the intended use. Leather or canvas work gloves should be worn in lieu of or in addition to standard gloves for work activities requiring additional strength or abrasion resistance.

5. Use of industrial safety equipment, such as hard hats, in Contamination, High Contamination, and Airborne Radioactivity Areas should be controlled by the Hazardous Work Permit. Reusable industrial safety equipment designated for use in such areas should be distinctly colored or marked.

6. Shoe covers and gloves should be secured or taped at the coverall legs and sleeves when necessary to prevent worker contamination. Tape should be tabbed to permit easy removal.

7. Supplemental pocket or electronic dosimeters should be worn outside the protective clothing, in a manner accessible to the worker. Workers should protect such dosimeters from contamination by placing them in an outer coverall pocket or in plastic bags or pouches.

8. Outer personal clothing should not be worn under protective clothing for entry to High Contamination Areas or during work conditions requiring a double set of protective clothing.

Removal of Protective Clothing

Potentially contaminated protective clothing should be removed without spreading contamination and in particular without contaminating the skin. Workers should be instructed not to touch the skin or place anything in the mouth during protective clothing removal.

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

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

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

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

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

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

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

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

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

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

Use of Multiple Step-Off Pads

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

    a. The inner step-off pad should be located immediately outside the highly contaminated work area, but still within the posted area;
    b. The worker should remove highly contaminated outer clothing prior to stepping on the inner step-off pad;
    c. Additional secondary step-off pads, still within the posted area, may be utilized as necessary to restrict the spread of contamination out of the immediate area; and,
    d. The final or outer step-off pad should be located immediately outside the Contamination Area.

Table 8.3-1. Guidelines for Selecting Protective Clothing (PC)

| | REMOVABLE CONTAMINATION LEVELS | WORK ACTIVITY | LOW (1 to 10 times 10 CFR 835, Appendix D values) |
|---|---|---|---|
| **MODERATE** (10 to 100 times 10 CFR 835, Appendix D values) | **HIGH** (> 100 times 10 CFR 835, Appendix D values) | Routine | Full set of PCs |
| Full set of PCs | Full set of PCs, double gloves, double shoecovers | Heavy work | Full set of PCs, work gloves |
| Double set of PCs, work gloves | Double set of PCs, work gloves | Work with pressurized or large volume liquids, closed system breach | Full set of non-permeable PCs |
| Double set of PCs (outer set non-permeable), rubber boots | Double set of PCs and non-permeable outer clothing, rubber boots | | |

Note:

For hands-off tours or inspections in areas with removable contamination at levels 1 to 10 times the values in Appendix D, 10 CFR 835, labcoats, shoecovers, and gloves may be used instead of full PCs.

# ATTACHMENT 8.4

## CHECKLIST FOR REDUCING OCCUPATIONAL RADIATION EXPOSURE

# CHECKLIST FOR REDUCING OCCUPATIONAL RADIATION EXPOSURE

Preliminary Planning and Scheduling

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

Preparation of Technical Work Documents

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

Temporary Shielding

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

Rehearsing and Briefing

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

Performing Work

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

# ATTACHMENT 8.5

## PHYSICAL ACCESS CONTROLS FOR HIGH AND VERY HIGH RADIATION AREAS

# PHYSICAL ACCESS CONTROLS FOR HIGH AND VERY HIGH RADIATION AREAS

One or more of the following features should be used for each entrance or access point to a High Radiation Area and shall be used for each entrance or access point to a High Radiation Area where radiation levels exist such that an individual could exceed a whole body dose of 1 rem in any one hour:

- A control device that prevents entry to the area when high radiation levels exist or upon entry causes the radiation level to be reduced below that level defining a High Radiation Area;
- A device that functions automatically to prevent use or operation of the radiation source or field while personnel are in the area;
- 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;
- Entryways that are locked, except during periods when access to the area is required, with positive control over each entry;
- Continuous direct or electronic surveillance that is capable of preventing unauthorized entry; and,
- A control device that automatically generates audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source.

In addition to the above requirements, additional measures shall be implemented to ensure personnel are not able to gain access to Very High Radiation Areas.

Physical access controls over High and Very High Radiation Areas shall be established in a manner that does not prevent an individual from leaving the area.

# ATTACHMENT 8.6

## GUIDELINES FOR PERSONNEL CONTAMINATIONMONITORING WITH HAND HELD INSTRUMENTS

# GUIDELINES FOR PERSONNEL CONTAMINATION MONITORING WITH HAND-HELD SURVEY INSTRUMENTS

General Requirements

1. Verify that the instrument is in service, set to the proper scale, and the audio output can be heard during frisking.

2. Hold probe less than 1/2 inch from surface being surveyed for beta and gamma contamination, approximately 1/4 inch for alpha contamination.

3. Move probe slowly over surface, approximately 2 inches per second.

4. If the count rate increases during frisking, pause for 5 to 10 seconds over the area to provide adequate time for instrument response.

5. If the count rate increases to a value greater than a pre-established contamination limit or the instrument alarms, remain in the area and notify Radiological Control personnel.

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

Performance of Monitoring:

1. Frisk the hands before picking up the probe.

2. Perform the frisk in the following order:

   a. Head (pause at mouth and nose for approximately 5 seconds)
   b. Neck and shoulders
   c. Arms (pause at each elbow for approximately 5 seconds)
   d. Chest and abdomen
   e. Back, hips and seat of pants
   f. Legs (pause at each knee for approximately 5 seconds)
   g. Shoe tops
   h. Shoe bottoms (pause at sole and heel for approximately 5 seconds)
   i. Personnel and supplemental dosimeters.

3. Return the probe to its holder and leave the area. The probe should be placed on the side or face up to allow the next individual to monitor their hands before handling the probe.

# TENNELEC SERIES 5 LOW BACKGROUND COUNTING SYSTEM

STANDARD OPERATING PROCEDURE

## 1.0 INTRODUCTION

Gas flow proportional counting is recognized as one of the most practical methods for performing gross alpha and/or beta measurements. Measuring the gross radioactivity in a sample provides a simple direct method for screening samples. Most of the natural and man-made radionuclides of interest decay by alpha emission or beta decay. Their detection in the proportional counter can be correlated to the number of atoms decaying in the sample per unit time that is, by definition, the activity.

There are many significant advantages to using a gas-flow proportional system for gross quantitative measurements. The selection of this technique is often related to the types of samples to be measured. Considerations for sample preparation, sample size, desired detection limit, and post-process wastes are also significant issues underlying the choice of the counting method. Gas flow proportional counting systems are capable of providing accurate radioactivity measurements, at and below naturally occurring levels, for a variety of sample types.

### *1.1 Purpose*

The purpose of this document is to provide personnel operating the Tennelec Series 5 low background counting system (TS5) and personnel who support those operations with one procedure for the instrument's operation. This will ensure the quality and continuity of data, and minimize duplicate efforts.

### *1.2 Applicability*

This procedure is applicable to all LEHR site personnel, contractors and subcontractors using the TS5 for the purposes specified in this procedure.

### *1.3 Responsibilities*

All personnel operating the TS5 are responsible for adherence to the requirements of this procedure.

1.3.1 Instrument Custodian

The TS5 is the property of the United States Department of Energy (DOE). DOE shall appoint one person who shall be responsible for the following:

Maintenance of the instrument by the manufacturer or equivalent technical personnel.

Ensuring that only appropriately trained or supervised personnel are permitted to utilize the instrument. This shall be verified through observation by the instrument custodian.

Accountability for radioactive sources associated with the instrument

Controlling storage, handling and disposal of sample material after use in accordance with section 7.2 and reference 9.3.

1.3.2 Operators

All personnel who will utilize the TS5 in the performance of their duties are responsible for:

Operating the instrument in accordance with the requirements of this procedure.

Keeping the laboratory clean and free of contamination.

Properly segregating samples after analysis into contaminated and non contaminated disposal locations.

# 2.0 FACTORS AFFECTING SAMPLE MEASUREMENTS

There are several factors that can directly affect the quality of results using a gas flow proportional counter. The following are some of the most common factors.

## *2.1 Gas Composition and Quenching*

While many gases work in an ionization detector, this is not true for proportional detectors. The quality and composition of counting gas has a direct effect on the performance of the counter. In proportional detectors, the output signal is derived from the collection of free electrons. Any creation of negative ions competes with free electron production and collection; therefore affects the proportionality of the output pulses. The fill gas must not contain any molecular gas components that are strong electron attractors that form anions. The noble gases are ideal for proportional detectors.

Another consideration in the selection of the counting gas for proportional detectors is that secondary Townsend avalanches are infrequent. These secondary avalanches result when ultraviolet photons produced by atomic de-excitation occurs in the gas. The addition of a quenching agent, usually a polyatomic gas such as methane that is added to the argon gas, suppresses further ionization from excited gas atoms. The quenching agent absorbs the UV photons and then de-excites by dissociation or radioactive modes of de-excitation that do not result in localized avalanches in the gas. As discussed above, when these secondary avalanches do occur, they may result in higher background or spurious counts in the detector. The most commonly used counting gas, P-10, utilizes this principle in its 90% argon and 10% methane mixture.

## *2.2 Background Radiation*

The background radiation levels associated with both the instrument's environment and other background radiations associated with events taking place outside the sample itself will have an affect on the instruments performance. The following is a discussion of the means by which this affect is minimized.

### 2.2.1 Voltage Discrimination

The counting gas is not sensitive to fast electrons as it is to alphas and heavily charged particles; therefore, operating the detector at the alpha plateau voltage results in beta output pulses that do not exceed the counting voltage threshold. Under these conditions, many possible sources of background are eliminated. The observed background in a proportional detector is a function of the threshold setting that defines the minimum ionization required for a count to be recorded.

### 2.2.2 Environmental Background Radiation

Another phenomenon which influences all counting is the inevitable background produced by environmental radiation. Several sources of radiation can affect the sensitive scintillation solution and the detection process.

- Cosmic radiation which is variable and influenced by sun spot activity and barometric pressure.
- Fallout from nuclear tests which might be contained in the air.
- The building materials of the laboratory which contain radioactivity.
- Natural radioactivity in detector materials, associated equipment, supports, shielding and circuitry near the detector.
- Stray radiation from sources of activity in the laboratory, or apparatus producing radiation such as x-rays or magnetic fields.

The sample in the counting chamber and the gas flow proportional detector is surrounded by lead, typically about two inches (5 cm) in all directions. This lowers the background to reasonable proportions for all but very low activity measurements.

The instrument should optimally be installed away from all sources of radiation, including magnetic sources. It is permissible to store small check sources of low activity in the same room as the instrument so long as they are not stored immediately adjacent to the instrument.

## *2.3 Sample and Guard Detectors*

The sample detector is a 2.25 inch diameter pancake style gas-flow proportional detector. The detector features twin anodes for excellent counting uniformity and an ultra-thin 80 g/cm$^2$ entrance window for high counting efficiency.

The guard detector is a large-area gas-flow proportional detector with six anode wires for excellent counting uniformity. The bottom of the guard detector is contoured to encompass the sample detector, thus reducing the exposure of the sample detector to un-guarded external background sources.

### *2.4 User Specified Parameters*

2.4.1 Count Time

Both the length of count and the number of counts per sample will affect the outcome of the analysis. A longer count time will result in a decrease in the Lower Limit of Detection (LLD), and subsequent Minimum Detectable Activity (MDA), achieved during the analysis. Increasing the number of counts associated with an individual sample will increase the level of confidence associated with that sample analysis.

Count times and the number of times to count each sample are specified in section 5 for those individual analysis.

## 3.0 OPERATION

### *3.1 Equipment*

The following equipment will be required for the performance of the analysis described in this procedure. Additional equipment may be required if additional analysis are to be performed.

3.1.1 Tennelec Series 5

This procedure has been written for use of the Oxford Instruments Tennelec Series 5 Gas Flow Proportional Counting System. If another type of gas flow proportional counting system is to be used, this procedure should be changed to reflect the equipment used.

Prior to use, the TS5 shall be installed by qualified personnel in accordance with the manufacturers instructions and in a location described in section 2.2.2.

3.1.2 Standards

Electroplated standards for both beta and alpha radiations are required for the performance of High Voltage Plateaus, Efficiency Analysis and daily source checks. Standards will be selected based on nuclides of interest.

Standards should be checked annually for leakage of source material. Standards should be handled carefully to minimize scratching which may lead to source material leakage.

3.1.3 Sample Media

For surface activity measurements, a media which is wiped over the surface being assayed is needed. This media is typically a 47 mm cloth swatch or similar material.

## *3.2 Precautions*

The following precautions are to be observed during the performance of all activities associated with this procedure.

3.2.1 Radiological Controls

Since the analysis described in this procedure are being performed to determine the level of radioactive content in a sample media, standard radiological control practices specified in reference 9.4 shall be used to control worker exposures and the potential spread of radioactive contamination during sampling operations.

## *3.3 Prerequisites*

3.3.1 Instrument Setup

Prior to use, the instrument shall be installed by qualified personnel in accordance with the manufacturers instructions. A high voltage plateau, efficiency count procedure and efficiency regions of interest shall be performed in accordance with section 4.1 of this procedure.

3.3.2 Establishing Counting Procedures

Procedures shall be created for use during analysis are described in section 5. These procedures specify how the instrument controls the counting of individual sample sets and defines parameters to be applied to that sample's analysis. The parameters to be included in the counting procedure associated with the individual analysis are described in section 5.

## *3.4 Sample Collection*

Samples shall be collected in accordance with the requirements of the procedures which direct them to be taken.

Samples shall be prepared in an area and in a manner which minimizes the chance of cross contamination of samples and surfaces. Radiological controls procedures to be followed when handling potentially radioactive materials are specified in reference 9.4.

## *3.5 Sample Counting*

All samples will be field checked prior to being counted by the TS5. Once collected, samples shall be placed on metal planchets and on sample carrier(s), for loading in the instrument. A Group plate

**must** precede all samples placed onto right sample carrier holder for counting. An end plate **must** be placed after the last sample carrier of a particular survey.

Double click the Eclipse icon on the Windows 95 desktop. Click the title Procedure located on the title bar. A drop down window will appear, chose Select. Another window will appear. On the left side of window is the Group column, select the group associated with the samples to be counted. Next, select the procedure to be used for sample analysis, then select the appropriate sample reporting format. **NOTE: The Eclipse software will select a default reporting format. This reporting format has been modified to meet the LEHR Project reporting criteria.** Click the OK button when finished. To start the sample counting routine selected click the GO button on the toolbar.

# 4.0 PERFORMANCE VERIFICATION

## *4.1 Calibration*

Calibration of the TS5 is required prior to its use. Refer to reference 9.1 Chapter 10 on the correct calibration procedure. Additionally, any changes in the instrument location, large verifiable changes in ambient background or repairs to the instrument will require a new calibration.

## *4.2 Daily Source and Background Checks*

Performance of the instruments response to ambient background and known calibration standards will be performed in accordance with LEHR RPP. A set of three planchets have been set aside for daily checks. Each of the three planchets are marked with indelible ink on the bottom; one for the beta standard, one for the alpha standard, and one for background. These planchets will be stored in a zip lock style container in a secure location to prevent use for routine smear counting.

### 4.2.1 Performance of Daily Checks

Retrieve the standards from the source cabinet. Place the standards in the appropriate planchet. NOTE: One planchet should be empty. Place the three planchets in to sample carriers. Select the Group A plate and place it on the right side carrier holder. Place the three planchets on top of the group A plate. Place an End plate on the last planchet. It is not important which planchet, source or background, is counted first.

Double click the Eclipse icon on the Windows 95 desktop. Click the title Procedure located on the title bar. A drop down window will appear, chose Select. Another window will appear. On the left side of window is the Group column, select the Group A. Next, select Daily Source and Background Check. Place a check mark in the box next to Print Report Automatically. **NOTE: The Eclipse software will select a default reporting format. This reporting format has been modified to meet the LEHR Project reporting criteria.** Click the OK button when finished. To start the sample counting routine selected click the GO button on the toolbar.

Data from daily source and background checks will be recorded on the appropriate forms stored in the Daily Instrument Checklist binder. Any unsatisfactory reading will require and additional performance of the daily checks. If three unsatisfactory readings are reported, notify the instrument custodian. **NOTE: The TS5 shall not be used until all corrective actions have been completed as verified by the instrument custodian.**

### *4.3 Level of QA*

Analytical options available to support data collection activities are typically presented in five general categories. Of these, only two will apply to analysis associated with using the TS5. These are described below.

4.3.1 Level II - Field Analysis

This level is typically characterized by the use of portable analytical instruments which can be used in field laboratories. Depending upon the types of contaminants, sample matrix, and personnel skills, both qualitative and quantitative data can be obtained. This level of quality will be applicable to most analysis performed using the LEHR Site TS5.

4.3.2 LEVEL IV - Contract Laboratories Services

In the event that the procedures directing the performance of the samples described in this procedure require, additional outside validation of duplicate samples may be analyzed to this level of quality.

## 5.0 5.0 SCOPE OF USE

This document describes the procedures to be followed when utilizing the TS5 for specific analysis. This section will delineate those specific analysis and direct the operator how to utilize this procedure to perform those analysis.

### *5.1 Analysis of Smears*

This section will describe the procedures to be followed during the performance of the above named analysis.

5.1.1 Creating a Procedure

A counting procedure for routine smear counting has been created in accordance with section 12 of reference 9.1.

5.1.2 Sample Preparation

Samples will be carried to the LEHR Count Room in a closed zip lock style bag. Samples shall be placed onto metal or paper planchets in an area designated by the instrument Custodian. Planchets containing samples will be placed on TS5 sample carriers in the order in which the samples were

collected. TS5 sample carriers are number coded 1-100, it is important to use sample carriers with sequential numbering.

5.1.3 Instrument Operation

Ensure the TS5 is setup and operating as described in section 3.3 and that a daily source and background check has been performed within the past 23 hours. Review the daily source and background check data to ensure that the instrument is operating within specification and in accordance with additional requirements specified in procedures directing the use of the instrument. Performance of daily checks are discussed in section 4 of this procedure.

Double click the Eclipse icon on the Windows 95 desktop. Click the title Procedure located on the title bar. A drop down window will appear, chose Select. Another window will appear. On the left side of window is the Group column, select the Group whose plate will precede samples. Next, select Routine Smears. Place a check mark in the box next to Print Report Automatically. **NOTE: The Eclipse software will select a default reporting format. This reporting format has been modified to meet the LEHR Project reporting criteria.** Click the OK button when finished. To start the sample counting routine selected click the GO button on the toolbar.

Verify printer is online and has sufficient paper.

NOTE: INFORMATION CONCERNING SAVING SAMPLE DATA IS CONTAINED IN SECTION 6.2. SAMPLE DATA SHOULD BE SAVED WHEN PERFORMING SURVEYS IN ACCORDANCE WITH REFERENCE 9.2.

## *5.2 Analysis of Air Samples*

This section will describe the procedures to be followed during the performance of the above named analysis.

5.2.1 Creating a Procedure

A counting procedure for Air Sample counting has been created in accordance with section 12 of reference 9.1.

5.2.2 Sample Preparation

Samples will be carried to the LEHR Count Room in a closed zip lock style bag. Samples shall be placed onto metal or paper planchets in an area designated by the instrument Custodian. Planchets containing samples will be placed on TS5 sample carriers in the order in which the samples were collected. TS5 sample carriers are number coded 1-100, it is important to use sample carriers with sequential numbering.

5.2.3 Instrument Operation

Ensure the TS5 is setup and operating as described in section 3.3 and that a daily source and background check has been performed within the past 23 hours. Review the daily source and

background check data to ensure that the instrument is operating within specification and in accordance with additional requirements specified in procedures directing the use of the instrument. Performance of daily checks are discussed in section 4 of this procedure.

Double click the Eclipse icon on the Windows 95 desktop. Click the title Procedure located on the title bar. A drop down window will appear, chose Select. Another window will appear. On the left side of window is the Group column, select the Group whose plate will precede samples. Next, select Air Samples . Place a check mark in the box next to Print Report Automatically. **NOTE: The Eclipse software will select a default reporting format. This reporting format has been modified to meet the LEHR Project reporting criteria.** Click the OK button when finished. To start the sample counting routine selected click the GO button on the toolbar.

Verify printer is online and has sufficient paper.

# 6.0 DATA STORAGE

Since the OXFORD TS5 is a computer processor based instrument, information associated with both data quality and individual sample data may be stored on both electronic and physical media.

## *6.1 Printing and Storage of QA Data*

QA data associated with the systems performance can be accessed by starting the Eclipse program and selecting File and then selecting Open. All files associated with the Eclipse program will be displayed in the drop down window. To open the QA file either double click the appropriate file name or highlight the file name by clicking the appropriate file and then selecting OK. The results of individual High Voltage Plateaus and Efficiency Counts are stored on the system's primary hard drive under the Eclipse sub-directory. The resultant information from each High Voltage Plateau and Efficiency Count shall be printed and retained in a binder by the instrument's custodian for future reference. To print the QA data, open the appropriate file as described above and click the printer icon located on the toolbar.

## *6.2 Printing and Storage of Sample Data*

Results of the sample analysis will be printed automatically by the instrument, when directed by the operator, as the samples are analyzed using the external printer.

Data associated with a specific sample analysis may be retained for future use by copying it to disk with the external disk drive. This shall be performed when required by the procedures initially directing the samples to be obtained.

# 7.0 CONTROL OF SAMPLES AFTER ANALYSIS

In order to properly minimize the production of radioactive wastes, any samples identified during analysis as being contaminated shall be handled and segregated as described below.

### *7.1 Responsibilities*

The instrument custodian is responsible for control and disposal of samples and sample containers.

Personnel operating the instrument are responsible for controlling their samples after use in accordance with the requirements of this procedure.

### *7.2 Sample Controls*

Samples which are identified during analysis as containing radioactive materials in excess of site limits shall be placed in the location designated by the instrument custodian for contaminated samples. In order to track the cumulative activity of the samples requiring disposal, the sample shall be placed into a zip-lock style bag and marked indicating it's identity and contents. A copy of the sample results shall be placed in a secure storage location determined by the instrument custodian. These samples shall be handled and disposed of in accordance with the requirements specified in reference 9.3.

Samples which are identified during analysis as not containing radioactive materials shall be placed in the location designated by the instrument custodian for non contaminated samples. These samples shall be disposed of by the instrument custodian in accordance with LEHR procedures.

The instrument custodian shall initiate appropriate steps to ensure the proper disposal, handling, segregation and storage of samples. This may include:

- Posting written instructions in the vicinity of the instrument identifying storage locations and associated requirements.
- Performing periodic recounts of samples from both the contaminated and non-contaminated storage locations to verify analytical data.
- Monitoring the use of the instrument by site personnel.

## 8.0 RECORDS

Records generated as the result of operations associated with this procedure shall be retained in accordance with the following requirements:

- Results of High Voltage Plateaus and Efficiency Counting data shall be retained by the instrument custodian in a binder located in the vicinity of the instrument. The last year's data shall be retained in this manner. Previous year's data shall be retained in accordance with LEHR project records procedures. Copies of this quality related data shall be made available to personnel using the instrument for inclusion in contractor project records.
- Results of sample analysis shall be retained in accordance with the requirements of the procedure(s) requiring the use of the instrument.

# 9.0 REFERENCES

***9.1*** *OXFORD Instruments, "Series 5 HP & XLB Instrument Operations Manual Version 1.17", 1997*

***9.2*** *U.S. NRC, "NUREG/CR-5849, Manual for Conducting Radiological Surveys in Support of License Termination", June 1992*

***9.3*** *PNL/LEHR, "Waste Management Plan for the Laboratory For Energy Related Health Research", March 1994*

***9.4*** *D.O.E./LEHR, "LEHR Radiological Control Manual", July 1993*

# LIQUID SCINTILLATION ANALYZER (LSC)

STANDARD OPERATING PROCEDURE

## 1.0 INTRODUCTION

Liquid Scintillation Counting today is the most sensitive and widely used technique for the detection and quantification of radioactivity. This measurement technique is applicable to all forms of nuclear decay emissions (alpha and beta particle, electron capture, and gamma ray emitting radionuclides). Liquid scintillation counting is an analytical technique in which a sample is combined with a liquid chemical medium capable of converting the kinetic energy of nuclear emissions into emitted photons. These photons are subsequently detected by opposing photomultiplier tubes enclosed within a light-tight detection chamber. This chamber is constructed of lead to reduce the effects of external radiation. The pulses from the photomultiplier tubes (PMT), are accumulated in the Spectralyzer™ spectrum analyzer circuit and stored. This spectrum of the sample is then analyzed in 4,000 linear channels for visual presentation and quantification.

### *1.1 Purpose*

The purpose of this document is to provide personnel operating the Liquid Scintillation Analyzer and personnel who support those operations with one procedure for the instrument's operation. This will ensure the quality and continuity of data, and minimize duplicate efforts.

### *1.2 Applicability*

This procedure is applicable to all LEHR site personnel, contractors and subcontractors using the LSC for the purposes specified in this procedure.

### *1.3 Responsibilities*

All personnel operating the LSC are responsible for adherence to the requirements of this procedure.

1.3.1 Instrument Custodian

The LSC is the property of the University of California, Davis (UCD). UCD shall appoint one person who shall be responsible for the following:

- Maintenance of the instrument by the manufacturer or equivalent technical personnel
- Ensuring that only appropriately trained or supervised personnel are permitted to utilize the instrument. This shall be verified through observation by the instrument custodian.

- Accountability for radioactive sources associated with the instrument
- Controlling storage, handling and disposal of sample vials after use in accordance with reference 9.3.

1.3.2 Operators

All personnel who will utilize the LSC in the performance of their duties are responsible for:

- Operating the instrument in accordance with the requirements of this procedure.
- Keeping the laboratory clean and free of contamination.
- Properly segregating samples after analysis into contaminated and non contaminated disposal locations.

## *1.4 Definitions*

**Automatic Efficiency Control** - A method used by the Tri-Carb LSC to compensate for the effect of quenching on the sample spectrum. AEC extracts the equivalent keV data for the specified region from the Spectralyzer spectrum analyzer. AEC is based on TSIE or SIE.

**Chemiluminescence** - Random single photon events generated because of the chemical interaction of sample components. The coincidence circuit excludes most chemiluminescent events except at high rates.

**Chemical Quenching** - A reduction in scintillation intensity seen by the photomultiplier tubes due to materials present in the scintillation solution interfering with the process leading to the production of light. The result is fewer photons per kev of beta particle energy and usually a reduction in counting efficiency.

**Coefficient of Variation** - The ratio of the standard deviation of a distribution to its arithmetic mean.

**Dual Label** - Two different radionuclides in a sample.

**Efficiency Tracing** - A technique that uses spectral distribution analysis to calculate certain absolute activities of the sample at 100% efficiency.

**External Standard** - A radioactive source placed adjacent to the liquid standard to produce scintillations in the sample thus monitoring the sample's level of quench.

**Figure of merit** - A term applied to a numerical value used to characterize the performance of a system. In liquid scintillation counting, specific formulas have been derived for quantitatively comparing certain aspects of counter performance and cocktail performance.

**Full Spectrum DPM** - Advance spectrum analysis technique used to separate the individual radionuclide spectra in dual-label samples to calculate DPM results.

**Lower Limit** - Defines the lower energy level of a region or channel.

**Optical Quenching** - A reduction in the scintillation intensity seen by the photo-multiplier tubes due to absorption of the scintillation light by material present in solution or deposited on the walls of the sample container or optic. The result is fewer photons per kev of beta particle energy and usually a reduction in counting efficiency.

**Photoluminescence** - Delayed and persistent emission of single photons of light following activation by radiation such as ultraviolet.

**Quench Indicating Parameter** - A value indicating the level of quenching in a sample (may be SIE, SIS, SCR, ESR or TSIE).

**Sigma, Percent** - An expression of the standard deviation as a percentage. It is numerically equal to 100 times the Standard Deviation divided by the mean.

**Single Label** - Only one radionuclide in a sample.

**Spectral Index of External Standard** - A number obtained from the spectrum analyzer that is calculated from the spectral distribution of the external standard and is used as an index of the level of quenching in the sample.

**Spectral Index of the Sample** - A number obtained from the Spectralyzer spectrum analyzer that is calculated from the spectral distribution of the sample and is used as an index of the level of quenching in the sample.

**Spectralyzer™ Spectrum Analyzer** - The spectral-analytical section of the Packard Tri-Carb Liquid Scintillation Counter.

**Spillover** - A term used to describe the situation in dual-label counting where a portion of the spectrum from one radionuclide is included in the region used to count the other radionuclide.

**Transformed Spectral Index of the External Standard** - A number obtained from the Spectralyzer spectrum analyzer that is calculated from the spectral distribution of the external standard and is used as an index of the level of quenching in the sample.

# 2.0 FACTORS INFLUENCING OPERATION

## *2.1 Environmental Conditions*

The instrument can be adversely affected by a range of environmental conditions and should be installed and used in a location which minimizes these affects. Once the instrument has been installed in an appropriate location, fluctuations in environmental conditions, within the ranges specified below, should not affect the machine's performance.

2.1.1 Temperature

The instrument should be located in a controlled environment having an ambient temperature range of 59°F to 95°F.

2.1.2 Humidity

The instrument should be located in a controlled environment having an ambient humidity range of 30% to 85%, noncondensing.

## *2.2 Background Radiation*

The background radiation levels associated with both the instrument's environment and other background radiations associated with events taking place outside the sample itself will have an affect on the instruments performance. The following is a discussion of the means by which this affect is minimized.

2.2.1 Electronic Background Discrimination

The sensitivity of detecting radioactive events is limited by the presence of background radiation. To increase counting sensitivity, the ratio of count rate to background must be maximized. Recent advances in counter technology allow the discrimination of background radiation from sample activity. This new technique supplements coincidence counting and is based on Time-Resolved Spectrum Analysis. Time-Resolved spectrum analysis can be used to exclude some of the background pulses from the beta spectrum by using pulse index discrimination. This unique feature gives superior counting performance and low-level counting sensitivity. For more information see the Electronic Background Discrimination section of reference 9.1.

2.2.2 Environmental Background Radiation

Another phenomenon which influences all counting is the inevitable background produced by environmental radiation. Several sources of radiation can affect the sensitive scintillation solution and the detection process.

- Cosmic radiation which is variable and influenced by sun spot activity and barometric pressure.
- Fallout from nuclear tests which might be contained in the air.
- The building materials of the laboratory which contain activity.
- Natural activity in glass sample vials and the walls of the photomultiplier tubes.
- Stray radiation from sources of activity in the laboratory, or apparatus producing radiation such as x-rays or magnetic fields.

The sample in the counting chamber and the PMTs are surrounded by lead, typically about two inches (5 cm) in all directions. This lowers the background to reasonable proportions for all but very low activity measurements.

The instrument should optimally be installed away from all sources of radiation, including magnetic sources. It is permissible to store small check sources of low activity in the same room as the instrument so long as they are not stored immediately adjacent to the instrument. Such check sources do not refer to the LSC standards normally stored in the machine.

## *2.3 Sample Interferences and Considerations*

### 2.3.1 Coincidence Circuitry

The coincidence requirement that each PMT produce a response sets a limit of detection. The beta particle must have sufficient energy to produce at least two photons and one must interact with each PMT. Inevitably, because the photons are radiated in all directions, some will be lost despite the reflector. Thus, the probability of a photon entering each PMT decreases with decreasing beta particle energy. Below a few keV of energy the yield of photons, under ideal conditions, is 7-8 photons per keV.

The photocathode of a PMT is not 100% efficient. The conversion efficiency from a photon to a photoelectron (the quantum efficiency) is only about 30%. Hence, when dealing with H-3, where the average beta energy is less than 6 keV, this radionuclide cannot be detected at 100% efficiency as many events do not produce a sufficient number of photons.

The net effect of these two factors creates a threshold of detection below which an event is unlikely to be recorded. This level is referred to as the coincidence threshold and in energy terms occurs below 1 keV.

### 2.3.2 Chemical Luminescence/Photoluminescence

Chemiluminescence is the production of light as a result of a chemical reaction. This most typically occurs in samples of alkaline pH and/or containing peroxides, when mixed with emulsifier-type scintillation cocktails.

Photoluminescence results in the excitation of the cocktail and/or vial by ultraviolet light. This can occur by exposure to sunlight or florescent lights used in the laboratory.

In terms of decay, there is a difference between chemiluminescence and photoluminescence in that chemiluminescence has a fairly slow decay time (from 0.5 hr. to more than a day dependent on temperature) while photoluminescence decays more rapidly (less than 0.1 hr.).

In terms of spectral analysis, there is no apparent difference between chemiluminescence and photoluminescence. Luminescence is a single photon event and is registered as a count due to the probability of having coincident events at high luminescent activity. The pulse height distribution

depends only slightly on the intensity of the reaction. The spectrum has a pulse height distribution overlapping the H-3 spectrum.

The maximum pulse height corresponds to approximately 6 keV and the spectrum is (chemical) quench independent (as the events are not generated by converting beta particles to photons but by the reaction itself).

These characteristic properties of the luminescence spectrum make it easy to distinguish from a beta energy spectrum, using spectrum analysis. Delayed coincidence counting and spectral stripping techniques are applied to correct the results for luminescence influence.

2.3.3 Quenching

The counting efficiency of the solvent-solute system may be reduced by many different factors. These are briefly described below.

- Photon quenching - incomplete transfer of beta particle energy to solvent molecules;
- Chemical quenching (sometimes called impurity quenching) - causes energy losses in the transfer from solvent to solute;
- Optical quenching - causes the attenuation of photons produced in the solution.

The total effect is collectively referred to as "quenching" and the result is energy loss in the liquid scintillation solution. As a result, the energy spectrum detected from the radionuclide appears to shift toward lower energies.

From this change in energy distribution, it appears that the counting efficiency is dependent on the degree of quenching and thus on the nature of the sample, the scintillator used and the preparation method.

It is therefore essential to monitor the counting efficiency in each sample by comparisons with standards or other samples. In modern automatic scintillation counters, the counting efficiency is determined for each sample and the detected counts are converted to disintegrations to correct for quenching effects.

The application of high resolution spectrum analysis allows the calculation of two efficient and very accurate parameters to monitor quench levels.

The Spectral Index of the Sample (SIS) uses the sample spectrum to derive a quench index, while the Transformed Spectral Index of the External Standard Spectrum (tSIE) is calculated from the Compton spectrum, induced in the sample by the external standard source (133Ba).

Both parameters provide fast and accurate radionuclide efficiency values for virtually all types of liquid scintillation samples.

## *2.4 Equipment and Reagents*

### 2.4.1 Vial Selection

Vial sizes and configurations are specified in reference 9.1. Vials of several sizes and construction materials are available for use. Vial selection should be made based on the requirements of the sample. For the analysis described in this procedure, 20 ml. plastic vials, supplied by the manufacturer of the instrument, or equivalent, should be used.

### 2.4.2 Scintillation Cocktail Selection

Determination of the scintillation solution to be used is based on several factors:

- The ability of the solvent to dissolve the sample into a homogeneous state
- The amount of sample which can be loaded into solution
- The efficiency of the solution to detect the analytes at the desired level of confidence
- The level of hazard associated with working with the solution
- Disposal considerations

These factors cannot generally be optimized in one solution and therefor should be carefully evaluated to determine the scintillation cocktail to be used for each analysis. In all cases, the generation of mixed waste should be avoided. For this reason the instrument custodian shall have ultimate control over the selection of scintillation cocktail.

For the analysis described in this procedure, several environmentally benign scintillation cocktails are available that are marketed as non-hazardous. Use of these cocktails will minimize the controls necessary for their use, storage and disposal while maintaining counting efficiencies comparable to other high efficiency cocktails. The instrument custodian will work in conjunction with operators of the machine to determine which scintillation cocktails are used and to determine the associated disposal requirements.

### 2.4.3 Sample Loading and Collection

The scintillation cocktails described in this procedure are capable of sample loadings in aqueous solutions of up to 50% water. Overloading of the scintillation cocktail with too much sample could adversely affect sample results. In all cases, sample loading should be consistent for a given sample type and is specified in section 5 for the scope of analysis associated with this procedure.

For analysis involving a wipe test, the ability of the sample media to collect the desired analyte will be a factor which will affect the results of those analysis. Removal efficiency has been considered in conjunction with the sample media's affects on sample quench and geometry. Whatman 1 filters have been chosen for use during wipe tests because the filter's quench and geometry effects are far outweighed by the filter's high removal efficiency when dampened with demineralized water.

## *2.5 User Specified Parameters*

### 2.5.1 Count Time

Both the length of count and the number of counts per sample will affect the outcome of the analysis. A longer count time will result in a decrease in the Lower Limit of Detection (LLD), and subsequent Minimum Detectable Activity (MDA), achieved during the analysis. Increasing the number of counts associated with an individual sample will increase the level of confidence associated with that sample analysis.

Count times and the number of times to count each sample are specified in section 5 for those individual analysis.

### 2.5.2 Method of Quench Determination

The various methods of quench determination which can be used by the Packard LSC are described in section 2.3.3. For the scope of analysis described in section 5, the tSIE of the sample will be used to determine its corresponding level of quench. This method provides the most accurate method of quench determination available with this instrument.

Once the tSIE of the individual sample is determined, the instrument will compare it to the quench curves supplied by the manufacturer to determine the level of quench associated with the sample.

If required by a particular analysis, the instrument custodian, in conjunction with the persons performing that analysis, may specify additional quench curves to be used during this determination. Additional quench curves may be obtained through the use of quenched standards available from the manufacturer of the instrument or may be produced locally.

### 2.5.3 Method of DPM Determination

Determination of a specific activity corresponding to counts obtained in a specified region can be done in various ways. This factor will have a significant impact on the outcome of individual analysis. The method chosen to perform this determination is specified in section 5 for the individual analysis described in this procedure.

For the specified analysis, the dpm option chosen is dual DPM. This method was chosen based on the nuclides used at LEHR and the instrument's ability to quantify those isotopes. Since both H-3 and C-14 were used, use of the dual DPM option provides the highest level of accuracy for determination of the sample activity. The dual dpm option optimizes the instrument's capability to identify separate peaks observed in overlapping regions of the energy spectrum. This overlapping of energy ranges is referred to as spillover.

# 3.0 OPERATION

## *3.1 Equipment*

The following equipment will be required for the performance of the analysis described in this procedure. Additional equipment may be required if additional analysis are to be performed.

### 3.1.1 Liquid Scintillation Analyzer

This procedure has been written for use of the Packard Tri-Carb® Liquid Scintillation Analyzer. If another type of LSC is to be used, this procedure should be changed to reflect the equipment used.

Prior to use, the LSC shall be installed by qualified personnel in accordance with the manufacturers instructions and in a location described in sections 2.1 and 2.2. The performance of the instrument shall be evaluated by performing a baseline IPA. This baseline consists of the initial 5 data sets from which the limits for the 8 parameters evaluated during the IPA will be obtained. The procedure for performance of an IPA is described in section 4.2 of this procedure.

### 3.1.2 Standards

Unquenched standards for both C-14 and H-3 as well as a manufacturer supplied background sample will be necessary for the performance of the SNC and IPA.

A series of quenched standards for H-3 or C-14 is no longer necessary for the performance of quantitative analysis. The manufacturer of the instrument has installed a set of quench curves into the instrument's memory for the isotopes and scintillant specified in this procedure. In the event that additional scintillation cocktails are used or different analysis are performed, the use of these quench curves to quantify results should be evaluated.

### 3.1.3 Vials

The vials to be used in the performance of these analysis are 20 ml. plastic vials. These vials are readily available from the manufacturer as well as various scientific equipment suppliers. Additional information concerning the affects of various vail sizes and types may be found in section 2.4 of this procedure and in reference 9.1.

### 3.1.4 Reagents

The LSC process requires that the sample be placed in a container with scintillation solution. In this combination the scintillation solution (cocktail) is the solvent and the sample is the solute.

The scintillation cocktail recommended for use in the performance of the analysis described in this procedure is Packard's Ultima-Gold scintillation cocktail. This scintillation solution is marketed as non-hazardous and should be easily disposed of after use. Scintillation solutions classified as hazardous should not be used without the concurrence of the instrument custodian and the LEHR RCM.

### 3.1.5 Sample Media

For surface activity measurements, a media which is wiped over the surface being assayed is needed. This media is typically a filter paper or similar material. For the analysis described in this procedure, a Whatman 1 filter paper should be used where required.

## *3.2 Conversation*

Conversation allows the instrument operator to define new protocols, edit or copy existing protocols, enter active counting conversations, or group PrioStat conversations, spectrum display, etc. All program interaction is performed via the keyboard and does not interrupt automatic operation of the system. All conversation is displayed as a series of related questions and answers. The following is a description of the most common pages displayed during conversation.

### 3.2.1 Status Page

The **Status Page** gives a visual representation of what the instrument is currently doing and the status of all protocols. This page also gives access to all other conversation pages. The **Status Page** displays system messages (such as Counting Protocol 16 or Idle) at the top of the screen along with the date and time.

The screen displays the information for the sample being counted as well as a description of listed protocols and their assigned names. Protocols being counted are tagged as (A)-active, protocols whose cycles are complete are tagged (C)-complete, and protocols being used by Group PrioStat are tagged (P)-Group PrioStat.

The function keys are defined at the bottom of the screen. All other screens are accessed from the **Status Page** through the use of these function keys.

### 3.2.2 Edit Protocol Page

The **Edit Protocol Page** is selected using the function keys from the **Status Page**. The **Edit Protocol Page** displays all the defined protocols and their names. The program allows the user to edit any of the 30 available protocols. Once a protocol has been selected for editing, the **CPM Page** is displayed.

### 3.2.3 CPM Page

The **CPM Page** allows the user to edit various portions of the selected protocol. When the cursor is moved to a question, the possible responses are listed on the help line just above the function keys. The function keys change definition with each question. If the question requires a numeric or alpha response the keyboard is used. If the range of options is small, the function keys are used.

A table listing each question along with a brief description of what the question is asking can be found in Chapter 5 of reference 9.1. The table also gives a range of responses and the default value assigned to the system.

### 3.2.4 DPM Page

The **DPM Page** of conversation is displayed as a function of the response to the "Data Mode?" question on the **CPM Page**. This page of conversation allows the user to select how the quenched standards data are to be entered into the system. For the scope of operations defined in this procedure, "Use Curve" should be selected unless otherwise directed by the instrument custodian or if specified in another procedure directing the use of the instrument.

### 3.2.5 Additional Features Page

The **Additional Features Page** allows the user to select installed options to be applied to the selected protocol including the option of saving the sample data and/or spectrum to disk.

A table listing each question along with a brief description of what the question is asking can be found in Chapter 5 of reference 9.1. The table also gives a range of responses and the default value assigned to the system.

### 3.2.6 Print Format Page

The **Print Format Page** allows the user to define the format for the printout of sample results. In this page of conversation, the user may define the printout to contain as much or little information as desired. Each item that may be printed are referred to as a cell. The "Flags" field should always be included to ensure the user is alerted to any flags which are tripped during the counting of a sample set using the assigned protocol.

A table listing each question along with a brief description of what the question is asking can be found in Chapter 5 of reference 9.1. The table also gives a range of responses and the default value assigned to the system.

### 3.2.7 Sample Changer Control

The **Sample Changer Control Page** is accessed from the **Status Page** and is used to gain manual control over the sample changer. There are four options available to the user once this page of conversation is entered.

**Forward** - The sample changer will move continuously in the forward direction. In this mode, the system will bypass all samples and protocol plugs until another function is selected.

**Reverse** - The sample changer will move continuously in the reverse direction. In this mode, the system will bypass all samples and protocol plugs until another function is selected.

**Next Sample** - The sample being counted will be unloaded and the sample changer will advance to the next available sample in line.

**Stop** - This function causes the sample changer into an idle condition until another function key is depressed.

3.2.8 Spectrum Page

The **Spectrum Page** is accessible from the **Status Page** and will generate a live spectrum display for each sample counted. The only available question in this page of conversation is the full scale value of the keV axis. The spectrum display can be used for routine observations of counting conditions.

3.2.9 IPA Page

The **IPA Page** is accessed from the **Protocol Page** and allows setup and assessment of IPA functions. The assay values and corresponding dates for the unquenched standards are entered into memory in the **IPA Page** of conversation. These values should not be changed without the concurrence of the instrument custodian. The values for H-3 $E^2/B$ and C-14 $E^2/B$ Threshold, determined during the performance of the baseline IPA, have been entered here and should not need to be changed.

From the **IPA Page**, the user can review the data from any of the eight parameters monitored during the performance of the IPA. This data can be viewed and/or printed in tabular or chart format.

## *3.3 Precautions*

The following precautions are to be observed during the performance of all activities associated with this procedure.

3.3.1 Radiological Controls

Since the analysis described in this procedure are being performed to determine the level of radioactive content in a sample media, the standard radiological control practices specified in reference 9.4 shall be used to control worker exposures and the potential spread of radioactive contamination during sampling operations.

3.3.2 Hazardous Material Controls

This procedure currently recommends the use of an environmentally benign cocktail for use in sample preparation. This chemical still retains properties which need to be considered when it is handled. A current MSDS for the cocktail(s) used shall be kept readily accessible in the vicinity of the sample preparation area. Personnel who prepare samples for analysis or otherwise come in contact with the scintillation cocktail should become familiar with the MSDS for those cocktail(s) prior to handling. To prevent dermal contact with the cocktail, nitrile gloves shall be worn by all personnel when preparing samples for analysis.

In the event that the use of additional reagent chemicals is added to this procedure, the approved Health and Safety Plan(s) associated with the individual personnel operating the instrument shall be utilized to control the use, handling and storage of those material(s).

## *3.4 Prerequisites*

3.4.1 Instrument Setup

Prior to use, the instrument shall be installed by qualified personnel in accordance with the manufacturers instructions. A baseline IPA shall have been performed in accordance with section 4.2 of this procedure.

3.4.2 Establish Protocols

Protocols shall be defined for use during the analysis described in section 5. These protocols specify how the instrument controls the counting of individual sample sets and defines parameters to be applied to that sample's analysis. The parameters to be included in the protocols associated with the individual analysis described in this procedure are described in section 5.

The basic procedure for entering into conversation with the instrument and defining a protocol is described in section 3.2.

## *3.5 Sample Preparation*

Samples shall be obtained in accordance with the requirements of the procedures which direct them to be taken. In all cases the considerations described in section 2.4 of this procedure should be followed when preparing samples for analysis.

Samples shall be prepared in an area and in a manner which minimizes the chance of cross contamination of samples and surfaces. Radiological controls procedures to be followed when handling potentially radioactive materials are specified in reference 9.4.

Adequate time shall be allowed prior to counting samples in order to minimize the effects of luminescence in the sample. Operating experience at the LEHR site indicates that approximately 4 hours of time should be allowed to eliminate these affects. Chemical and photoluminescence is described in section 2.3.2 of this procedure.

## *3.6 Sample Counting*

Once prepared, samples shall be placed in sample cassette(s), for loading in the instrument. For the scope of analysis currently included in this procedure, first vial background samples shall be placed in the first sample slot in the cassette. Background vials for wipe samples should be a dampened filter paper placed in a sample vial with the same mixture of scintillant/water as the sample that will be analyzed.

Insert the appropriate protocol plug in the cassette and move the flag to the left, thus identifying to the instrument which protocol is to be applied during the sample analysis.

Enter into conversation with the instrument and from the status page, start the sample count by pressing F2. Once all the samples loaded into the instrument have been counted and analyzed, the instrument will place itself into an idle condition until directed to perform additional analysis.

# 4.0 PERFORMANCE VERIFICATION

## *4.1 Self-normalization and Calibration*

Self-normalization and calibration (SNC) adjusts each photomultiplier tube (PMT) to balance its response to sample activity and calibrates the spectrum analyzer in keV. The instrument utilizes the unquenched C-14 source to sequentially adjust the high voltage applied to each PMT to be half of the normal SIS of that standard. The instrument will then apply voltage to both PMTs, test the SIS and adjust each PMT until tSIE is 1000.

The LSC will automatically perform an SNC count every 23 hours. The following describes the necessary steps to manually perform a self-normalization and calibration:

4.1.1 Insert the SNC protocol plug into the SNC cassette. Load the unquenched C-14 standard into position number one of the cassette and load the cassette into the sample changer.

4.1.2 The instrument will now perform an SNC count the next time the SNC cassette is recognized and every 23 hours thereafter. To initiate the count manually, set the cycle flag on the SNC cassette to the left and initiate the count by pressing the F2 key from the status page.

For the purposes of this procedure, the SNC cassette will be further utilized in the IPA procedure described in section 4.2.

## *4.2 Instrument Performance Assessment (IPA)*

The IPA and Auto QA features of the LSC use the system's SNC capability to monitor the background, efficiency, Figure of Merit ($E^2/B$), and Chi-squared values for both the H-3 and C-14 regions.

4.2.1 System Functions and Configuration

Three separate samples are used for the IPA procedure and are placed in the SNC cassette in the following order:

- Position 1 - C-14 Unquenched Standard
- Position 2 - H-3 Unquenched Standard
- Position 3 - Background Standard

The C-14 unquenched standard is used to initially calibrate the system to obtain optimal performance by adjusting the voltage applied to the PMT's as described in section 4.1 (SNC portion of IPA). The

C-14 sample is then counted for one minute using regions of 0-156 keV for efficiency determination and 4-156 keV for $E^2/B$ determination. The standard is then counted 20 times for 0.5 minute each in order to determine the Chi-square of the instrument using the 74-156 keV region for C-14.

The H-3 unquenched standard is counted for one minute to determine the H-3 efficiency in the 0-18.6 keV region and the $E^2/B$ performance for H-3 in the 1-18.6 keV region is calculated. The Chi-square for H-3 is then determined for 20 counts of 0.5 minutes each using a region of 0-18.6 keV.

The background standard is then counted for 60 minutes in the following regions:

- 0-18.6 keV for H-3 background determination
- 0-156 keV for C-14 background determination
- 1-18.6 keV for H-3 $E_2/B$ determination
- 4-156 keV for C-14 $E_2/B$ determination

4.2.2 IPA Setup and Conversation

The IPA setup and assessment can be accessed from the Main Protocol Page by pressing the F10-etc function key followed by the IPA function key. The following steps should be completed prior to performing an IPA:

- The assay values and dates for the unquenched H-3 and C-14 sources shall have been entered into memory in order for the system to determine the exact DPM of the standards. These values need not be changed unless different standards are to be used.
- Set the IPA configuration to automatically determine the Chi-square for H-3 and C-14.
- Determine the C-14 and H-3 $E^2/B$ thresholds in accordance with the procedure specified in reference 9.1 and enter the values here. Once set, these values should not need to be changed.

4.2.3 IPA Performance Assessment

In order for the system to automatically perform an IPA every 23 hours, the SNC cassette and the standards shall be left in the sample changer during normal operations.

The system uses the results of the IPA to monitor the performance of the instrument by establishing certain criteria for each of the eight IPA parameters. If any of these limits are exceeded, an error message is printed. In the event that an error message is received, the performance of the system shall be evaluated by qualified personnel prior to the system being used for quantitative analysis.

The system retains the results of each IPA performed in memory and tracks them in both a tabular and chart format. These results shall be retained as specified in section 6.1 of this procedure.

### *4.3 Level of QA*

Analytical options available to support data collection activities are typically presented in five general categories. Of these, only three will apply to analysis associated with using the LSC. These are described below.

4.3.1 Level II - Field Analysis

This level is typically characterized by the use of portable analytical instruments which can be used in field laboratories. Depending upon the types of contaminants, sample matrix, and personnel skills, both qualitative and quantitative data can be obtained. This level of quality will be applicable to most analysis performed using the LEHR Site LSC.

4.3.2 Level III - Laboratory Analysis (Other)

This level of quality is applicable to analysis using standard EPA approved procedures. Analysis applying this level of quality may be performed with the LEHR Site LSC providing the appropriate procedures and protocols are followed by the user of the instrument.

4.3.3 LEVEL IV - Contract Laboratories Services

In the event that the procedures directing the performance of the samples described in this procedure require, additional outside validation of duplicate samples may be analyzed to this level of quality.

## 5.0 SCOPE OF USE

This document describes the procedures to be followed when utilizing the LSC for specific analysis. This section will delineate those specific analysis and direct the operator how to utilize this procedure to perform those analysis and obtain results at the desired level of confidence.

### *5.1 Screening Analysis of Smears for Low-Level Beta Emitters*

This section will describe the procedures to be followed during the performance of the above named analysis.

5.1.1 Define a protocol to be used in the performance of this analysis. Procedures for defining a protocol are contained in section 3.4.2 of this procedure as well as in reference 9.1. The parameters listed below should be included in the protocol chosen. Parameters which have been changed from the default value are printed in italics. For parameters not specified below, use the system default values:

## DPM Page

- 1 minute count time
- 1 count per vial
- 1 vial per standard
- 1 vial per sample
- First vial bkgd - *Yes*
- Radionuclide - *Manual*

- Enter the following energies for regions A, B, & C

  Region A: *0.0 to 12.0 kev*

  Region B: *12.0 to 156.0 kev*

  Region C: *156 to 2000 kev*

- 2 Sigma % - 0
- LCR - 0
- QIP - *tSIE/AEC*
- ES Terminator - Count
- % Reference - No
- Data Mode - *dual DPM*

## DPM Page

- Standards Data - *Use Curve*
- Constant Quench - No
- Replot - No
- Edit Stds? - 0

## Additional Features Page

- Single Photon Count - No
- Colored Samples - No
- RS-232 Output - No
- Heterogeneity Monitor - No
- Luminescence Corr. - No
- Data - *See note below*

NOTE: INFORMATION CONCERNING SAVING SAMPLE DATA AND SPECTRUMS IS CONTAINED IN SECTION 6.2.

5.1.2 Ensure the LSC is setup and operating as described in section 3.1 and that an SNC has been performed within the past 23 hours. Review the SNC/IPA data to ensure that the instrument is operating within specification and in accordance with additional requirements specified in procedures directing the use of the instrument. SNC and IPA performance are discussed in section 4 of this procedure.

5.1.3 Verify printer is online and has sufficient paper.

5.1.4 Wipe samples should be obtained by lightly dampening them with demineralized water and wiping the dampened media over the surface to be assayed. The media should immediately be placed in the sample vial containing a mixture of 10 ml. demineralized water and 10 ml. of scintillation cocktail. Sample preparation is further described in section 3.5 of this procedure.

5.1.5 Place samples in cassette and begin counting as specified in section 3.6.

5.1.6 Sample results will download to printer at the completion of each count. Copies of sample results should be retained as directed in section 8.

## *5.2 Analysis of Smears for Low-Level Beta Emitters During License Termination Surveys*

This section will describe the procedures to be followed during the performance of the above named analysis.

5.2.1 Define a protocol to be used in the performance of this analysis. Procedures for defining a protocol are contained in section 3.4.2 of this procedure as well as in reference 9.1. The parameters listed below should be included in the protocol chosen. For parameters not specified below, use the system default values:

## DPM Page

- 1 minute count time
- 4 counts per vial
- 1 vial per standard
- 1 vial per sample
- Yes - *First vial bkgd*
- Radionuclide - *Manual*

- Enter the following energies for regions A, B, & C

  Region A: *0.0 to 12.0 keV*

  Region B: *12.0 to 156.0 keV*

  Region C: *156 to 2000 keV*

- 2 Sigma % - 0
- LCR - 0
- QIP - *tSIE/AEC*
- ES Terminator - Count
- % Reference - No
- Data Mode - *dual DPM*

## DPM Page

- Standards Data - *Use Curve*
- Constant Quench - No
- Replot - No
- Edit Stds? - No

## Additional Features Page

- Single Photon Count - No
- Colored Samples - No
- RS-232 Output - No
- Heterogeneity Monitor - No
- Luminescence Corr. - No
- Data - *See note below*

NOTE: INFORMATION CONCERNING SAVING SAMPLE DATA AND SPECTRUMS IS CONTAINED IN SECTION 6.2. SAMPLE DATA AND SPECTRUM SHOULD BE SAVED WHEN PERFORMING SURVEYS IN ACCORDANCE WITH REFERENCE 9.2.

5.2.2 Ensure the LSC is setup and operating as described in section 3.1 and that an SNC has been performed within the past 23 hours. Review the SNC/IPA data to ensure that the instrument is operating within specification and in accordance with additional requirements specified in procedures directing the use of the instrument. SNC and IPA performance are discussed in section 4 of this procedure.

5.2.3 Verify printer is online and has sufficient paper.

5.2.4 Wipe samples should be obtained by dampening them with demineralized water and wiping the dampened media over the surface to be assayed. The media should immediately be placed in the sample vial containing a mixture of 10 ml. demineralized water and 10 ml. of scintillation cocktail. Wipe samples should be taken in quantity and at locations as specified in reference 9.2 to achieve desired data quality objectives. Sample preparation is further described in section 3.5 of this procedure.

5.2.5 Place samples in cassette and begin counting as specified in section 3.6.

5.2.6 Sample results will download to printer at the completion of each count. Copies of sample results should be retained as directed in section 8.

# 6.0 DATA STORAGE

Since the Packard LSC is a computer processor based instrument, information associated with both data quality and individual sample data may be stored on both electronic and physical media.

## *6.1 Printing and Storage of QA Data*

QA data associated with the systems performance can be accessed through the **IPA Setup** conversation page. The results of individual IPAs are stored in the system's memory for a period of 2 months. The resultant information from each of the eight parameters monitored during the IPA shall be printed on a monthly basis and retained in a binder by the instrument's custodian for future reference. To print the IPA data, highlight "IPA Operation?" and choose the appropriate function key listed at the base of the **IPA Page** to print the tables.

## *6.2 Printing and Storage of Sample Data*

Results of sample analysis will be printed automatically by the instrument as the samples are analyzed using the external printer.

Data associated with a specific sample analysis may be retained for future use by copying it to disk with the external disk drive. This shall be performed when required by the procedures initially directing the samples to be obtained.

Directing sample data and spectrum to be saved is performed from within the **Additional Features Page** of conversation for the selected Protocol. The options available to the user include saving to

the floppy disk or the hard disk. Both the sample data and spectrum may be saved in either a short or long format. Care should be taken to not run out of disk space when saving sample data and spectrums to the system's hard drive.

The user specifies the path and drive in standard DOS format as well as the file name and extension. If a numerical extension is chosen, each subsequent sample saved will be incremented by the program.

Step by step procedures for saving sample data and spectrums to disk are contained in chapter 5 of reference 9.1.

# 7.0 CONTROL OF SAMPLES AFTER USE

In order to properly minimize the production of hazardous and radioactive wastes, any samples identified during analysis as being contaminated shall be handled and segregated as described below.

## *7.1 Responsibilities*

- The instrument custodian is responsible for control and disposal of samples and sample containers.
- Personnel operating the instrument are responsible for controlling their samples after use in accordance with the requirements of this procedure.

## *7.2 Sample Controls*

Samples which are identified during analysis as containing radioactive materials in excess of site limits shall be placed in the location designated by the instrument custodian for contaminated samples. In order to track the cumulative activity of the samples requiring disposal, the sample shall be marked indicating it's identity and contents, and a copy of the sample results shall be placed in the storage location along with the sample. These samples shall be handled and disposed of in accordance with the requirements specified in reference 9.3.

Samples which are identified during analysis as not containing radioactive materials shall be placed in the location designated by the instrument custodian for non contaminated samples. These samples shall be disposed of by the instrument custodian in accordance with UCD procedures.

The instrument custodian shall initiate appropriate steps to ensure that samples are properly segregated, handled, stored and disposed of. This may include:

- Posting written instructions in the vicinity of the instrument identifying storage locations and associated requirements.
- Performing periodic recounts of samples from both the contaminated and non-contaminated storage locations to verify analytical data.

- Monitoring the use of the instrument by site personnel.

## 8.0 RECORDS

Records generated as the result of operations associated with this procedure shall be retained in accordance with the following requirements:

- Results of SNC and IPA data shall be retained by the instrument custodian in a binder located in the vicinity of the instrument. The last year's data shall be retained in this manner. Previous year's data shall be retained in accordance with UCD records procedures. Copies of this quality related data shall be made available to personnel using the instrument for inclusion in contractor project records.
- Results of sample analysis shall be retained in accordance with the requirements of the procedure(s) requiring the use of the instrument.

## 9.0 REFERENCES

*9.1* *Packard, "Tri-Carb Liquid Scintillation Analyzer Operation Manual, Model 2100TR/2300TR", 1994*

*9.2* *U.S. NRC, "NUREG/CR-5849, Manual for Conducting Radiological Surveys in Support of License Termination", June 1992*

*9.3* *Weiss Associates/LEHR, "Waste Management Annual Report for Fiscal Year (FY) 1997 and Waste Management Plan",*

*9.4* *D.O.E./LEHR, "LEHR Radiological Control Manual", July 1993*

# CHECK-IN AND ORIENTATION FOR RADIOLOGICAL WORKERS, GENERAL EMPLOYEES OR MEMBERS OF THE PUBLIC

STANDARD OPERATING PROCEDURE

## 1.0 PURPOSE

This procedure describes the check-in and orientation requirements for anyone entering to the Laboratory for Energy-related Health Research Environmental Restoration (LEHR ER) Project Site for any purpose related to the site restoration and defines the requirements for documentation and implementation of check-in and orientation procedures. Issuance of dosimetry will be in accordance with SOP 38.2, External Dosimetry Issuance (Reference 2.3).

## 2.0 REFERENCES

*2.1* *10 CFR 835 Occupational Radiation Protection; Final Rule, November 1998. Department of Energy*

*2.2* *29 CFR 1910.120 Hazardous Waste Operations and Emergency Response; Final Rule*

***2.3*** ***SOP 38.2, External Dosimetry Issuance***

*2.4* *SOP 38.3, Radiation Protection Records*

## 3.0 DEFINITIONS

### *3.1 ALARA*

"As Low As is Reasonably Achievable" (ALARA) is the approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. As used in this part, ALARA is not a dose limit but a process which has the objective of attaining doses as far below the applicable limits of this 10 CFR 835 (Reference 2.1) as is reasonably achievable

### *3.2 Contractor*

Any entity under contract with the Department of Energy (DOE) with the responsibility to perform activities at a DOE site or facility

### *3.3 Controlled Area*

An area to which access is controlled by or for DOE to protect individuals from exposure to radiation and/or radioactive materials

### *3.4 DOE*

Department of Energy

### *3.5 GERT*

General Employee Radiation Training

### *3.6 General Employee*

General Employee (GE) is an individual who is either a DOE or DOE Contractor employee; an employee of a subcontractor to a DOE contractor; or an individual who performs work for in conjunction with DOE or utilizes DOE facilities

### *3.7 ITEH*

Institute for Toxicology and Environmental Health

### *3.8 LEHR*

Laboratory for Environmental Health and Restoration, (LEHR) Project Office (LPO): two trailers (Health and Safety-brown trailer; Administrative-silver trailer) located on the north side (ITEH).

### *3.9 Member of the Public*

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

### *3.10 Prime Contractor*

Contractor to whom DOE has awarded the prime contract for managing the environmental restoration project at the LEHR Site.

### *3.11 Radiation Safety Training*

Radiation safety training 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:

- Risks of exposure to radiation and radioactive materials, including prenatal radiation exposure:
- Basic radiological fundamentals and radiation protection concepts;
- Physical design features, administrative controls, limits, policies, procedures, alarms, and other measures implemented at the facility to manage doses and maintain doses ALARA, including both routine and emergency actions;
- Individual right and responsibilities as related to implementation of the facility radiation protection program;
- Individual responsibilities for implementing ALARA measures; and,
- Individual exposure reports that may be requested in accordance with 10 CFR 835 (Reference 2.1).

## 4.0 RESPONSIBILITIES

### *4.1 Project Manager (PM)*

The Project Manager (PM) is responsible for the safe and effective implementation of this procedure.

### *4.2 Site Health and Safety Officer (SHSO)*

The Site Health and Safety Officer (SHSO) is responsible for the initial issuance of dosimetry and for the continued normal change out of those dosimeters. The SHSO is responsible for maintaining a supply of dosimeters for issuance to other project personnel (subcontractors) working at the LEHR Site, and for the collection of those dosimeters when these personnel leave the site. The SHSO acts in the capacity of a Dosimetry Program Manager and ensures that applicable LEHR personnel follow the procedures that have been developed for external dosimetry issuance, dosimetry use, data interpretation and records control. The SHSO will also check on training styles of hazardous waste workers (Reference 2.2).

## 5.0 GENERAL CHECK-IN INFORMATION

All persons entering the LEHR site for purposes related to DOE site restoration activities should report to the Health and Safety LEHR Project Office (HSLPO) or their regular on-site contractor supervisor for check-in and orientation. Contractors and other on-site staff/general employee who will be working regularly at the LEHR Site shall report to their supervisor on their initial visit, and

may not begin work until they have completed required processing and paperwork. On-site contractors will check-in and provide orientation for their sub-contractors, their General Employees, their visitors, General Employees to their subcontractors, and visitors to their sub-contractors. ITEH Staff and ITEH members of the public are not involved with site remediation work and, as such, do not come under the provisions of this procedure, except when entering areas where DOE environmental restoration project work is in progress.

The SHSO, RSO, or RCM may withhold site access to any individual.

# 6.0 MEMBERS OF THE PUBLIC CHECK-IN

Members of the public (visitors) shall report to the Health and Safety LEHR Project Office or to the controlling contractor office on each visit to the site. LEHR site visitors shall have a contact person who is aware of their intended visit and who knows the nature of the visit. If the contact person is aware of the visit in advance, then the contact person is responsible for informing the prime contractor through the SHSO or other designated individual.

## *6.1 Members of the Public Log*

All visitors shall sign in and out each day on the LEHR Visitor Sign-In Log (Attachment 10.1) or on the subcontractor's office log. A Visitor Orientation Sheet captures information identifying the reason for the visit and the site contact person. The prime contractor is responsible for assuring that appropriate site-related training and personnel safety requirements are met. In the event of a site emergency or evacuation, the LEHR Visitor Sign-In Log should be reviewed to assure everyone on-site has been safely accounted for. Visitors who are on-site *solely* for the purpose of attending a meeting held in an administrative area do not need to sign the Visitor Check-In Log if the meeting includes an attendance list, which will be included in project records.

A single page of the log may be used for the day, week, or month, depending on the number of members of the public signing in. The numbering system for the log shall be monthly--if four pages are used during the month they will be numbered from 1 of 4 to 4 of 4. At the end of the month, all site visitor logs will be filed in the LEHR Visitor Sign-In Folder located in SHSO office.

## *6.2 Members of the Public Orientation*

Members of the public visitors visiting the LEHR Site shall read and sign the Visitor Orientation Form (Attachment 10.2) or an equivalent form prepared by the hosting prime contractor. The Members of the Public Orientation Sheet is completed only on the initial visit; any changes will be updated after the initial visit.

Visitors will not enter radiological controlled areas. Visitors will be given written and verbal radiation safety training (see Section 3.1) if they are to enter controlled areas unescorted.

# 7.0 GENERAL EMPLOYEE WORKER CHECK-IN

General Employees shall report to their assigned controlling contractor supervisor for orientation, site-specific training, completion of required employment documents, and evaluation of additional training needs required to begin work. In addition, the law requires workers assigned more than 30 working days a year at a waste site to be in a medical surveillance program. Results of record evaluation and training documentation shall be provided to the prime contractor before the employee begins work. If external dosimetry is required, see Section 8.0.

## *7.1 General Employee Orientation*

Contractors shall provide training and orientation as appropriate for the tasks the general employee will be expected to perform. For workers whose assignments involve site remediation of radiological and/or hazardous waste, training shall include 29 CFR 1910.120 HAZWOPER (Reference 2.2) training requirements and DOE Radiological Worker training. This training shall be completed prior to any assignment involving hazardous waste operations. In addition, all general employees shall receive site emergency training in accordance with the site Contingency Plan and General Emergency Response Procedures.

General employees who may routinely encounter radiological barriers and postings shall receive General Employee Radiological Training (GERT). General Employee Radiological Training shall include the standardized core course training materials, including site-specific information, such as site-specific radiation types, alarm responses and policies. The expected time to complete the standardized core and site-specific GERT is approximately 2 hours and may be communicated by classroom lecture, videotape, or other applicable methods, such as the computer module that are available on-site. Applicable information pertaining to GERT training shall be included on the "GERT Log" (Attachment 10.3).

Training beyond GERT is necessary for unescorted entry into Radiological Buffer Areas or areas posted for radiological control. Additional information on this training is provided in HSP 20.1, Employee Subcontractor Training Requirements.

# 8.0 RADIOLOGICAL WORKER CHECK-IN

The information within this section is required for radiological worker check-in.

The SHSO will issue dosimetry to site workers and general employees who enter radiological controlled areas.

8.1.1 A completed copy of a Personal/Occupational History sheet (Attachment 10.4) will be filed in each individual's training file. The personal history includes full name, unique identification number, date of birth, current home address/phone number, current employer/address/phone number, and radiation exposure history if any. A Training Certificate List identifying training requirements is also filed in the Individuals Training Folder (Attachment 10.6).

8.1.2 A radiation history request letter signed by the company and/or general employee stating the employee's lifetime occupational radiation exposure and annual "to-date" occupation radiation exposure. This is required when an employee has had previous occupational exposure (a 'zero'-exposure is considered a reportable exposure). The radiation history information should be equivalent to requirements defined with 10 CFR 835.702, Individual Monitoring Records and as stated in SOP 38.3 (Reference 2.4), Individual Monitoring Records. Request for Report of Radiation History (Attachment 10.5) will be filled out and signed by the individual, reviewed and initialed by the SHSO.

### *8.2 External Dosimetry Issuance*

See SOP 38.2, External Dosimetry Issuance (Reference 2.3)

## 9.0 [SECTION RESERVED FOR FUTURE USE]

## 10.0 ATTACHMENTS

### *10.1 LEHR Visitor Sign-In Log*

### *10.2 Visitor Orientation Form*

### *10.3 General Employee Radiation Training Log (GERT)*

### *10.4 Personal/Occupational History*

### *10.5 Request for Report of Radiation History*

### *10.6 Training Certificate List*

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# ATTACHMENT 10.1

## LEHR VISITOR SIGN-IN LOG

# LEHR VISITOR SIGN-IN LOG

MONTH _____ YEAR _____

| DATE | | | | | NAME | COMPANY | PHONE | CONTACT | REASON FOR VISIT |
|---|---|---|---|---|---|---|---|---|---|
| MO/DAY/YR | | | TIME IN | TIME OUT | | | | | |
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# ATTACHMENT 10.2

## VISITOR ORIENTATION FORM

# VISITOR ORIENTATION FORM

**Escort and/or Contact Person:** _____

| | |
|---|---|
| **Name:** | |
| **Home Address:** | |
| **Identification # and type:** | |
| **Date of Birth:** | |
| **Reason for Site Visit:** | |
| **Employer:** | |
| **Work Phone:** | |
| **Company Address:** | |

**Please Read and Sign Below**

Members of the Public must go through a site-specific orientation according to The Radiation Protection Program (10 CFR 835). The following information is one of the tools to satisfy this requirement:

- Radiological and/or Chemical hazards are not present in areas where tours, group walks or meetings are held.

- Strontium 90, radium 226, and cesium 137, and tritium are the main radionuclides identified in the soil. Tritium is also identified in the ground water. Members of the Public will not be permitted in areas under investigation and/or remediation, or in storage areas for radiation waste. These areas will be posted, and roped, chained, or taped off with clearly marked sign(s). The following signs are examples radiation warnings with the standard radiation symbol of yellow background and magenta or black logo:

**RADIOACTIVE MIXED WASTE**

**RADIOACTIVE MATERIALS**

- Specific training is required to go beyond the posted boundaries.

- Types of LEHR site potential emergency conditions include fire, earthquake, hazardous or radioactive chemical spills, and heavy equipment failure. In the event of an emergency, an emergency signal horn ( an air horn or car horn) will be used to alert LEHR. One long blast from the emergency signal horn requires all staff to report immediately to the **northwest corner parking lot**, or to another location designated by your escort or health and safety personnel.

- Radiological Exposure Limits for members of the public, as stated in the 10 CFR 835, is 0.10 Rem (or 100 mRem) per year (a year measured by 2080 hours). The LEHR administrative level limit for members of the public is 0.08 (or 80 mRem) per year. REM, Radiation Equivalent Man, is a unit for measuring dose equivalence. A dose is the quantity of radiation absorbed over a period of time. Measuring dose equivalence considers the energy absorbed (dose) and the biological effect on the body. A person flying 2084 hours (1 year) in an airplane would receive a dose of 1040 mRem. Compare 100 mRem per year to 1040 mRem per year. As you can see both 10 CFR 835 and LEHR administrative control limits are conservative.

- Photography of the site or of site work must be cleared with the Project Manager.

***I have read and understood the above information:*** _____ ***Date:*** _____

# ATTACHMENT 10.3

## GENERAL EMPLOYEE RADIATION TRAINING LOG (GERT)

# General Employee Radiation Training Log (GERT)

1. Basics of Radiation
2. Risks in Perspectives
3. ALARA Responsibilities
4. Radiological Control

| Print Name | Company | Identification No. | Signature | Date of Training | P/F |
|---|---|---|---|---|---|
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(When page is full or at end of the calendar year, place this roster in project training files)

# ATTACHMENT 10.4

## PERSONAL/OCCUPATIONAL HISTORY

# PERSONAL/OCCUPATIONAL HISTORY

| Full Name | Parent Company/Co. Phone: |
|---|---|
| Home Street Address: | Department: |
| City/State/Zip: | Supervisor: |
| Home Phone: | Company Address: |
| Social Security: # | City/State/Zip: |
| Birth Date: | If Sub-Contracted, Name of Sub-Contractor: |

Start Date: _____ Previously at LEHR? _____ If Yes, Specify Date(s): _____

Previous External Radiation History (if you have no previous history, write NONE): _____

Company Name: _____

Company Address: _____

Dates Employed: _____

Company Name: _____

Company Address: _____

Dates Employed: _____

Lifetime: _____ Current Year: _____ Current Quarter: _____

Previous Internal Radiation History: Yes: _____ No: _____

If Yes, Specify: _____

Previous doses from therapeutic and diagnostic medical radiation, or participated as a subject in medical research programs: Yes: _____ No: _____

If Yes, Specify: _____

**I acknowledge that copies of this form and signature are valid.**

_____

**Signature Authorization** **Date**

*For Office Use Only* SHSO initial after each TLD issuance

TLD # _____ Grp. # _____ Badge date _____ Issue date _____ Return date _____

TLD # _____ Grp. # _____ Badge date _____ Issue date _____ Return date _____

TLD # _____ Grp. # _____ Badge date _____ Issue date _____ Return date _____

TLD # _____ Grp. # _____ Badge date _____ Issue date _____ Return date _____

# ATTACHMENT 10.5

## REQUEST FOR REPORT OF RADIATION HISTORY

# REQUEST FOR REPORT OF RADIATION HISTORY

**Date** _____

**Company** _____

_____

_____

_____

**Attention** _____

Please provide any internal and/or external dose history for the person below.

**Name** _____

**SSN** _____

**DOB** _____

**Time Period** ❑ All Years ❑ _____ to _____

**Stated Time Frame**

*I hereby authorize the release of the requested information to Weiss Associates. I acknowledge that copies of this form and signature are valid.*

**Signature Authorization** **Date:**

Reports should include exposure information such as hot particle exposures, planned special exposures, etc., as applicable. This information is requested in accordance with 10 CFR 835, Final 11/98.

Please address your reply to:

**Weiss Associates,**
**Attention: Kim Warren, Dosimetry Manager,**
**UC Davis, Old Davis Road,**
**ITEH Bldg., Davis, CA 95616,**
**Fax (530) 752-6918**
**Phone (530) 752-1348**
(Please follow-up any faxed response with a hard copy.)

Thank you,

Kim Warren
Dosimetry Manager

# ATTACHMENT 10.6

## TRAINING CERTIFICATE LIST

# TRAINING CERTIFICATE LIST

Required certificates must be on file in SHSO office before work can begin

## REQUIRED TRAINING CERTIFICATE LIST (Training addressed in the PHSP Section 14 & 18)

- **OSHA 40 hour:** 29 CFR 1910.120
- **OSHA-8-hour-Refresher:** 29 CFR 1910.120
- **Radiation Worker** (RW): 10 CFR 835
- **Radiation Worker Refresher:**(RWR), 10 CFR 835
- **Core**[1]: 29 CFR 1910 General Industry Standards, 29 CFR 1926 Construction Safety, 10 CFR 835 Occupational Radiation Protection Program
- **Medical Exam:** PHSP Section 18.1, 29 CFR 1910.120f

## SUPPLEMENTAL TRAINING CERTIFICATE LIS (Individual's Applicable Certificates Filed)

- **Bioassay:** PHSP 18.3
- **Respiratory Fit Test:** 29 CFR 1910.134
- **Escort Trained:** 10 CFR 835
- **OSHA 8 hour Supervisor:** 29 CFR 1910.120
- **General Employee Radiation Training (GERT):** 10 CFR 835
- **Radiation Control Technician (RCT):** 10 CFR 835
- **Radiation Control Technician (RCT Oral exam):** 10 CFR 835
- **Adult CPR: annual:** 29 CFR 1910.1030
- **1st Aid: every 3 years:** 29 CFR 1910.10
- **Excavation Competent Person:** 29 CFR part 1926, Subpart P.
- **Excavations and Trenches:** CCR Title 8 1504, 1539-1547
- **Nuclear Density Gauge**: as required by U S Nuclear Regulatory Commission
- **Hazardous Transportation Broker:** 49 CFR Part 173, subpart H
- **Confined Space:**
- **Radiation Safety Officer (RSO):** 10 CFR 835
- **Radiation Safety Officer (RSO refresher):** 10 CFR 835
- **Blood Born Pathogen: one time** 29 CFR 1910.10
- **Whole Body Count (WBC)** PHSP 18.3
- **Letter of Notification copy:** 10 CFR 835
- **Radiation History Request copy:** 10 CFR 835
- **Off-site Radiation History copy:** 10 CFR 835

**1. Core: Site Specific Core Training**

Medical

Medical Services and First Aid, Respiratory Protection, Heat Stress

Emergency Response

Employee Emergency Plans and Fire Prevention Plans, Accidental Prevention Signs and Tags, Contingency Plan, and General Emergency Procedures,

Health & Safety

Project Health and Safety Plan, Health and Safety Procedures

Labels of Injurious Substances, PPE, Proposition 65 Issues, HWP,

Miscellaneous Valley Elderberry Longhorn Beetle Mitigation

Radiological Protection

Radiological Protection Procedures, Rev. 0,1/30/98, ALARA Program, ALARA Training, Embryo/Fetus

Hazard Communication

HMIS Hazardous Materials Identification System, Preparation of Hazardous Materials for Transport

Construction

'ety Training and Education, Emergency Medical Services and First Aid, Specific Excavation Requirements, ,tection Systems at Excavations, Electrical Safety, Quality Assurance Protection Program

# EXTERNAL DOSIMETRY ISSUANCE

STANDARD OPERATING PROCEDURE

## 1.0 PURPOSE

The purpose of this external dosimetry issuance procedure is to document issuance wear, care use, reporting and records relating to personnel dosimeters that have been issued at LEHR in accordance with SOP 38.1 (Reference 2.2) and HPS 15.1 (Reference 2.4) for conformance with 10CFR835 (Reference 2.1). LEHR has submitted to DOE an exception to DOELAP accreditation request and presently uses a laboratory for dosimetry which is NVLAP certified.

## 2.0 REFERENCES

*2.1* *10 CFR 835 - "Occupational Radiation Protection Program," Final Rule, November 4, 1998*

*2.2* *SOP 38.1 Check-In and Orientation for General Employees, Radiological Workers, and Members of the Public*

*2.3* *SOP 38.3, Radiation Protection Records*

*2.4* *HSP 15.1, External Radiation Exposure Control*

*2.5* *Technical Basis for Monitoring of External Dose to Individuals*

*2.6* *TLD Service Documentation, Radiation Detection Company, California Dosimetry Vendor*

## 3.0 DEFINITIONS

### *3.1 Committed Dose Equivalent*

Committed dose equivalent is the dose equivalent calculated to be received by a tissue or organ over a 50 year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem (or sievert) (1 rem =0.01 sievert).

### *3.2 Committed Effective Dose Equivalent*

The sum of the committed dose equivalents to various tissues in the body ($H_{T,50}$), each multiplied by the appropriate weighting factor ($w_T$)--that is, $H_{E,50} = \Sigma w_T H_{T,50}$. Committed effective dose equivalent is expressed in units of rem (or sievert).

### *3.3 Controlled Area*

Any area to which access is managed by DOE or for DOE to protect individuals from exposure to radiation and/or radioactive materials.

### *3.4 Deep Dose Equivalent*

Deep Dose Equivalent is the dose equivalent derived from external radiation at a depth of 1 centimeter in tissue.

### *3.5 Dose*

Is a general term for absorbed dose, dose equivalent, effective dose, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent as defined in 10 CFR 835 definitions.

### *3.6 Dosimeter*

A portable instrument for measuring and registering the total accumulated exposure to ionizing radiation.

### *3.7 Dosimetry*

The theory and application of the principles and techniques involved in the measurement and recording of radiation doses. Its practical aspect is concerned with the use of various types of radiation instruments with which measurements are made.

### *3.8 Effective Dose Equivalent*

The summation of the products of the dose equivalent received by specified tissues of the body ($H_T$) and the appropriate weighting factor ($w_T$)--that is, $H_E = \Sigma w_T H_T$. It includes the dose from radiation sources internal and/or external to the body. For purposes of compliance with 10 CFR 835, deep dose equivalent to the whole body may be used as effective dose equivalent for external exposures. The effective dose equivalent is expressed in units of rem (or sievert).

### *3.9 High Radiation Area*

Any area, accessible to individuals, in which radiation levels could result in an individual receiving an deep dose equivalent, (effective dose equivalent to the whole body), in excess of 0.1 rem (0.001 Sievert) in one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

### *3.10 Ion*

An atom that has too many or too few electrons, causing it to be chemically active; an electron that is not associated (in orbit) with the nucleus.

### *3.11 Ionizing radiation*

Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. Examples: alpha, beta, gamma, e-rays and neutrons.

### *3.12 National Voluntary Laboratory Accreditation Program (NVLAP)*

Adheres to compliance with Title 15, Part 295 Code of Federal Regulations. These criteria encompass the requirements of ISO/IEC guide 25 and the relevant requirements of ISO 9002 (ANSI/ASQC Q 92-1987) for ionizing radiation dosimetry. Current certificate on file in SHSO office.

### *3.13 Radiation Area*

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

### *3.14 Radiological Worker*

Radiation Worker is a general employee whose job assignment involves operation of radiation producing devices or working with radioactive materials, or who is likely to be routinely occupationally exposed above 0.1 rem (0.001 sievert) per year total effective dose equivalent.

### *3.15 Spare Badge or Spare TLD*

A group of generic TLDs are ordered for issuance to radiological workers new to the LEHR site. Each TLD has a unique identifier, but no preprinted name.

### *3.16 Supplemental Dosimetry*

Supplemental Dosimeters include, but are not limited to, electronic dosimeters, pocket dosimeter, and other self-reading, alarming dosimeters. Supplemental dosimeters are required for any individual entering a High Radiation Area,10 CFR 835.502a(1), and recommended when a person could exceed 10% of an administrative control level from external radiation in one work day.

### *3.17 Thermoluminescent Dosimeter (TLD)*

LEHR uses Radiation Detection Company, (dosimetry vendor) Type 09, XBG (x-ray, beta, gamma) badge, containing two lithium fluoride TLD-100 capsules as detection elements and a single TLD chip to enable monitoring of beta radiation and beta/photon mixtures (Reference 2.6).

### *3.18 Total Effective Dose Equivalent (TEDE)*

Total Effective Dose Equivalent (TEDE) is the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

### *3.19 Whole Body*

Whole Body, for the purposes of external exposure, is the head, trunk (including male gonads), arms above and including the elbow, or legs above and including the knee.

## 4.0 RESPONSIBILITIES

### *4.1 Project Manager (PM)*

The Project Manager (PM) is responsible for the safe and effective implementation of this procedure.

### *4.2 Radiological Control Manager (RCM)*

The RCM shall ensure that the implementation of this procedure is consistent with 10CFR835, DOE Orders/Guidelines and LEHR project requirements. The RCM is also responsible for other assignments as noted throughout this procedure.

### *4.3 Site Health and Safety Officer (SHSO)*

Site Health and Safety Officer (SHSO) is responsible for managing the dosimetry program, for communication with the dosimetry vendor, ordering dosimeters, new radiation worker dosimeter issuance and dosimeter collection from terminating individuals, quarterly frequency of TLD supply exchange with the dosimeter vendor. The SHSO will keep two supplies of dosimeters:

- A supply of preprinted badges for radiological workers working a full quarter or more.
- A supply of generic badges for any radiological workers coming to LEHR in between the quarter frequency.

The SHSO is responsible for ensuring appropriate check-in and orientation of LEHR site personnel. (Reference 2.2). The SHSO is also responsible for other assignments as noted throughout this procedure. The SHSO performs the duties of a Dosimetry Program Manager and reports to the RCM. The SHSO is responsible for ensuring that LEHR on-site personnel have followed applicable sections of external dosimetry related procedures (Reference 2.2, 2.3 and 2.4).

The SHSO is responsible for maintaining a dosimeter storage area in a low background area for issued dosimeters not in use. The SHSO is responsible for ensuring that all radiological workers are trained to this procedure and understand its requirements. The SHSO is responsible for ensuring: the tracking of all reported radiological worker employment changes; the collecting of all TLDs from terminated employees; and, the return of TLDs with individuals full name and departure date.

### *4.4 Radiation Safety Officer (RSO)*

The RSO is responsible for ensuring all radiological workers are wearing required dosimetry prior to entry into any posted radiation area or per Hazardous Work Permit (HWP) requirement. The RSO is responsible for ensuring that LEHR site personnel covered by 10 CFR 835.402(a) are provided with and use personnel dosimetry for their assigned tasks. The RSO is also responsible for other assignments as noted throughout this procedure. The RSO reports to the RCM and provides the SHSO with necessary technical direction.

### *4.5 Site Personnel*

Radiological workers are responsible for wearing issued dosimeters as required by 10 CFR 835. Each individual is responsible for returning his/her TLD to the designated storage area at the end of the work day. Each individual is responsible for returning his/her TLD to the RSO at the time of his/her work assignment termination at LEHR

## 5.0 SAFETY PRECAUTIONS/PREREQUISITES

- The SHSO shall obtain radiation history from all radiological workers prior to dosimetry issuance.
- The radiation history of a radiological worker showing the current year history will be requested from the previous radiological work site(s) or an estimate of the current year signed by the radiological worker will suffice until records are retrieved from the previous radiological work sites.
- All issued dosimeters must be in calibration and comply with the requirements of the NVLAP for individual usage.

- A copy of the Dosimeter Vendor's current NVLAP certificate is on file in the SHSO office.
- Exposure from background, therapeutic and diagnostic medical radiation and voluntary participation in medical research program shall not be included in radiation history records or in the assessment of compliance with the occupational exposure limits.

# 6.0 PROCEDURE

## *6.1 Issuance of Dosimetry*

6.1.1 Designation of the LEHR site personnel to be issued dosimeters is detailed in LEHR HSP 15.1, External Radiation Exposure Control (Reference 2.4) and Technical Basis for Monitoring of External Dose to Individuals (Reference 2.5).

6.1.2 The SHSO shall not issue dosimeters to radiological workers who can not provide current year radiation history from prior radiological work sites or an estimate of current year radiation history. An estimate of current year radiation history will have the individual's authorized signature to verify that he provided an estimate during the interim of receiving the history from prior radiological sites or if those records can not be retrieved from prior radiological sites.

6.1.3 The SHSO shall maintain a log of all issued dosimeters. The log shall record, at a minimum, the individual's name, unique employee number, TLD identifier, and date of issuance.

## *6.2 Wearing and Use of Dosimetry*

6.2.1 All radiological workers shall wear TLD's and/or supplemental dosimetry on the front of body between the neck and waist. Placement of the dosimeter can be modified by the RSO when normal location will not result in the potential whole-body dose being measure.

## *6.3 Proper Use and Care of Dosimeter*

6.3.1 Thermoluminescent badges are stored with a control thermoluminescent group badge. The storage area must be equal to or less than background, ambient temperature, and away from direct sunlight. The storage area will be designated by the RSO. All thermoluminescent badges will be gathered at this spot at the beginning of each workday and returned at the end of each workday. Do not take the TLD off the site. Do not leave the TLD in your car. Do not immerse the TLD in water.

6.3.2 All radiological workers will return their TLDs to the RSO at the time of termination ***before*** leaving the LEHR site.

6.3.3 All TLDs will remain with the appropriate group control badge throughout the monitoring frequency. The SHSO will obtain worker termination dates from the RSO. This information will be compiled on a no-less-than-quarterly basis.

## *6.4 TLD Monitoring Period*

6.4.1 The annual monitoring period is divided into quarter intervals with which the previous quarter TLDs are collected and new quarter TLDs are issued. The quarter intervals are as follow:

- First quarter-January 1 - March 31
- Second quarter-April 1 - June 30
- Third quarter-July 1 - September 30
- Fourth quarter October 1 – December 31

6.4.2 The SHSO receives the new quarter TLDs about one week before for the current quarter. The TLD's are counted and matched to the packing slip. The SHSO will contact the RSO during the arrival of the new batch of TLDs to give him a heads-up that an exchange will take place on the first of the month.

6.4.3 The SHSO shall exchange the previous quarter TLDs with the new quarter's TLDs. The previous quarter's TLDs will be QA (checked in) to the yellow field log book. The TLDs will be placed in vendors shipping materials and returned for processing.

6.4.4 Radiological worker job assignment termination before the end of the quarter.

- Radiological worker(s)will return their TLD(s) to the RSO. The RSO will return the necessary information and TLD(s) to the SHSO. The SHSO will check in (QA) the TLD(s) against the yellow log.
- Radiological workers that have terminated at LEHR within a month of the end of the quarter will be held and will be sent to the processor at the end of the monitoring quarter.

## *6.5 Dosimetry Reports*

6.5.1 The SHSO will receive a quarterly report from the Dosimetry Vendor for the monitored individuals. The reports will be filed in the SHSO office after review.

6.5.2 The SHSO will request a termination report for the monitored individual(s) that have left the site and will not return within the monitor year. The report will be reviewed and the SHSO will send a copy of the termination report to the monitored individual in a timely manner.

6.5.3 The SHSO and RSO will discuss any abnormal or unexpected results compared to prior reports. The RSO will make a dose estimate for a monitored individual if an error has been determined. The dose estimate will be documented and filed with the monitored individuals site records.

# 7.0 LOST DOSIMETRY

Lost dosimetry shall be reported to the RSO and SHSO immediately. The RSO will fill out a lost dosimeter form and will calculate the estimated dose. The lost dosimeter form and associated estimated dose calculations will be filed in the RIDS personnel files.

# 8.0 RECORDS

All dosimetry records and dose histories are to be maintained as required by SOP 38.3, Radiation Protection Records (Reference 2.3)

# 9.0 ATTACHMENTS

None.

# RADIATION PROTECTION RECORDS

STANDARD OPERATING PROCEDURE

## 1.0 PURPOSE

The purpose of this procedure is to describe records maintenance and retention for Radiation Protection Records.

## 2.0 REFERENCES

*2.1* *10 CFR 835 - "Occupational Radiation Protection Program"*

*2.2* *HSP 15.1 - "External Radiation Exposure Control"*

*2.3* *HSP 16.1 - "Internal Dosimetry Procedure"*

*2.4* *HSP 18.1 - "Personnel Contamination"*

*2.5* *HSP 19.1 - "Embryo-Fetus Protection Program"*

*2.6* *SOP 25.1 - "Radiological Surveys and Instrumentation"*

*2.7* *SOP 38.1 - " Check-in and Orientation for General Employees, Radiological Workers, and Members of the Public"*

*2.8* *SOP 38.2 - "External Dosimetry Issuance"*

*2.9* *SOP 38.4 - "Radiological Protection Program Audits"*

## 3.0 DEFINITIONS

*3.1* *Records Inventory and Disposition Schedule (RIDS)*

# 4.0 RESPONSIBILITIES

## *4.1 Project Manager (PM)*

The Project Manager PM is responsible for the effective implementation of this procedure.

## *4.2 Radiological Control Manager (RCM)*

The Radiological Control Manager (RCM) is responsible for ensuring all dosimetry and radiological protection records are maintained pursuant to the requirements of this procedure.

## *4.3 Radiation Safety Officer (RSO)*

The Radiation Safety Officer (RSO) is responsible for ensuring that all internal and skin dose calculations, and radiation protection records are reviewed. All reviewed records will be retained according to this procedure.

## *4.4 Site Health and Safety Officer (SHSO)*

The Site Health and Safety Officer (SHSO) is responsible for record retention as required by this procedure and for providing applicable records for review by the RSO (or other designated radiation protection personnel).

# 5.0 SAFETY PRECAUTIONS/PREREQUISITES

None.

# 6.0 PROCEDURE

## *6.1 Radiological Survey Records*

Copies of radiological survey records are retained in the RSO working files. The original is retained in the RIDS LEHR Project files.

6.1.1 Equipment and radioactive shipment surveys can be retained in the RSO working files and transferred to RIDS LEHR Project files, no less than annually.

6.1.2 Equipment and radioactive shipment surveys can be retained in the RSO working files and transferred no less than annually to the RIDS LEHR Project files.

## *6.2 Radiological Instruments and Equipment*

6.2.1 All copies of radiological instruments and equipment maintenance and calibration results records (Reference 2.6) will be retained in the RSO working files and will be transferred, no less than annually, to the RIDS LEHR Project files for archiving.

6.2.2 Equipment, techniques, and procedure document changes used for monitoring the workplace will be retained in the RSO working files and transferred no less than annually to the RIDS LEHR Project files.

## *6.3 Individual Monitoring Records*

6.3.1 All copies of dose estimates for all skin contamination as required by HSP 18.1, "Personnel Contamination" (Reference 2.4), can be retained in the RSO working files and the original retained in the RIDS LEHR Project files.

6.3.2 Copies of dose estimates for all internal exposures (Reference 2.3) and external exposures (Reference 2.2 and 2.8) can be retained in the RSO working files and the original retained in the RIDS LEHR Project files.

6.3.3 All skin contamination dose estimate records and all internal dose estimate records including all data used in the estimates shall retained in the Personnel section of the RIDS LEHR Project files.

## *6.4 Administrative Records*

6.4.1 All records generated in performance of the Occupational Radiation Protection Program assessments and audits shall be maintained in accordance with the requirements as outlined in SOP 38.4, "Radiological Protection Program Audits" (Reference 2.9).

6.4.2 Completed Declaration of Pregnancy forms or revocation of Declaration of Pregnancy forms shall be kept in the Personnel section of the RIDS LEHR Project files (Reference 2.5).

6.4.3 The following lists some of the employee training records required by federal regulation (Reference 2.7). These records and similar records are retained in the RIDS LEHR Project files:

- General Employee radiological training
- Radiological worker training
- Periodic retraining
- Radiation Worker training

6.4.4 Actions taken to maintain occupational exposures as-low-as-reasonably-achievable, including the actions required by 10 CFR 835 (Reference 2.1), as well as administrative control actions required by 10 CFR 835, shall be documented and documentation shall be retained in the RIDS LEHR Project files.

# 7.0 DOCUMENTATION/RECORDS

*7.1* *Records shall be maintained to document compliance with 10 CFR 835, Occupational Radiation Protection Program and with Radiation Protection Programs required by 835.101.*

*7.2* *All records listed in this procedure are to be retained until final disposition is authorized by the DOE as per 10 CFR 835.701.*

*7.3* *All records required by this section shall be retained until transferred to the DOE upon cessation of activities at the site that could cause exposure to individuals.*

*7.4* *Unless otherwise specified, radiological control records shall use the special units of curie, roentgen, rad, and rem, including multiples of these units or as otherwise provided within 10CFR835.*

*7.5* *Individual Monitoring Records shall be maintained to document doses received by all individuals for whom monitoring was required pursuant to 10 CFR 835.402 unplanned doses exceeding the monitoring thresholds of 10 CFR 835.402.*

*7.6* *Individual Monitoring Records shall be sufficient to evaluate compliance with subpart C of 10 CFR 835*

*7.7* *Individual Monitoring Records shall include the dose equivalent to the embryo/fetus of a declared pregnant worker.*

*7.8* *The records specified in this section that are identified with a specific individual shall be readily available to that individual.*

*7.9* *Data necessary to allow future verification or reassessment of the recorded doses shall be recorded.*

*7.10* *All documentation and records will be collected, maintained and retained according to 10 CFR 835 subpart H.*

*7.11* *The individual monitoring records shall be sufficient to evaluate compliance with Section 835.202.*

*7.12* *The individual monitoring records shall be sufficient to provide dose information necessary to complete reports required by subpart I of 10 CFR 835 and by*

*Departmental requirements for occurrence reporting and processing, to include person, social security number or a unique identification number.*

***7.13*** *The individual monitoring records required by this section shall include the following quantities for external dose received during the year:*

- the effective dose equivalent from external sources of radiation (deep dose equivalent may be used as effective dose equivalent for external exposure);
- the lens of the eye dose equivalent;
- the shallow dose equivalent to the skin; and,
- the shallow dose equivalent to the extremities.

***7.14*** *The individual monitoring records shall include the following quantities for internal dose resulting from intakes received during the year:*

- committed effective dose equivalent;
- committed dose equivalent to any organ or tissue of concern; and,
- estimated intake and identity of radionuclides.

***7.15*** *The individual monitoring records shall include the following quantities for the summation of the external and internal dose:*

- total effective dose equivalent in a year;
- for any organ or tissue assigned an internal dose during the year, the sum of the deep dose equivalent from external exposures and the committed dose equivalent to that organ or tissue; and,
- cumulative total effective dose equivalent.

***7.16*** *Documentation of all occupational exposure received during the current year shall be obtained when demonstrating compliance with Section 835.202 (a).*

***7.17*** *The results of individual external and internal dose measurements that are performed but are not required by Section 835.402 shall be recorded. Recording of the non-uniform shallow dose equivalent to the skin caused by contamination on the skin (see Section 835.205) is not required if the dose is less than 2 percent of the limit specified for the skin in Section 835.202(a) (4).*

***7.18*** *Results of monitoring for radiation and radioactive material shall be conducted as required by subparts E and L of 10 CFR 835, except for monitoring required by §*

*835.1102(d). Results of monitoring shall be used to determine individual occupational dose from external and internal sources if required by 10CFR835.*

***7.19*** *Records shall be maintained as necessary to demonstrate compliance with the requirements of 835.1201 and 835.1202 for sealed radioactive source control, inventory, and source leak tests.*

## 8.0 ATTACHMENTS

None.

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# RADIOLOGICAL PROTECTION PROGRAM AUDITS

STANDARD OPERATING PROCEDURE

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes guidelines and requirements for performing internal audits of the LEHR Radiation Protection Program (RPP) as required by 10 CFR 835.102, and Section 18 of the Quality Assurance Project Plan.

- 10 CFR 835.102 states that "Internal audits of the radiation protection program, including examination of program content and implementation, shall be conducted through a process that ensures that all functional elements are reviewed no less frequently than every 36 months"
- Section 18 of the QAPP states that "... Planned and scheduled audits will be performed to verify compliance with all aspects of this document, SAP and Work Plan(s), as applicable" to the LEHR RPP

## 2.0 REFERENCES

*2.1 10 CFR 835 "Occupational Radiation Protection"*

*2.2 Quality Assurance Project Plan (QAPP)*

*2.3 SQP 4.2 - "Records Management"*

*2.4 SQP 12.1 – "Quality Audits"*

*2.5 LEHR Radiological Protection Program (RPP)*

## 3.0 DEFINITIONS

### *3.1 Audit*

A planned and documented activity performed to determine by investigation, examination, or evaluation of objective evidence the adequacy of and compliance with established procedures, instructions, drawings, and other applicable documents, and the effectiveness of implementation. An

### *4.2 Project Manager (PM)*

The PM is responsible for the approval and implementation of this procedure.

### *4.3 Radiological Control Manager (RCM)*

The RCM, or designee, is responsible for ensuring regulatory and operational compliance with the requirements of this procedure. The RCM is also responsible for coordinating and ensuring RPP assessments (e.g., surveillance, audit, inspection) of project activities are performed in compliance with the LEHR RPP (Reference 2.5) and procedures.

### *4.4 Project Quality Assurance Manager (PQAM)*

The PQAM is responsible for implementing quality aspects of the RPP and following up on findings or observations which involve or impact the Quality Assurance Program.

### *4.5 Project Records Administrator (PRA)*

The PRA is responsible for maintaining the records required in this procedure.

### *4.6 Radiation Safety Officer (RSO)*

The RSO is responsible for assisting in scheduling of resources to participate in RPP assessments.

## 5.0 SAFETY PRECAUTIONS/PREREQUISITES

- In conducting audits, the requirements of the RPP, PHSP, HWP's or any other applicable control documents shall be complied with by audit personnel.
- The audit program shall involve qualified personnel (e.g., Radiation Protection personnel, Health & Safety personnel etc.), as needed to assist in any radiological areas of concern (i.e., Controlled Areas, Contamination Areas, etc.) in performance of audit.

## 6.0 PROCEDURE

### *6.1 Discussion*

6.1.1 Internal assessments of the LEHR RPP content and implementation shall be performed to verify and document compliance with requirements of 10 CFR 835 (Reference 2.1) and the QAPP, as applicable to the LEHR RPP. These assessments are set on cycles that ensure all functional elements are reviewed no less frequently than every 36 months. See Attachment 8.1 for indicated assessment (audit) cycles. These audits should consist of a review of

# 8.0 ATTACHMENTS

## *8.1 Audit Plan Schedule*

# ATTACHMENT 8.1

# RPP AUDIT PLAN SCHEDULE

| 10 CFR 835 Subpart | Title | Audit Cycle Year |
|---|---|---|
| A | General Provisions | 1 |
| B | Management and Administrative Requirements | 1 |
| C | (Reserved) | N/A |
| D | (Reserved) | N/A |
| E | Monitoring of Individuals and Measurements | 2 |
| F | Entry Control Program | 2 |
| G | Posting and Labeling Log | 2 |
| H | Records | 1 |
| I | Reports to Individuals | 1 |
| J | Radiation Safety Training | 2 |
| K | Design and Control | 3 |
| L | Radioactive Contamination Control | 3 |
| M | Sealed Radioactive Source Control | 3 |
| N | Emergency Exposure Situations | 3 |

[1)] Variations in audit cycle may occur to facilitate an expedited audit schedule.

# OCCUPATIONAL EXPOSURE REPORTS

STANDARD OPERATING PROCEDURE

## 1.0 PURPOSE

This procedure describes the requirements for the reporting of personnel exposures to chemicals, radiation, radioactive material, or other hazardous materials encountered during environmental assessment and decontamination and decommissioning activities at the LEHR facility. DOE sites are required to submit the results of occupational radiation exposure monitoring to DOE Headquarters on an annual basis in accordance with DOE Order 231-1 (Reference 2.3). The format and content of the reports are specified in DOE Manual 231-1.1 Appendix G.

## 2.0 REFERENCES

*2.1* *10 CFR 835, "Occupational Radiation Protection Program"*

*2.2* *29 CFR 1910, "Occupational Safety and Health Standards," and 1926, "Safety and Health Regulations for Construction"*

*2.3* *DOE Order 231.1*

*2.4* *DOE ORDER Manual 231.1, September 1995*

## 3.0 DEFINITIONS

None.

## 4.0 RESPONSIBILITIES

### *4.1 The Project Manager (PM)*

The PM is responsible for the effective implementation of this procedure.

### *4.2 The Radiological Control Manager (RCM)*

The RCM is responsible for ensuring employee exposure reports are prepared and provided to site personnel pursuant to the requirements of this procedure and of applicable federal regulations.

6.2.3 Each DOE or DOE-contractor-operated site for facility shall, on an annual basis, provide a radiation dose report to each individual monitored during the year at that site or facility in accordance with 10 CFR 835.402.

- DOE sites are required to submit the results of occupational radiation exposure monitoring to DOE Headquarters on an annual basis in accordance with DOE Order 231.1.
- The format and content of the reports are specified in DOE Manual 231-1.1 Appendix G.

6.2.4 REMedit Validation:

- Refer to the web site http:// rems.eh.gov.\reportin.1 for current report update.

6.2.5 Detailed information concerning any individuals' exposure shall be made available to the individual upon request of that individual, consistent with the provisions of the Privacy Act of 1974.

6.2.6 When a DOE contractor is required to report to the Department, pursuant, to Departmental requirements for occurrence reporting and processing, any exposure of an individual to radiation and/or radioactive material, or planned special exposure in accordance the 10 CFR 835.204(e), the contractor shall also provide that individual with a report on his or her exposure data included therein. Such report shall be transmitted at a time not later than the transmittal to the Department.

### *6.3 Hazard Communication*

6.3.1 The SHSO or Radiation Safety Officer (RSO) shall inform all site personnel of the presence of new chemicals or hazardous materials brought onto the project site.

## 7.0 DOCUMENTATION/RECORDS

Copies of reports shall be documented and maintained in accordance with SOP 38.3, Dosimetry Program.

## 8.0 ATTACHMENTS

None.

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# LEHR SITE INSPECTION

STANDARD OPERATING PROCEDURE

## 1.0 PURPOSE

The purpose of the LEHR Weekly site inspection is to check the DOE controlled buildings radiological waste storage areas, former dog pens areas, the non-operating mixed waste storage shed, the former Imhoff area and the fenced in southwest corner of the site for entry control. The degree of control shall be commensurate with existing and potential radiological hazards, storage of radiological waste, storage of chemical hazards or storage of other hazardous materials encountered during environmental assessment and decontamination/decommissioning activities at the LEHR facility. One or more of the following methods shall be used to ensure control:

- Signs and barricades;
- Control devices on entrances;
- Conspicuous visual and/or audible alarms;
- Locked entrance way; or,
- Administrative controls.

## 2.0 REFERENCES

### *2.1 SQP 7.1, Receipt Inspection*

## 3.0 RESPONSIBILITIES

### *3.1 Project Manager*

The Project Manager is responsible for ensuring the following:

- the LEHR Site Inspections are conducted in accordance with this procedure and any other appropriate procedures.
- Addresses/advises corrective actions for weekly outstanding issues reported by the inspector.

# 5.0 PROCEDURE

## *5.1 LEHR Site Inspections*

Performed weekly, or as necessary to assess any adverse effects from occurrences such as heavy rainstorms, windstorms power outages.

Performed as required by SQP 7.2 (Reference 2.1).

## *5.2 Corrective Actions*

Copy any outstanding issues to the Project Manager and Waste Coordinator.

Copy corrective action documentation follow-up to the Project Manager and Waste Coordinator.

# 6.0 DOCUMENTATION/RECORDS

## *6.1 LEHR Site Inspection Form*

The most current version of the LEHR Site Inspection Form and completed LEHR Site Inspections shall be kept in the LEHR Project Files. Completed LEHR Site Inspections shall also be copied to the Project Manager, and any requesting subcontractor.

# 7.0 ATTACHMENTS

None.

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# AIRBORNE RADIOACTIVITY MONITORING

HEALTH AND SAFETY PROCEDURE

## 1.0 PURPOSE

This procedure describes the airborne radioactivity monitoring program requirements for field investigation and decommissioning and decontamination activities at LEHR.

## 2.0 REFERENCES

*2.1* *10 CFR 835, "Occupational Radiation Protection"*

*2.2* *SOP 24.1, "Radiological Areas and Posting"*

*2.3* *SOP 38.3, "Radiation Protection Records"*

*2.4* *HSP 16.1, "Internal Dosimetry Procedure"*

## 3.0 DEFINITIONS

### *3.1 Air In-leakage*

Leakage of air around a sample holder or into any fitting of a sample line that may affect the amount of deposition of radioactive material on the collector or the accuracy of sample volume measurements.

### *3.2 Air Monitoring*

Actions to detect and quantify airborne radiological conditions by the collection of an air sample and the subsequent analysis, either in real-time or offline laboratory analysis, of the amount and type of radioactive material present in the workplace atmosphere.

### *3.3 Air Sampling*

A form of air monitoring in which an air sample is collected and analyzed at a later time, sometimes referred to as retrospective air monitoring.

### *3.10 Grab Sample*

A single sample removed from the workplace air over a short time interval, typically less than one hour.

### *3.11 Minimum Detectable Activity (MDA)*

The smallest amount/activity of a radionuclide in a sample that will yield a result above the decision level with a $\beta$ probability of non-detection (Type II error) while accepting an $\alpha$ probability of erroneously detecting that radionuclide in an appropriate blank sample (Type I error). The MDA depends on both $\alpha$ and $\beta$. Measurement results are compared to the decision level, not the MDA; the MDA is used to determine whether a program has adequate detection capability. Typically, the MDA is calculated assuming Type I and Type II errors of 0.05.

## 4.0 RESPONSIBILITIES

### *4.1 Project Manager (PM)*

The PM is responsible for the safe and effective implementation of this procedure.

### *4.2 Radiation Safety Officer (RSO)*

The RSO ensures that all Radiological Control Technicians (RCT) and project personnel are trained on this procedure and understand its requirements. The RSO is also responsible for reviewing results of all airborne radioactivity monitoring, directing collection of bioassay samples, and performing field estimates of internal dose.

### *4.3 Radiological Control Technicians (RCTs)*

The RCTs are responsible for conducting and calculating air concentrations from airborne radioactivity monitoring.

### *4.4 Site Health and Safety Officer (SHSO)*

The SHSO is responsible for record retention as required by this procedure.

## 5.0 SAFETY PRECAUTIONS AND PREREQUISITES

### *5.1 Equipment*

All air monitoring/sampling equipment used shall be calibrated for flow rate on an annual basis.

patterns in the area should be considered in placing samplers so that the sampler is likely to be in the airflow downstream of the source and prior to or coincident with the location of the worker.

6.1.6 Continuous air monitors shall be routinely calibrated and maintained, and should be capable of measuring one DAC when averaged over eight hours (eight DAC hours).

6.1.7 Air samplers shall be calibrated annually and maintained in accordance with the manufacturer's instruction manuals.

6.1.8 Real-time air monitoring, using continuous air monitors, shall be performed in normally occupied areas where an individual is likely to be exposed to a concentrations > 40 DAC -hours in one week and where there is a need to detect and provide warning of airborne radioactivity concentrates that warrant immediate action to terminate inhalation of airborne radioactive material. Measurement equipment shall have an audible alarm.

6.1.9 The DAC values given in Appendices A and C to 10 CFR 835 shall be used in the control of occupational exposures to airborne radioactive material. Note: the DAC's listed in 10CFR835 account only for immersion in a semi-infinite cloud and do not account for inhalation or ingestion exposures. Therefore, general employees who, under typical conditions, are likely to receive a committed effective dose equivalent of 0.1 rem or more from all occupational radionuclide intakes in a year shall participate in the internal monitoring program as required by Reference 2.4.

## *6.2 Monitoring Requirements*

6.2.1 Airborne monitoring/sampling shall be performed:

- During any work or operation known or suspected to cause airborne radioactivity, including any grinding, welding, or burning on contaminated equipment.
- During any work or operation that involves the breach of a radioactively contaminated system where it can be reasonably anticipated that the opening of the system could result in radiological workers receiving a committed effective dose equivalent of 0.1 rem or more from all occupational radionuclide intakes.
- During initial entry into any area known or suspected to contain airborne radioactivity concentrations in excess of 2% of DAC or loose surface contamination in excess of 200 dpm/100 cm2 alpha or 10,000 dpm/100 $cm^2$ beta/gamma.
- Immediately following the discovery of a significant spill or spread of radioactive materials or any other time airborne radioactivity levels may have changed.
- Periodically (e.g., daily) in contamination areas where there is the potential for airborne radioactivity and where work is being performed.
- Any time respiratory protection devices or DAC hours are used to control internal exposures.

should be performed. At a minimum, the flow rates should be verified when sample filters are exchanged. Rapid or significant changes in flow rate should be investigated immediately. These instances may indicate the need for more frequent changes of filter media or loss of integrity of filter or sampling equipment. The sample flow rate used for estimating air concentration should be the average of the flow rate when the sample was started and the flow rate when the sample medium was removed.

6.3.1.7 After the minimum collection time to meet the MDA, record the final flow rate and time, and turn off the air sampling unit. Remove the air filter and place in sample envelope or equivalent. All samples collected should be assigned an identification number that cannot be confused with samples taken at another location. Sample designators should be placed on all collection envelopes or containers to reduce the possibility of mislabeling a sample.

6.3.2 Lapel Samples

6.3.2.1 Select a lapel air sampler and install a 25mm diameter filter in the filter cassette head. Calibrate the flow rate and record the calibration data.

6.3.2.2 Determine the time and flow rate necessary to sample a volume sufficient to ensure that an adequate MDA is obtained. Due to the low flow rate of lapel air sampling pumps, it is usually necessary to operate the pump a minimum of four hours. A six to eight hour sample, if possible, is preferable.

6.3.2.3 Select a worker with a high potential for exposure to airborne radioactive materials. Instruct the worker regarding the wearing of the lapel sampler. Ensure the filter head is positioned in the breathing zone.

6.3.2.4 Record the name of the worker and the nature of the work being performed. Record any other pertinent information (ie., respiratory protection being used).

6.3.2.5 Turn on the air sampling pump, adjust the flow rate to a calibrated value, and record the time, initial flow rate, and identity of the RCT issuing the lapel monitoring pump.

6.3.2.6 Periodically, check the work area and air sampling unit for proper monitoring and operation. Excessive filter dust loading interferes with alpha particle detection and reductions in flow rate result in uncertainties in the total air volume sampled, periodic verification of flow rates should be performed. At a minimum, the flow rates should be verified when sample filters are exchanged. Rapid or significant changes in flow rate should be investigated immediately. These instances may indicate the need for more frequent changes of filter media or loss of integrity of filter or sampling equipment. The sample flow rate used for estimating air concentration should be the average of the flow rate when the sample was started and the flow rate when the sample medium was removed.

6.3.2.7 When a sufficient sample has been collected or when work has stopped, record the final flow rate and time, and turn off the air sampling unit. Remove the air filter and place it in the sample envelope or equivalent. All samples collected should be assigned an identification number that cannot be confused with samples taken at another location. Sample designators should be placed on all collection envelopes or containers to reduce the possibility of mislabeling a sample.

6.3.2.8 Check the calibration of the final flow rate by calibrating the flow rate.

6.6.2 Workers shall have an estimate made of their internal exposure to radioactive material by calculating DAC-hours based on air sample results as required by HSP 16.1, "Internal Dosimetry Procedure" (Reference 2.4).

6.6.3 Calculation of DAC-hours are documented by completing Attachment 8.3, "Field Estimate of Internal Exposure."

6.6.4 Completed "Field Estimate of Internal Exposure" forms shall be forwarded to the SHSO or designee for tracking and incorporation into dosimetry records.

6.6.5 Workers who have received greater than 20 DAC-hours shall submit a bioassay sample. Initial time of sample collection shall be determined by the RSO.

6.6.6 The estimation of internal dose SHALL be based on bioassay data rather than air concentration values unless bioassay data are: (1) unavailable; (2) inadequate; or (3) internal dose estimates based on air concentration values are demonstrated to be as or more accurate.

## 7.0 RECORDS

Attachments 8.1, 8.2 and 8.3 are quality assurance records and shall be maintained in site files by the SHSO in accordance with SOP 38.3, "Radiation Protection Records" (Reference 2.3).

## 8.0 ATTACHMENTS

### *8.1 Air Sampling Data Sheet*

### *8.2 Sample Count Record*

### *8.3 Field Estimate of Internal Exposure*

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# AIR SAMPLING DATA SHEET

Date: _____

**Part I: AIR SAMPLING EQUIPMENT**

| | | |
|---|---|---|
| Pump Type: Breathing Zone | Low Volume General Air | High Volume General Air |
| Serial #: | | |
| Calibration Due: | | |
| Filter Type: | | |
| Filter Size: | | |

**Part II: SAMPLING PARAMETERS**

| | | |
|---|---|---|
| Sample Start Date: | Time: | Flow Rate (L/min): |
| Sample End Date: | Time: | Flow Rate (L/min): |
| Total Sample Time (T): min | Average Flow Rate (F): | Liters/min |

Sample Volume (V) = T _____ (min) X F _____ (L/min) X 1000 = _____ (mL)

**Part III: WORKER/WORKPLACE DATA**

| **Breathing Zone** | **General Air** |
|---|---|
| Name of Worker Monitored: | General Area and Specific Work Location: |
| Type of Work Performed: | |
| Work Permit Number: | |
| General Area and Specific Work Location: | Type of Operation/Equipment in Area: |
| Respiratory Protection Used:<br>None Full Face<br>Half Face Other | Names of Workers: |

# SAMPLE COUNT RECORD

Survey Number: _____

| | Date and Time | Hour of Count | Instrument Model/Serial | Inst Eff | BKGD Counts | BKGD Time (mins) | BKGD Count Rate (cpm) | Sample Gross Counts | Sample Count Time (Mins) | Sample Gross Count Rate (cpm) | *Net Sample Count Rate (cpm) | **Sample Activity (µCi/mL) | ***Inst MDA (µCi/mL) | Limit | Technician |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Alpha | | | | | | | | | | | | | | | |
| 1 Beta | | | | | | | | | | | | | | | |
| 2 Alpha | | | | | | | | | | | | | | | |
| 2 Beta | | | | | | | | | | | | | | | |
| 3 Alpha | | | | | | | | | | | | | | | |
| 3 Beta | | | | | | | | | | | | | | | |
| 4 Alpha | | | | | | | | | | | | | | | |
| 4 Beta | | | | | | | | | | | | | | | |

* Net Sample Count Rate = Sample Gross Count Rate - BKGD Count Rate

$$**\text{Activity} = \frac{\text{Net Sample Count Rate}}{2.22 \times 10^6 \cdot \text{Vol} \cdot \text{Eff}}$$

$$***\text{MDA} = \frac{2.71 + 4.65 \cdot (C_B\, t_{bkgd})^{0.5}}{2.22 \times 10^6 \cdot \text{Eff} \cdot t_s \cdot \text{Qty}}$$

Reviewed By: _____ Date: _____

# FIELD ESTIMATE OF INTERNAL EXPOSURE

| Date | Individual | Employee # | Air Sample # | (1)(2)DAC Fraction x Time (hrs) = DAC – hours | DAC – hours |
|---|---|---|---|---|---|
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |

Reviewed By: _____ Date: _____

(1) DAC Fraction = Measured Activity Concentration/DAC

(2) If mixture of radionuclides, the DAC Fraction must be a summation of all applicable DAC Fractions.

# EXTERNAL RADIATION EXPOSURE CONTROL

HEALTH AND SAFETY PROCEDURE

## 1.0 PURPOSE

The purpose of this procedure is to describe the methods and responsibilities for controlling radiation exposure to LEHR site personnel issued personnel dosimeters for the purpose of monitoring individual exposures to external radiation as may be required for compliance to 10CFR835.402(a) (Reference 2.1)

The technical basis for use of external dosimetry at LEHR is provided within the document entitled Technical Basis for Monitoring of External Dose To Individuals (Reference 2.6).

## 2.0 REFERENCES

*2.1* *10 CFR 835, "Occupational Radiation Protection"*

*2.2* *SOP 38.1, "Check-in and Orientation for General Employees, Radiological Workers and Members of the Public"*

*2.3* *SOP 38.2, "External Dosimetry Issuance*

*2.4* *SOP 38.3, "Radiation Protection Records"*

*2.5* *HSP 19.1, "Embryo-Fetus Protection Program"*

*2.6* *Technical Basis for Monitoring of External Dose to Individuals*

## 3.0 DEFINITIONS

### *3.1 ALARA*

As low as reasonably achievable, the approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the members of the 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 controlling limits as is reasonably achievable.

### *3.2 Absorbed Dose (D)*

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

### *3.3 Background*

Background is naturally occurring radioactive materials which have not been technologically enhanced.

### *3.4 Collective Dose*

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

### *3.5 Cumulative Total Effective Dose Equivalent*

The sum of all total effective dose equivalent values recorded for an individual, where available, for each year occupational dose was received, beginning January 1, 1989.

### *3.6 Deep Dose Equivalent*

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

### *3.7 Dose Equivalent (H)*

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

### *3.8 Declared Pregnant Worker*

A woman who has voluntarily declared to her employer, in writing, her pregnancy for the purpose of being subject to the occupational dose limits to the embryo-fetus as provided in 835.206. This declaration may be revoked at any time by the declared pregnant worker.

### *3.9 Dosimeter*

Radiation-sensitive element(s) in a holder used to provide a cumulative irradiation record of an individual.

### *3.10 Effective Dose Equivalent ($H_\Sigma$)*

The summation of the products of the dose equivalent received by specified tissues of the body ($H_T$) and the appropriate weighting factor ($W_T$), that is, $H_E = \Sigma W_T H_T$. It includes the dose from radiation

sources internal and/or external to the body. Deep dose equivalent to the whole body may be used as effective dose equivalent for external exposures. The effective dose equivalent is expressed in units of rem (or sievert).

### *3.11 External Dose or Exposure*

The portion of the dose equivalent received from radiation sources (e.g., "external sources") outside the body.

### *3.12 Extremity*

Means hands and arms below the elbow, and feet and legs below the knee.

### *3.13 Lens of the Eye Dose Equivalent*

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

### *3.14 Hazardous Work Permit (HWP)*

A document used solely for the purpose of informing workers of task hazards, radiological conditions, required personal protective clothing, and special instructions to be followed during the conduct of work.

### *3.15 High Radiation Area*

An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem (0.001 sievert) in one hour at 30 cm from the radiation source or from any surface that the radiation penetrates.

### *3.16 Occupational Dose*

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

### *3.17 Quality Factor*

The principal modifying factor used to calculate the dose equivalent from the absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate quality factor (Q).

### *3.18 Shallow Dose Equivalent*

The dose equivalent deriving from external radiation at a depth of 0.007 cm in tissue.

### *3.19 Total Effective Dose Equivalent (TEDE)*

The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

### *3.20 Weighting Factor*

The fraction of the overall health risk, resulting from uniform, whole body irradiation, attributable to specific tissue (T). The dose equivalent to tissue T, is multiplied by the appropriate weighting factor to obtain the effective dose equivalent contribution from that tissue.

### *3.21 Radiation Area*

An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem, but less than 0.1 rem, in one hour at 30 cm from the radiation source or from any surface that the radiation penetrates.

### *3.22 Whole Body*

The head, trunk, gonads, arms between the elbow and trunk, and legs between the knees and trunk. The remaining parts of the body are considered to be individual extremities.

## 4.0 RESPONSIBILITIES

### *4.1 Project Manager (PM)*

4.1.1 The PM is responsible for the safe and effective implementation of this procedure.

### *4.2 Radiological Control Manager (RCM)*

The RCM is responsible for administrative review and control of personnel external radiation exposure levels. The RCM also approves all planned exposures in excess of administrative limits and dose estimates made for external dose assessment. The RCM shall ensure that the implementation of this procedure is consistent with 10CFR835, DOE Orders/Guidelines and LEHR project requirements. The RCM is also responsible for other assignments as noted throughout this procedure.

### *4.3 Radiation Safety Officer (RSO)*

The RSO is responsible for ensuring that LEHR site personnel covered by 10 CFR 835.402(a) are provided with and use personnel dosimetry for their assigned tasks. The RSO is also responsible for other assignments as noted throughout this procedure. The RSO reports to the RCM and provides the SHSO with necessary technical direction.

### *4.4 Site Health and Safety Officer (SHSO)*

The Site Health and Safety Officer (SHSO) is responsible for maintaining and issuing personnel dosimetry devices (Reference 2.3) and for maintaining dosimetry records pursuant to LEHR SOP 38.3, Radiation Protection Records (Reference 2.4). The SHSO is also responsible for providing reports to personnel on their radiation exposure history within 30 days of receiving a written request and for approving/maintaining records required by the embryo-fetus protection program. The SHSO is responsible for reviewing personnel dosimeter results (in cooperation with the RSO) to ensure doses are ALARA and for obtaining from previous employers a worker's radiation exposure history or, when not practical, estimating the worker's previous dose. The SHSO is responsible for ensuring appropriate check-in and orientation of LEHR site personnel. (Reference 2.2). The SHSO is also responsible for other assignments as noted throughout this procedure. The SHSO performs the duties of a Dosimetry Program Manager and reports to the RCM. The SHSO is responsible for ensuring that LEHR on-site personnel follow applicable sections of procedures (References 2.2, 2.3 and 2.4) dealing with external dosimetry.

## 5.0 PROCEDURE

The overriding premise used at LEHR is to maintain worker dose ALARA. For most projects this is accomplished by planning the task and executing the plan. If a task appears to require a total man-rem dose expenditure of 150 mrem, then planning efforts shall require evaluation of dose reduction methods. This includes facility or equipment design, shielding, etc. These methods shall be employed based on an ALARA evaluation.

### *5.1 External Radiation Exposure Control Methods*

5.1.1 The RSO shall be responsible for identifying and controlling sources of radiation. Also, the RSO should review all reported exposure data and ensure any data irregularities are resolved.

5.1.2 The RCM shall establish dose limits and administrative dose control levels.

5.1.3 The SHSO shall issue dosimeters to radiological workers to monitor for potential radiation exposure.

5.1.4 The RSO shall track exposures received.

### *5.2 Regulatory Dose Limits*

5.2.1 Individual doses for monitored radiological workers shall not, within any calendar year, exceed any of the limits listed in Table 1, Regulatory and Administrative Dose Limits, Column 1, excluding natural background, medical radiation exposures, including all occupational exposure received during the current year when demonstrating compliance with 10CFR835.

5.2.2 Approval by the RCM is required for any individual to exceed this limit.

5.2.3 The RCM shall inform the U.S. Department of Energy's Oakland Operations Office of any instance in which an individual receives more than 5 rem in a calendar year.

5.2.4 For the purpose of monitoring individual exposures to external radiation, personnel dosimeters shall be provided to and used by:

- Radiological workers who, under typical conditions, are likely to receive one or more of the following:
  - An effective dose equivalent to the whole body of 0.1 rem (0.001 sievert) or more in a year;
  - A shallow dose equivalent to the skin or to any extremity of 5 rems (0.05 sievert) or more in a year;
  - A lens of the eye dose equivalent of 1.5 rems (0.015 sievert) or more in a year;
- Declared pregnant workers who are likely to receive from external sources a dose equivalent to the embryo/fetus in excess of 10 percent of the limit at § 835.206(a);
- Occupationally exposed minors likely to receive a dose in excess of 50 percent of the applicable limits at § 835.207 in a year from external sources;
- Members of the public entering a controlled area likely to receive a dose in excess of 50 percent of the limit at § 835.208 in a year from external sources; and,
- Individuals entering a high or very high radiation area.

External dosimetry is only required at LEHR to meet requirements of 10CFR835 or at the written direction of the RCM.

5.2.5 Total radiation dose to the unborn child of a declared pregnant worker shall not exceed 0.2 rem (200 mrem) as the ALARA level.

- Female radiological workers, and contractors shall inform the RSO and SHSO of pregnancy (Reference 2.5).
- All employees (e.g., male and female) shall be instructed in the effects of radiation exposure on the unborn child.
- Substantial variations above a uniform exposure rate that would satisfy the limits provided in Table 1, shall be avoided.

If exposure is already determined to have met or exceeded 0.2 rem (200 mrem) by the time of notification, worker will be removed to an area where no additional occupational exposure is likely for the remainder of the gestation period.

## *5.3 Administrative Dose Control for Radiological Workers*

5.3.1 Radiological workers shall be responsible for controlling their exposure to radiation hazards such that their annual dose remains below 10% of the regulatory limits.

5.3.2 The RSO shall inform the SHSO when project personnel approach the administrative control limit.

5.3.3 The SHSO shall not permit personnel to receive occupational radiation exposure in excess of the administrative limit unless the following are instituted:

- Approval by the RCM is granted.
- Stay-times are determined and used to limit the amount of time that the person is permitted to remain in a radiation area so that no more than one-half (50%) of his/her remaining administrative dose limit shall be incurred on an entry.

5.3.4 The SHSO shall verify that the need exists for the individual to exceed the administrative control limit. Examples of a need to use workers over their administrative limit include:

- Other qualified individuals with lower accumulated exposures are not available.
- The unique ability or experience of the individual will minimize collective exposure.

5.3.5 The RCM shall investigate instances in which administrative dose control limits are exceeded without authorization.

5.3.6 The RSO shall perform an ALARA review for projects where it is anticipated that the total man-rem dose may exceed 100 mrem cumulative TEDE.

## *5.4 Monitoring Requirements*

5.4.1 The SHSO shall provide each radiological worker with a primary dosimeter capable of measuring the individual's whole body and skin exposure, in accordance with the provisions of SOP 38.2, "Dosimetry Issuance Program," (Reference 2.3) who, under typical conditions are likely to receive one or more of the following:

- An effective dose equivalent to the whole body of 0.1 rem or more in a year;
- A shallow dose equivalent to the skin or to any extremity of 5 rems or more in a year; or,
- A lens of the eye dose equivalent of 1.5 rems or more in a year.

5.4.2 All personnel with the potential for entering Radiological Buffer Areas, handling any radioactive material, or entering, for any purpose, areas controlled by a Hazardous Work Permit (HWP) shall wear their dosimetry, if issued and as requested by the SHSO or RSO.

## *5.5 Previous Exposure History*

5.5.1 Personnel who require monitoring for radiation exposure shall have their previous internal and external exposure to radiation or radioactive materials determined or estimated. Exposures from background, therapeutic and diagnostic medical radiation, and voluntary participation in medical research programs shall not be included in dose records or in the assessment of compliance with the occupational exposure limits.

5.5.2 Each individual shall complete Attachment 7.1, "Personal/Occupational History".

5.5.3 The SHSO shall request previous exposure histories from an individual's former employer(s) whenever possible. Requests for exposure histories shall be initiated by completing a "Request for Report of Radiation History" form (Attachment 7.2). If the SHSO is unable to obtain records then an estimate given by the individual documented with the individual's signature will suffice.

5.5.4 Personnel shall not be permitted to exceed 100 mrem of whole body occupational exposure without a known or estimated exposure history on file.

## *5.6 Supplementary Dosimetry*

5.6.1 The SHSO shall provide each individual who may enter a "High Radiation Area" as part of their work with a self-indicating, dose integrating dosimeter such as a Supplemental Dosimeter, which is considered to be a "secondary" dosimeter.

5.6.2 Each employee shall place the primary dosimeter and the Supplemental Dosimeter within a hand's width of each other on the part of the whole body that is expected to receive the highest exposure.

5.6.3 Personnel should read their Supplemental Dosimeter periodically when in radiation areas and frequently in high radiation areas to ensure doses received are consistent with expectations.

5.6.4 The RSO shall identify workers whose Supplemental Dosimeter total indications are at or near administrative dose levels, process their primary dosimeter, and exclude them from further exposure until primary dosimeter results are available and evaluated.

5.6.5 At no time should an employee wear a Supplemental Dosimeter without a primary dosimeter.

## *5.7 Placement of Dosimetry*

5.7.1 Personnel shall place the primary dosimeter between the waist and neck on the front of the body, unless another part of the whole body is likely to receive the highest exposure, or as directed by a RSO. In such a case, the dosimeter will be worn on the area likely to receive the highest exposure.

5.7.2 Radiological workers may be required by the HWP or the RSO to wear additional dosimetry on those parts of the whole body that might receive the highest exposure.

5.7.3 Only RSOs and RSO designees are authorized to move personnel dosimetry.

## *5.8 Monitoring Extremity Exposures*

5.8.1 For work situations in which extremity exposures are expected to be significantly greater than whole body exposures, or if extremity exposures are expected to exceed 1000 mrem per calendar quarter, the RSO shall specify additional dosimetry to be placed on the extremities to measure dose to specific extremities of concern.

5.8.2 Each extremity of a radiological worker shall be provided with a dosimeter if the extremity is to be placed into an exposure field (including both penetrating and non-penetrating radiation) in which the extremity could receive 1000 mrem or more than twice the expected whole body dose.

5.8.3 Radiological workers shall wear extremity dosimetry such that the dosimeter is as close as possible to the source without restricting the use of the extremity.

## *5.9 Monitoring Skin Exposure*

5.9.1 Skin dose rates should be controlled by shielding or decontamination due to the difficulty of assessing skin exposure accurately. Dose to the skin of the extremities is considered to be extremity dose and not dose to the skin of the whole body.

5.9.2 The RSO shall perform a calculation of skin dose if a worker may have received significant dose from skin contamination (e.g., 100 mrad) or if detectable skin contamination cannot be removed by decontamination.

5.9.3 Calculating Skin Dose

- If the area of skin irradiated is 100 $cm^2$ or more, the non-uniform dose equivalent received during the year shall be averaged over the 100 $cm^2$ of the skin receiving the maximum dose, added to any uniform dose equivalent also received by the skin, and recorded as the shallow dose equivalent to any extremity or skin for the year.
- If the area of skin irradiated is 10 $cm^2$ or more, but less than 100 $cm^2$. the non-uniform dose equivalent (H) to the irradiated area received during the year shall be added to any uniform dose equivalent also received by the skin and recorded as the shallow dose equivalent to any extremity or skin for the year. H is the dose equivalent averaged over the 1 $cm^2$ of skin receiving the maximum absorbed, D, reduced by the fraction, f, which is the irradiated area in $cm^2$ divided by 100 $cm^2$ (i.e., $H = fD$). In no case shall a value of f less than 0.1 be used.
- If area of skin irradiated is less than 10 $cm^2$ the non-uniform dose equivalent shall be averaged over the 1 $cm^2$ of skin receiving the maximum dose. This dose equivalent shall:

  (a). be recorded in the individual's occupational exposure history as a special entry; and,

(b). not be added to any other shallow dose equivalent to any extremity or skin recorded as the dose equivalent for the year.

## *5.10 Deployment, Storage, and Retrieval of Primary Dosimeters*

5.10.1 The SHSO shall retrieve the primary dosimeters issued to radiological workers and ship to the Dosimetry Processing Lab, at least quarterly.

5.10.2 The SHSO shall retrieve primary dosimeters from radiological workers who enter high radiation areas, at least monthly.

5.10.3 Primary dosimeters of radiological workers who enter radiation areas may be processed monthly, at the discretion of the SHSO, RSO or the RCM.

5.10.4 If an individual is known or suspected to have reached or exceeded an administrative exposure control level, the SHSO shall send the primary dosimeter to the Dosimetry Processing Lab prior to the individual's being allowed to receive additional external radiation exposure.

## *5.11 Assessment of External Dose*

5.11.1 A dose assessment, to determine an accurate estimate of external radiation dose received by monitored individuals, should include the following:

- Reading of the individual's undamaged dosimeter;
- Testing of damaged or possibly damaged dosimeters in order to ensure the device is operational prior to returning it to service or to determine why the dosimeter failed;
- Confirming undamaged dosimetry results or exposure estimates by determining the exposure received by co-workers or workers doing similar work and by calculating an exposure based on the time spent and the dose rates in the work area; or,
- If multiple whole-body dosimetry is used, assigning the worker the highest dose measured over the monitoring period on the whole body.

5.11.2 The RSO shall perform an assessment of a worker's dose under the following conditions:

- If a radiological worker does not wear or does not wear in the correct location a primary dosimeter;
- If a radiological worker's dosimeter is lost or damaged;
- If a secondary dosimeter alarms, indicates an off-scale condition, or is damaged;
- Any time multiple, whole-body dosimeters are worn; and,
- If a comparison of primary and secondary dosimeters for the same time period and body location shows a difference of greater than 25 percent in measured exposure and the exposure of either device exceeds 100 mrem.

5.11.3 If the radiological worker's dose is or is expected to be within 25 percent of the individual's administrative dose control level, a dose assessment shall be performed prior to permitting the worker to reenter radiation or high radiation areas.

5.11.4 Dose assessments shall be reviewed and approved by the RCM prior to assignment of a dose of record other than that measured by the primary dosimetry device.

5.11.5 The radiological worker should sign the dose assessment to verify that the information provided by the radiological worker is accurate and to indicate that the information on the assessment has been explained to them.

5.11.6 Contested dosimetry data and test reports should be presented to the RSO for appropriate technical resolution. The RSO may call on off-site technical personnel to assist in resolving the issues relating to the contested data. The findings of contested data shall be reviewed and signed by both the RSO and the RCM, discussed with the effected individual if appropriate, and documented to the effected individual's personnel file.

5.11.7 The results of a dose assessment shall be entered in the individual's radiation dose totals (Attachment 7.3), and a copy of the dose assessment shall be placed in the individual's exposure record file.

## *5.12 Trend Analysis of External Dosimetry Results*

5.12.1 The RSO shall determine the TEDE for each monitored person twice per year to ensure no individual exceeds the dose limits of 5.2.1. All occupational exposure received during the current year shall be included when determining a radiological worker's dose.

5.12.2 Trend analysis of personnel dosimetry and dose assessment results is an important ALARA tool.

5.12.3 The RSO should analyze the following parameters when the average worker dose exceeds 100 mrem/yr:

- Mean individual and collective external radiation exposure for personnel;
- Mean individual and collective external radiation exposure by job classification;
- Mean individual and collective external radiation exposure by a particular task; and,
- Frequency of personnel external exposure incidents.

## *5.13 Design and Control*

5.13.1 Measures shall be taken to maintain radiation exposure in controlled areas as low as is reasonably achievable through facility and equipment design and administrative control.

5.13.2 The primary methods used shall be physical design features (e.g., confinement, ventilation, remote handling, and shielding).

5.13.3 Administrative controls and procedural requirements shall be employed only as supplemental methods to control radiation exposure.

5.13.4 For specific activities where use of physical design features are demonstrated to be impractical, administrative controls and procedural requirements shall be used to maintain radiation exposures ALARA.

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

5.13.6 For materials used in facility construction and modification, the design objective shall be to select materials that facilitate operations, maintenance, decontamination, and decommissioning. Components should be selected to minimize the buildup of radioactivity. Control of contamination should be achieved by containment of radioactive material.

5.13.7 In justifying facility and physical controls, optimization methods shall be used.

### *5.14 Control Procedures*

5.14.1 During routine operations, the combination of design features and LEHR Administrative Control procedures shall provide that:

- the anticipated magnitude of the total effective dose equivalent shall not exceed 0.5 rems in a year;
- the anticipated magnitude of the committed dose equivalent to any organ or tissue, plus any deep dose equivalent from external exposure, shall not exceed 15 rems in a year;
- exposure levels are as low as reasonably achievable; and,
- compliance shall be demonstrated by appropriate monitoring pursuant to the provisions of subpart E of 10 CFR 835.

## 6.0 DOCUMENTATION/RECORDS

### *6.1 Individual Exposure Records*

Each individual dose record shall be monitored in accordance with SOP 38.3, "Radiation Protection Program Records" (Reference 2.4)

### *6.2 Monitoring Program Records*

The following program records shall be maintained in accordance with SOP 38.3, "Radiation Protection Program Records" (Reference 2.4):

- Investigation reports for instances in which significant external radiation exposures occur;

- Reports that summarize trends in external radiation exposures in workers;
- External dose assessments, including the bases for the dose assessment; and,
- Records of actions taken to maintain worker dose ALARA.

# 7.0 ATTACHMENTS

*7.1 Personal/Occupational History*

*7.2 Request for Report of Radiation History*

*7.3 Current Occupational External Radiation Exposure*

# TABLES

Table 1. Regulatory and Administrative Dose Limits

| Regulatory Target | Column 1 (10 CFR 835 Limit) | Column 2 (LEHR Administrative Limit) | Column 3 (ALARA Goal) |
|---|---|---|---|
| Total Effective Dose Equivalent (TEDE) | 5 rem | 0.5 rem | 0.4 rem |
| Organ or Tissue Committed Dose Equivalent | 50 rem | 15 rem | 10 rem |
| Lens of Eye Dose Equivalent | 15 rem | 5 rem | 1 rem |
| Shallow Dose Equivalent (skin) | 50 rem | 15 rem | 10 rem |
| Extremity Dose Equivalent | 50 rem | 15 rem | 10 rem |
| Declared Pregnant Female (embryo-fetus) | 0.5 rem (entire pregnancy) | 0.4 rem (entire pregnancy) | 0.2 rem |
| Visitor and Minor[1] (TEDE) | 0.1 rem | 0.08 rem | 0.05 rem |

[1]Shall not exceed 10% of the occupational dose limits specified at 835.202(a)(3) and (a)(4).

Table 2. Quality Factors

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

Notes:

When spectral data are insufficient to identify the energy of the neutrons, a quality factor of 10 shall be used

Table 3. Weighting Factors For Various Tissues

| Organs or Tissues, T | Weighting factor, $W_T$ |
|---|---|
| Gonads | 0.25 |
| Breasts | 0.15 |
| Red bone marrow | 0.12 |
| Lungs | 0.12 |
| Thyroid | 0.03 |
| Bone surfaces | 0.03 |
| Remainder[1] | 0.30 |
| Whole body[2] | 1.0 |

Notes:

[1] Weighting factors as defined in ICRP Publication 26 and NCRP Report 91 are used to convert organ or tissue dose equivalent to effective dose equivalent for the whole body. The effective dose equivalent is obtained by multiplying the organ dose by the weighting factor. For example, a 5 rem dose to the thyroid would be multiplied by the weighting factor 0.03 to yield a contribution of 0.15 rem to the total effective dose equivalent.

[2] "Remainder" means the five other organs or tissues with the highest dose (e.g. liver, kidney, spleen, thymus, adrenal, pancreas, stomach, small intestine, and upper large intestine). The weighting factor of 0.30 results from 0.06 for each of the five remainder organs [see 835.2(b), Weighting factor, Note 1].

[3] For the case of uniform external irradiation of the whole body, a weighting factor equal to 1 may be used in the determination of the effective dose equivalent [see 835.2(b), Weighting factor, Note 2].

# ATTACHMENT 7.1

## PERSONAL/OCCUPATIONAL HISTORY

# PERSONAL/OCCUPATIONAL HISTORY

| Full Name | Parent Company/Co. Phone: |
|---|---|
| Home Street Address: | Department: |
| City/State/Zip: | Supervisor: |
| Home Phone: | Company Address: |
| Social Security: # | City/State/Zip: |
| Birth Date: | If Sub-Contracted, Name of Sub-Contractor: |

Start Date: _____ Previously at LEHR? _____ If Yes, Specify Date(s): _____

Previous External Radiation History (if you have no previous history, write NONE): _____

Company Name: _____

Company Address: _____

Dates Employed: _____

Company Name: _____

Company Address: _____

Dates Employed: _____

Lifetime: _____ Current Year: _____ Current Quarter: _____

Previous Internal Radiation History: Yes: _____ No: _____

If Yes, Specify: _____

Previous doses from therapeutic and diagnostic medical radiation, or participated as a subject in medical research programs: Yes: _____ No: _____

If Yes, Specify: _____

**I acknowledge that copies of this form and signature are valid.**

_____

**Signature Authorization** **Date**

*For Office Use Only* SHSO initial after each TLD issuance

TLD # _____ Grp. # _____ Badge date _____ Issue date _____ Return date _____

TLD # _____ Grp. # _____ Badge date _____ Issue date _____ Return date _____

TLD # _____ Grp. # _____ Badge date _____ Issue date _____ Return date _____

TLD # _____ Grp. # _____ Badge date _____ Issue date _____ Return date _____

# ATTACHMENT 7.2

## REQUEST FOR REPORT OF RADIATION HISTORY

# REQUEST FOR REPORT OF RADIATION HISTORY

**Date** _____

**Company** _____

_____

_____

_____

**Attention** _____

Please provide any internal and/or external dose history for the person below.

**Name** _____

**SSN** _____

**DOB** _____

**Time Period** ❑ All Years ❑ _____ to _____

**Stated Time Frame**

*I hereby authorize the release of the requested information to Weiss Associates. I acknowledge that copies of this form and signature are valid.*

**Signature Authorization** **Date:**

Reports should include exposure information such as hot particle exposures, planned special exposures, etc., as applicable. This information is requested in accordance with 10 CFR 835, Final 11/98.

Please address your reply to:

**Weiss Associates,**
**Attention: Kim Warren, Dosimetry Manager,**
**UC Davis, Old Davis Road,**
**ITEH Bldg., Davis, CA 95616,**
**Fax (530) 752-6918**
**Phone (530) 752-1348**
(Please follow-up any faxed response with a hard copy.)

Thank you,

Kim Warren
Dosimetry Manager

# ATTACHMENT 7.3

## CURRENT OCCUPATIONAL EXTERNAL RADIATION EXPOSURE

# CURRENT OCCUPATIONAL EXTERNAL RADIATION EXPOSURE

| 1. Name (Print - Last, First, and Middle) | 2. Social Security No. | 3. Date of Birth Month/Day/Year | 4. Age in Full Years |
|---|---|---|---|
| 5. Dose recorded for: (Specify whole body; skin of whole body; or hands and forearms, feet and ankles.) | 6. Whole Body Dose Status (rem) | 7. Method of Monitoring (e.g., File Badge [FB]; Pocket Chamber [PC]; Calculations [calc])<br>X or Gamma _____<br>Beta _____<br>Neutrons _____ | |

| 8. Period of Exposure (From/to) | 9. X or Gamma Dose (rem) | 10. Beta Dose (rem) | 11. Neutron Dose (rem) | 12. Total Dose for the Period (rem) | 13. Running Total for Calendar Quarter (rem) |
|---|---|---|---|---|---|
| **LIFETIME ACCUMULATED DOSE** | | | | | |
| 14. Previous Total (rem) | 15. Total Qtrly Dose (date/rem) | 16. Total Accumulated Dose (rem) | 17. Permissible Accumulated Dose 5(N-18) rem | 18. Unused Part of Permissible Accumulated dose (rem) | |

# INTERNAL DOSIMETRY PROCEDURE

HEALTH AND SAFETY PROCEDURE

## 1.0 PURPOSE

The purpose of this procedure is to describe the methods and responsibilities for controlling internal radiation exposure. This procedure includes the essential elements of an Internal Dosimetry Technical Basis Document including: identification of the radionuclides of concern; criteria for implementation of routine and special bioassay; specification of the performance criteria of the measurement system; definition of action levels; rationale for selection of workers for bioassay monitoring; shipping instructions to the vendor approved laboratory; and methods for interpretation of bioassay results. This procedure is applicable to all field investigation, waste management, and decommissioning and decontamination activities at LEHR that involve radioactive materials or the potential for internal exposure to radioactive materials. This procedure applies to the prime contractor and subcontractor personnel performing work at LEHR. Based upon historical data, present administrative controls, ongoing project procedures, and future anticipated site activities at LEHR, it is not likely that any radiological worker, declared pregnant worker, minor, or member of the public will exceed the limits specified in 10 CFR 835.402(c). Therefore, the internal dosimetry program is designed to confirm the effectiveness of the radiation protection procedures and practices for preventing intakes of the radionuclides of concern, Sr-90 and Ra-226, and to provide for implementation of special bioassay procedures as needed.[1] Routine workplace monitoring (i.e. contamination monitoring and air sampling) is used to demonstrate that chronic exposures to radioactive materials are unlikely to lead to project personnel incurring an intake of radioactive materials in excess of 2% of the Annual Limit on Intake (ALI).[2] This procedure is not for the purpose of monitoring individuals to demonstrate compliance with CFR 835.402(a) or (c).

## 2.0 REFERENCES

### *2.1 10 CFR 835, "Occupational Radiation Protection"*

### *2.2 SOP 1.1, "Chain-of-Custody"*

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[1] The annual (routine) bioassay program is supplemented by a special bioassay program if the potential exists for workers to exceed a CEDE of 50 mrem on a task or project.

[2] In cases of true chronic exposure conditions (i.e. where equilibrium exists between the rate of intake and the rate of elimination) a single bioassay result, such as an annual urinalysis, can be used to calculate the body burden. Chronic exposure conditions do not exist at the LEHR project, therefore, the routine bioassay program is used to verify that significant intakes are not overlooked. The special bioassay procedures are used to insure that acute intakes are detected and investigated.

*2.3* *SOP 2.1, "Sample Handling, Packaging, and Shipping"*

*2.4* *SOP 38.3, "Radiation Protection Records"*

*2.5* *HSP 15.1, "External Radiation Exposure Control"*

*2.6* *HSP 18.1, "Personnel Contamination"*

*2.7* *"DOE Standard Internal Dosimetry", Draft, U.S. Department of Energy, December 6 , 1996*

*2.8* *NUREG/CR 4884, 1990, "Interpretation of Bioassay Results"*

*2.9* *"Performance Criteria for Radiobioassay", HPS N13.30-1996*

*2.10* *"DOE Implementation Guide, Internal Dosimetry Program", DOE G 441.3-1, Draft, July 1998*

*2.11* *"Internal Dosimetry for Mixed Fission Activation Products", HPS N13.42-1997*

*2.12* *"Use of Bioassay Procedures for Assessment of Internal Radionuclide Deposition", NCRP Report No. 87*

## 3.0 DEFINITIONS

### *3.1 Absorbed Dose (D)*

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

### *3.2 Annual Limit On Intake (ALI)*

The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man (ICRP Publication 23) that would result in a committed effective dose equivalent of 5 rems (0.05 sievert) or a committed dose equivalent of 50 rems (0.5 sievert) to any individual organ or tissue. ALI values for intake by ingestion and inhalation of selected radionuclides are based on Table 1 of the United States Environmental Protection Agency's Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, published September 1988. The

activity of a radionuclide which, taken into the body, would irradiate a person, represented by Reference Man, to the limit set by the regulatory agency for each year of occupational exposure.

### *3.3 As Low As Reasonably Achievable (ALARA)*

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

### *3.4 Approved Vendor*

A vendor that has recently been audited by another DOE site /facility in order to verify appropriateness of the vendor's quality assurance/control and staff training programs.

### *3.5 Bioassay*

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

### *3.6 Bioassay Monitoring*

The measurement of activity in the whole body, in a region of the body, in material eliminated from the body, or in the air to help estimate the intake of radioactive material. The term monitoring also includes interpretation of the measurements. Subset definitions are presented in this section.

**baseline bioassay**: An appropriate bioassay measurement obtained from a bioassay program participant prior to beginning or resuming work with radioactive material.

**routine bioassay monitoring**: Any bioassay measurement made on a predetermined, periodic schedule, to establish whether a worker has had any intake of radioactive material since previous bioassay measurements. Routine monitoring for this project involves annual urinalysis for the radionuclides of concern, Sr-90 and Ra-226, although intakes resulting in exposures above the limits requiring an internal dose evaluation program are not expected.

**special bioassay monitoring**: Any bioassay measurement that is required for confirmation of a suspected intake of radionuclides, or is required for follow-up evaluation of confirmed intakes. Special monitoring for this project includes bioassays conducted for specific tasks or more frequently than the routine monitoring program.

**termination bioassay**: A bioassay measurement performed for the purpose of documenting the retention of radioactive materials in the body due to occupational exposure either upon termination of employment or upon the cessation of potential exposure to a specific nuclide.

### *3.7 Collective Dose*

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

### *3.8 Committed Dose Equivalent (Ht50)*

The dose equivalent 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 dose equivalent is expressed in units of rem (or sievert).

### *3.9 Committed Effective Dose Equivalent (He50)*

The sum of the committed dose equivalents to various tissues in the body ($Ht50_i$), each multiplied by the appropriate weighting factor (Wt) - that is $\sum(Ht50_i * Wt_i)$. Committed effective dose equivalent is expressed in units of rem (or sievert).

### *3.10 Cumulative Total Effective Dose Equivalent*

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

### *3.11 Derived Investigation Level (*DIL*)*

A value of a bioassay or air monitoring measurement that indicates an intake resulting in a dose exceeding an Investigation Level *(IL)*.

### *3.12 Decision Level (*DL*)*

The value of a net observation (result) at or above which a decision is made that a positive quantity of the *analyte* is present. The *DL* depends on the acceptable probability ($\alpha$) of incorrectly concluding that there is analyte present (a *Type I error*); $\alpha$ is usually taken as 0.05. The DL calculation is given in Attachment 12.1.

### *3.13 Dose Reporting Level (DRL)*

The level above which dose from an intake needs to be recorded or reported. The result of the measurement should be reported in all cases but dose may be treated as zero for results less than the DRL. The DRL is set at 0.002 ALI.

### *3.14 Dose Equivalent (H)*

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

### *3.15 Direct Bioassay*

In vivo measurements to estimate the quantity of radioactive material in the human body using instrumentation that detects radiation emitted from the radioactive material.

### *3.16 Derived Air Concentration (DAC)*

For the radionuclides listed in Appendix A of 10 CFR 835 (reference 2.1), the airborne concentration that equals the ALI divided by the volume of air breathed by an average worker for a working year of 2000 hours (assuming a breathing volume of $2400m^3$). For radionuclides listed in Appendix C of 10 CFR 835, the air immersion DACs were calculated for a continuous, non-shielded exposure via immersion in a semi-infinite atmospheric cloud. The values are based upon the derived airborne concentration found in Table 1 of the U.S. Environmental Protection Agency's Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, published September 1988.

### *3.17 Effective Dose Equivalent (He)*

The summation of the products of the dose equivalent received by specified tissues of the body (Ht) and the appropriate weighting factor (Wt), that is, $\Sigma(Ht50_i*Wt_i)$. It includes the dose from radiation sources internal and/or external to the body. The effective dose equivalent is expressed in units of rem (or sievert).

### *3.18 Internal Dose or Exposure*

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

### *3.19 Indirect Bioassay*

Estimate of amount of radioactive material in the human body based on measurements of radioactive material in the excreta or in other biological materials from the body and on a biological model for movement of the material in body tissues and organs.

### *3.20 Investigation Level (IL)*

The value of the committed effective dose equivalent from an intake(s) of a radioactive material by a worker at or above which, for regulatory purposes, is regarded as sufficiently important to justify further investigation. The IL for this program is set at 0.1 rem (100 mrem).

### *3.21 Minimum Detectable Amount/Activity (MDA)*

The smallest amount/activity of a radionuclide in a sample that will yield a result above the decision level with a β probability of non-detection (*Type II error*) while accepting an α probability of erroneously detecting that radionuclide in an appropriate blank sample (*Type I error*). The *MDA* is computed using the same value of α as used for the *DL*. The *MDA* depends on both α and β. Measurement results are compared to the *DL*, not the *MDA*; the *MDA* is used to determine whether a program has adequate detection capability. The *MDA* will be greater than or equal to the *DL*. The MDA calculation is found in Attachment 12.1.

### *3.22 Radiation Worker*

A worker who is likely to be routinely occupationally exposed above 0.1 rem (100 mrem) per year total effective dose equivalent.

### *3.23 Total Effective Dose Equivalent (TEDE)*

The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures) for the year. For the purposes of compliance with 10 CFR 835, deep dose equivalent to the whole body may be used as an effective dose equivalent for external exposures.

### *3.24 Quality Factor*

The principal modifying factor used to calculate the dose equivalent from the absorbed dose; the absorbed dose is multiplied by the appropriate quality factor (Q).

### *3.25 Verification Level (VL)*

The level at or above which an attempt should be made to determine if the intake is real. The VL is set for this program at 0.02 ALI.

### *3.26 Weighting Factor (Wt)*

The fraction of the overall health risk, resulting from uniform, whole body irradiation, attributable to specific tissue (T). The dose equivalent to tissue, T, is multiplied by the appropriate weighting factor to obtain the effective dose equivalent contribution from that tissue.

### *3.27 Year*

The period of time beginning on or near January 1 and ending on or near December 31 of that same year used to determine compliance with the provisions of 10 CFR 835. The starting and ending date of the year used to determine compliance may be changed provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years.

### *3.28 Controlled Area*

Any area to which access is managed by or for DOE to protect individuals from exposure to radiation and/or radioactive material.

## 4.0 RESPONSIBILITIES

### *4.1 Project Manager (PM)*

The PM is responsible for the safe and effective implementation of this procedure.

### *4.2 Radiological Control Manager (RCM)*

The RCM is responsible for assuring that internal radiation exposures of personnel are maintained as low as is reasonably achievable (ALARA), approving all estimates of internal dose, and ensuring the availability of proper resources.

### *4.3 Radiation Safety Officer (RSO)*

The RSO is responsible for administering the project internal radiation monitoring program and for approving all planned exposures in excess of administrative limits.

### *4.4 Site Health and Safety Officer (SHSO)*

The SHSO is responsible for direct implementation and administration of this procedure, maintaining on-site internal exposure records, and establishing and coordinating the on-site bioassay schedule.

### *4.5 Project Personnel*

Project personnel are responsible for maintaining an awareness of the internal radiation dose limits, complying with LEHR policy in order to maintain their own internal radiation dose within prescribed limits, and participating in the internal radiation monitoring program.

### *4.6 Health Physicist (HP)*

The HP is responsible for checking initial internal bioassay calculations and establishing bioassay parameters to meet the goals of this procedure. The HP will provide standby support on any bioassay issues outside the qualifications and training of other radiation protection personnel. The HP will: review the bioassay results, on no less than an annual basis; assign doses, as applicable; ensure accepted DOE methodology, or other appropriate methodology, is used throughout the application of this procedure; and, evaluate/correct data for background/environmental/prior dose, using accepted procedures.

# 5.0 SAFETY PRECAUTIONS/PREREQUISITES

- An approved vendor shall be under contract to perform whole-body counting of project personnel, when necessary.
- An approved vendor shall be under contract to perform urine bioassay analyses. An approved vendor is a vendor that has recently been audited by another DOE site /facility in order to verify appropriateness of the vendor's quality assurance/control and staff training programs. Adequate documentation of the audit shall be maintained on file for the LEHR project.
- Doses from background, therapeutic and diagnostic medical radiation, and participation as a subject in medical research programs shall not be included in dose records or in the assessment of compliance with the occupational dose limits.
- All personnel exiting Contamination, High Contamination or Airborne Radioactivity Areas shall perform a whole body frisk paying special attention to face, mouth, nose, chest, and abdomen.

# 6.0 PROCEDURE

## *6.1 Regulatory Dose Limits*

6.1.1 Internal dose evaluation programs shall be adequate to demonstrate compliance with 10 CFR 835 and shall be accredited by DOELAP for radio bioassay or exempted by the DOELAP Program, when required by 10 CFR 835 or requested by DOE. However, DOE reviewed the LEHR Internal Dosimetry Program in June 1998 and recommended that additional quality control measures be implemented but did not recommend that the LEHR secure accreditation by DOE LAP for radiobioassay.

6.1.2 For the purpose of monitoring individual exposures to internal radiation, internal dose evaluation programs (including routine bioassay programs) shall be conducted for:[3]

- Radiological workers who, under typical conditions, are likely to receive 0.1 rem or more committed dose equivalent, and/or 5 rems or more committed dose equivalent to any organ or tissue, from all occupational radionuclide intakes in a year;

[3] Note: Based on 10 CFR 835.402(c), an internal dose evaluation program (including routine bioassay monitoring) is not required for the LEHR project. The routine program conducted at LEHR is used to confirm that radiation work controls are performing as expected and to insure that significant acute intakes are not overlooked. DOE has reviewed the LEHR Internal Dosimetry Program.

- Declared pregnant workers likely to receive an intake resulting in a dose equivalent to the embryo/fetus in excess of 0.05 rem annually[4]; or,
- Minors and members of the public who are likely to receive, in one year, an intake resulting in a committed effective dose in excess of 0.05 rem.[5]

## *6.2 Administrative Dose Limits*

6.2.1 Engineered controls shall be used and control shall be applied to contamination at the source, wherever practical, as the primary method of minimizing airborne radioactivity and internal exposure to workers. Administrative controls, including access restrictions and the use of specific work practices designed to minimize airborne radioactivity, shall be used as the secondary method to minimize worker internal exposure.

6.2.2 Individual internal doses should not exceed those associated with intake of radioactive materials at ten percent of the Annual Limit of Intake (ALI).

6.2.3 Approval by the RCM is required for any individual to exceed this limit.

6.2.4 In the event of an intake or suspected intake of radioactive material, the RSO shall:

- Initiate special bioassay monitoring for the affected individual;
- Perform a preliminary dose assessment for critical organ and whole body equivalent (see Attachment 12.10); and,
- Notify the RCM, HP and SHSO.

6.2.5 The RSO shall take the following steps if the preliminary dose assessment indicates an intake of radioactive materials that exceeds the administrative dose limits:

- Immediately cease all work activities in that area;
- Inform RCM and HP of the occurrence;
- Investigate the incident immediately;
- Determine the root cause(s) and identify corrective actions to prevent recurrence;
- Estimate worker doses (Total Effective Dose Equivalent and Organ Committed Equivalent Dose) using available data.;

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[4] Dose estimates for declared pregnant workers are given in Attachment 12.2.

[5] Radiological controls at the LEHR project are such that no member of the public has access to areas where an intake of radioactive materials is likely.

- Inform the RCM and HP of the results of the investigation and any corrective actions taken; and,
- Deny the individual involved further access into any radiologically controlled areas pending assessment of internal dose and investigation of the circumstances involved in this intake.

6.2.6 For cases in which the estimated dose exceeds the administrative dose limits, a qualified Health Physicist shall determine the internal radiation dose. The Health Physicist may, in some cases, refer the dose determination to a qualified internal dosimetry expert. The results of the internal dose calculation shall be approved by the RCM and retained permanently in the individual's exposure record by the SHSO.

6.2.7 Dose assessment shall be provided in the terms of rem.

## *6.3 Internal Dose Monitoring*

6.3.1 Direct Bioassay Program

6.3.1.1 If direct bioassay (whole-body counting) is used to monitor personnel for intakes of radionuclides it shall be capable of meeting the minimum detectable activities (MDA) found in Table C.3 of HPS N13.30-1996.

6.3.1.2 For purposes of initial dose estimates and/or nuclide identification, qualitative whole-body screening may be provided by UC Davis ITEH, if necessary.

6.3.1.3 If required, quantitative direct bioassay will be provided by an accepted subcontract laboratory meeting criteria presented in HPS 13.30 (such as Helgason Scientific Services, Pleasanton, California).

6.3.2 Indirect Bioassay Program

When required, and as appropriate, indirect bioassay (urinalysis) shall be used to monitor personnel for internal deposition of radionuclides.. The indirect bioassay program shall be adequate to demonstrate compliance with 10 CFR 835.202. The analytical method shall have a detection sensitivity as specified in Attachment 12.1 or in Table C.4 of HPS N13.30-1996 for other radionuclides.

Analysis of urine bioassays will be provided by an approved subcontract laboratory meeting criteria presented in HPS N13.30-1996 (such as Quanterra Laboratories, Richland, Washington).

6.3.3 Air Concentration Values can be used to estimate internal dose but only if bioassay data are:

- unavailable;
- inadequate; or,

- if internal dose estimates based on representative air concentration values are demonstrated to be as or more accurate.

Estimates of internal exposure by calculating DAC-hours shall be documented on "Field Estimate of Internal Exposure" form (Attachment 12.3).

## *6.4 Monitoring Frequency*

6.4.1 Appropriate bioassay may be performed in accordance with the following guidance as directed by the HP and RSO with concurrence of the RCM:

- Prior to start of field work and upon termination of field work on site for Radiation Workers; and,
- Annually for radiation workers that have a continuous on site assignment.

For personnel who are at the site for a short time, i.e., a few days to a few weeks, the need for a termination bioassay shall be determined by the RSO using results of air monitoring and tasks performed.

6.4.2 Special or non-routine bioassay shall be performed:

- After detection of facial contamination or positive nasal smear results;
- After detection of wound contamination;
- Following acute exposure to airborne radioactivity (>20 DAC hours) without respiratory protection in place; or,
- When it is suspected that an individual may have received an internal deposition that may result in a committed dose >50 mrem;
- As required by the RSO for specific tasks.

## *6.5 Validation of Bioassay Results*

The RSO/HP shall determine the validity of bioassay results prior to their inclusion in the internal dose assessment process. Factors affecting the validity of measurement results may include: sample collection errors; analysis errors such as background interference or calibration errors; or, calculation or reporting errors. Interpretation of the bioassay data (positive or unexpected data/results) and any incidental calculations will be referred to a qualified Health Physicist.

## *6.6 Urinalysis Sampling Frequency*

6.6.1 All personnel who perform work within any contamination area, airborne radioactivity area on a routine basis or work with radioactive materials shall submit a urine sample prior to beginning work at a project site and after termination of the work assignment at the site as required by the RSO

or RCM or equivalent with the concurrence of the HP during work on a project. Instructions for this activity shall be given during radiological orientation at the project site prior to commencement of the activity.

6.6.2 Bioassays shall be performed as necessary for any employees with the potential for occupational exposure to concentrated radioactive material according to action levels, guidelines, and procedures.

6.6.3 Non-routine samples shall be requested by the RSO whenever there is a reason to suspect that an employee may have sustained an internal deposition of radioactive material, if respiratory protection equipment is suspected of failing, if a bioassay result exceeds the verification level (Attachment 12.1), or during specific tasks that have a greater potential for internal exposures (see 6.4.2) or if there is detectable contamination on internal surfaces of a respirator face-piece.

6.6.4 When an individual is leaving the project site or employment, the RSO/RCM shall require a bioassay sample from the individual before he is allowed off-site if the employee could have received 0.1 rem CEDE. With prior knowledge of the employee leaving, this sample should include the first void of the day.

6.6.5 To facilitate collection of termination samples, the RCM/RSO should be given two days written notice for each worker who will be terminated from radiological work on site.

## *6.7 Collection Instructions*

6.7.1 Samples shall be collected in accordance with the analytical laboratory instructions. Samples shall include the first void of the day. Minimum acceptable volume for a 24-hour sample should be 1000 ml. Samples not meeting this requirement shall not be accepted and an immediate 24-hour resample shall be initiated. The original sample submitted shall not constitute a part of the resample volume and shall be discarded. Samples may be accepted under special conditions only, contact the HP for instructions.

6.7.2 Samples shall be collected prior to entry in an RCA, and in an area free of contamination, preferably off-site. The hands should be carefully washed prior to voiding.

Under unusual circumstances (emergency only) where specimens cannot be collected in this manner, the worker shall shower immediately prior to voiding. When a shower is not possible, disposable plastic or rubber gloves should be worn during voiding. Wiping the hands with alcohol swabs several times can also be done to clean the hands.

6.7.3 Urine sample kits shall be provided to the worker with instructions for a 24-hour voiding, prior to beginning radiological work at the site. Sample kits shall be issued from and returned to the personnel monitoring station. The RSO/RCM shall discuss the instructions for collection with the individuals giving a sample and shall inform them that disciplinary action is possible if the bioassay program is not correctly followed.

6.7.4 The RSO or representative should review instructions for sample collection with each employee when the sample kit is issued if more detailed instructions than those in step 6.7.3 are required.

6.7.5 Any routine, special and termination samples should be collected at least 36 hours but not more than 96 hours after leaving a project site.

6.7.6 As directed by the RSO/RCM, urine samples may be collected on a more frequent schedule.

6.7.7 Nasal swipes should be taken and analyzed if face or head contamination is suspected and documented.

6.7.8 Samples shall be collected and preserved in a manner which the loss of activity on the walls of the container is minimal.

6.7.9 The sample containers shall be maintained in an area that is free from contamination.

6.7.10 After collection, take precautions to assure the integrity of and prevent leakage from the containers or cross contamination of the samples.

## *6.8 Bioassay Forms*

6.8.1 The RSO will contact the SSHO when a sample is provided. The notification will provide void dates and bioassay participants names. The notification will also provide the dates worked on site corresponding with the participants name. The SSHO or designee shall assign sample numbers to the samples after receiving the notification The sample numbers shall be in sequential order and maintained in the sample number log, Attachment 12.4.

6.8.2 Fill out the Chain-of-Custody Record in accordance with SOP 1.1 (Chain-of-Custody). Include the following additional information (see Attachment 12.5):

- Identify the project name and number.
- Quantity Shipped: Total number of bioassay samples shipped, use additional forms as necessary.
- Specify the date shipped to lab and the method used (e.g. UPS, Fed Ex, etc.)
- Special Instructions: Indicate any comments or instruction deemed necessary for completeness. Identify any samples that are suspected of being highly contaminated here.
- Employee SSN: Include the social security number of each individual.
- Sample Number: Include the sample number as recorded from the log.
- Collection Start Date and Time: The date and time the bioassay sample collection started. (Samples should not be held for shipment greater than five (5) working days without chemical preservation).

- Collection Stop Date and Time: The date and time the bioassay sample collection stopped. Urine samples should include the first void of the day.
- Analyses Requested: Refer to the chain-of-custody control number; add additional information here.
- Sample Type: List the type of bioassay sample collected.
  - Urine = UR
  - Feces = FC
  - Nasal swipe = NS
  - Other = OT (specify, e.g. it could be wound, eye, ear, sputum)
  - If any other sample type is taken, an incident report may be required; contact the RSO.
- Purpose: List the reason for collecting the sample.
  - Bioassay Sampling = BL
  - Termination Sampling = TN
  - Routine Sampling = RT
  - Resample = RS
  - Special Sampling = SP
  - If a special sample is taken, an incident report may be required; contact the RSO.

6.8.3 All baseline and termination samples shall be analyzed as identified by the RSO.

## *6.9 Quality Control*

6.9.1 Each batch of urine samples should be analyzed concurrently with at least one method blank and one spike.

6.9.2 Laboratories used for bioassay purposes shall be selected by the RSO/RCM with the concurrence of the HP and the Project Quality Assurance Manager.

6.9.3 The analytical laboratory shall perform the Quality Control (QC) checks described in References 2.5 and shall report the results of these QC analyses along with the other sample results.

6.9.4 The results of the analysis shall be reviewed as described in References 2.5 and 2.6.

6.9.5 If the average deviation (actual-reported/actual) for the spiked samples accompanying a particular batch is less than 0.7, the batch of samples accompanying these spiked samples shall be rerun.

6.9.6 If the repeat analysis does not meet the criteria of Step 6.9.4 and 6.9.5, an investigation of the procedures for spiking and the procedures for laboratory analyses shall be made.

6.9.7 Blind split samples should be presented to the laboratory at the rate of 5% of the total samples submitted. Numbers and type of quality control samples should be in conformance with HPS 13.30.

6.9.8 LEHR may make use of other DOE sites that utilize the services of the subcontracted bioassay laboratory to verify the appropriateness of the laboratory's Quality Control and Assurance programs.

## *6.10 Laboratory Results*

6.10.1 The analytical laboratory should complete and report results of routine analysis within 45 days of sample collection. Results exceeding preset action levels shall be reported by telephone.

6.10.2 The analytical laboratory should complete and report results of analysis for samples submitted as special or emergency within 24 hours of receipt or within the time frame stipulated on the Chain-of-Custody.

6.10.3 The results from the laboratory shall be recorded on the Bioassay Results Log, Attachment 12.6.

6.10.4 The Decision Level (DL) and the Derived Dose Reporting Level (DDRL) shall be recorded on the Bioassay Results Log (Attachment 12.6). Results above the DL indicate that the analyte was present in the sample. Positive results above the DDRL should be converted to dose and recorded in the employee's exposure report. The DL should be reported by the laboratory or calculated from data supplied by the laboratory (reference 2.7 and Attachment 12.1). The DDRLs for routine annual urine analysis are given for Sr-90 and Ra-226 in Attachment 12.1.

6.10.5 Minimum detectable activities that should be specified on the work order are given in Attachment 12.1. LEHR standard bioassay analysis shall be periodically reviewed and updated by the HP.

6.10.6 The laboratory shall report all sample data uncensored using actual measured values and not "less than" values.

6.10.7 Each worker will be notified in writing of any bioassay results.

## *6.11 Incident/Routine Follow-up*

Whenever an inhalation, ingestion, or injection intake is suspected, prompt bioassay follow-up is required. An intake shall be suspected if any of the following criteria are exceeded:

- Exposure to airborne radioactivity is greater than or equal to 20 DAC-hr.
- Detection of extensive or extended personal skin or personal clothing contamination greater than or equal to 1000 dpm/100 $cm^2$ alpha or greater than 5000 dpm/100 $cm^2$ beta-gamma;
- Measurable nasal or saliva contamination; and,
- A routine bioassay measurement in excess of the action limit as shown in Section 7.0.

6.11.1 When any of the conditions are met as described in Section 6.11, the RSO or HP shall perform and document or ensures the performance of the documentation of the following appropriate in-vitro and/or in-vivo bioassay measurements:

- In-vivo (whole body ) measurement;
- Three urine samples. One sample shall be the initial morning void, the second sample shall be collected during the current work shift, while the third shall be collected prior to the start of the next work shift; and,
- Recommends additional bioassays as necessary.

6.11.2 The RSO shall identify potential uptakes that occur in the work-place under his area of responsibility.

Notification of the HP shall be made as soon as possible when suspected uptakes occur. If the HP personnel are unavailable, initiate the urine bioassay program per Step 6.11.1, and contact the HP as soon as practicable.

6.11.3 Radioactive material may pass directly into the bloodstream via broken skin. All wounds that occur inside a CA should be considered contaminated and a wound measurement should be performed.

When a wound occurs inside a CA, the RSO performs and documents, or ensures the performance and documentation of the following appropriate in-vitro and/or in-vivo bioassay measurements:

- Preliminary wound survey with survey instruments;
- Wound measurement at the in-vivo facility, as appropriate;
- If there is detectable contamination of the wound area, puncture wound caused by a contaminated item, or if there is contaminated debris associated with the wound three urine samples. One sample shall be the initial morning void, the

second sample shall be collected during the current work shift, while the third shall be collected prior to the start of the next work shift; and,

- Recommend additional bioassays as necessary.

6.11.4 All wounds that occur outside the CA shall be reported to the RCM and RSO to determine if restrictions from work is required. Proper medical dressings of wounds is required to prevent inadvertent ingress of radiological material.

# 7.0 ACTION LEVELS

If a bioassay sample exceeds the DL, the RSO/HP shall verify the validity of the results as described in Section 6.5. Additional sampling may be performed to confirm the results. Further actions are based on the action levels below.

## *7.1 Results Action Levels*

Results of the bioassay program will be used to evaluate the internal dose due to the inhalation or ingestion of radionuclides. Action levels are predetermined values that trigger a course of action when exceeded. The corresponding derived action levels are the time dependent expected bioassay measurements corresponding to the action level (i.e. the value against which specific bioassay results are compared). These are divided into three categories:

7.1.1 Dose Reporting Level (DRL) – The level above which dose from an intake needs to be recorded or reported. The result of the measurement should be reported in all cases but dose may be treated as zero for results less than the DRL. The DRL is set at 0.002 ALI. The Derived DRLs (DDRL) for the routine urinalysis program are given in attachment 12.1.

7.1.2 Verification Level (VL) – The level at or above which an attempt should be made to determine if the intake is real. The VL is set for this program at 0.02 ALI. The Derived VL (DVL) is equal to the Derived Investigation Level in Attachment 12.1.

7.1.3 Investigation Level (IL) – The level of dose or intake at or above which a bioassay result shall be investigated. The intent of this level is to investigate the circumstances and, to the extent reasonable, to determine actual conditions and parameters for dose evaluation. The IL is set at 0.02 ALI (100 mrem). Derived ILs are given for the routine bioassay program in Attachment 12.1. Corrective actions based on urinary results are presented in Attachment 1.2.7.

# 8.0 EXCEPTION TO ROUTINE BIOASSAY REQUIREMENTS

Dependent on exposure duration, contamination levels, radiological controls, and potential for exposure, the RSO may waive certain of the routine bioassay monitoring requirements. However, bioassay monitoring procedures (routine or special) should be invoked if intakes are likely to exceed 0.01 ALI

# 9.0 FAILURE TO PROVIDE A SAMPLE

9.1.1 All failures to comply with the urine sample submittal requirements shall be documented as a formal written notification (Attachment 12.9) from the RCM/RSO to the project manager. The worker's name, company, and sample container issue date shall also be documented on the notification. This notification shall also state that the employees radiation worker training is voided.

9.1.2 If a radiation worker fails to provide a urine sample, as required by this procedure, and has been previously disqualified at any DOE site, he/she may be permanently restricted from radiologically controlled areas. This permanent restriction shall be documented as a formal written notification from the RCM/RSO to the project manager and the person's employer.

9.1.3 Extenuating circumstances may be considered in determining if disqualification is imposed or training is voided. This determination will be discussed and documented at a special meeting of the ALARA committee.

# 10.0 SAMPLE SHIPMENT

Personnel responsible for shipping samples shall ensure that all lids are securely taped to the bottle with plastic tape and that each sample bottle is individually packaged in a plastic bag. Sample bottles shall be placed in appropriate shipping cartons with sufficient packing material to ensure safe transportation to the laboratory. A copy of the Chain-of-Custody Record shall accompany the sample shipment inside the package. Ship samples in accordance to any prescribed laboratory requirements and in conformance with applicable sections of SOP 2.1, Sample Handling, Packaging, and Shipping.

# 11.0 DOCUMENTATION/RECORDS

The following individual monitoring records shall be documented:

- Internal radiation exposure received during prior employment;
- Internal exposure received at other installations during current employment by LEHR;
- Results of individual whole body counts and bioassay results; and,
- Results of any dose assessment and all supporting documentation.

## *11.1 Records Maintenance*

Records shall be as maintained by the SHSO as per SOP 38.3, "Radiation Protection Records," Reference 2.2.

### *11.2 Confirmed Intake Data Requirements*

The following information shall be recorded for each confirmed intake.

- magnitude of intake (mass, activity, PAE);
- CEDE and/or CDE assigned;
- time course of intake (known or assumed);
- intake route (known or assumed);
- chemical and physical form of radionuclides involved;
- bioassay information pertinent to intake evaluation; and,
- methods and assumptions used in dose evaluation.

## 12.0 ATTACHMENTS

*12.1 LEHR Routine Bioassay Program Specifications*

*12.2 LEHR Special Bioassay Program Specifications and Dose Estimates for Declared Pregnant Workers*

*12.3 Field Estimate of Internal Exposure Form*

*12.4 Bioassay Logs*

*12.5 Bioassay Chain-of-Custody Addendum*

*12.6 Bioassay Results Log*

*12.7 Corrective Actions Based on Urinary Results*

*12.8 Intake Retention Functions*

*12.9 Failure to Provide Bioassay Letters (First and Second Instance)*

*12.10 Interpretation of Bioassay*

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# ATTACHMENT 12.1

## LEHR ROUTINE BIOASSAY PROGRAM SPECIFICATIONS

## LEHR Routine Bioassay Program Specifications

| Radionuclide | Lung Class | ALI (uCi) [3] | Expected MDA (pCi/L) | Investigation Level (IL) [4] | Derived Reporting Level [5] (pCi/sample) | Derived Investigation Level [6] (pCi/sample) | Minimum CEDE from result above the MDA [7] (rem) |
|---|---|---|---|---|---|---|---|
| Sr-90 | D | 2.00E+01 | ~5 | 100 mrem | 1.67 | 16.72 | 0.02 |
| Ra-226 | W | 6.00E-01 | ~0.01 | 100 mrem | 0.001 | 0.01 | 0..02 |

1 Routine bioassay is the program of baseline, termination, and annual bioassay conducted as part of the routine radiation protection program at LEHR.

2 Special bioassay is conducted if an internal exposure is suspected, as follow-up for confirmed intakes, or for task-specific measurements.

3 ALIs are taken from Table 1.b of Federal Guidance Report No. 11.

4 The IL is defined as 0.02 stochastic annual limit on intake (SALI) or 100 mrem.

5 The DDRL is equal to 0.002*ALI*$IRF_{24U}(365)$ for annual bioassay. The $IRF_{24U}(365)$ is the Intake Retention Function (interpolated value) from NUREG/CR-4884 at 365 days following a single intake for a 24-hour urine sample. DDRLs for other than annual sampling frequencies can be calculated by using the corresponding IRF from NUREG/CR-4884 or from data presented in Attachment 12.8.

6 The DIL is equal to 0.02*ALI*$IRF_{24U}(365)$ as described in HPS N13.42-1997 for annual bioassay. The $IRF_{24U}(365)$ is the Intake Retention function (interpolated value) from NUREG/CR-4884 at 365 days following a single intake for a 24-hour urine sample. DILs for other than annual sampling frequencies can be calculated by using the corresponding IRF from NUREG/CR-4884 or from data presented in Attachment 12.8. Reference Man urine excretion rate is 1.4 liters/day.

7 This is the minimum CEDE for a positive result (equal to or greater than the MDA). For evaluation of dose it is assumed that the intake occurred midway between the previous and current bioassay date. Therefore, for annual bioassay, the $IRF_{24U}(182)$ is used. The MDA (pCi/L) is multiplied by 1.4 to obtain pCi/sample.

Equations for calculation of Decision Level (DL) and Minimum Detectable Activity (MDA)

DL in cps (or cpm) = $1.645\sqrt{Rb(1/tb + 1/tg)}$

MDA in Bq = $\dfrac{(3+3.29)\sqrt{Rbtg(1+tg/tb)}}{Ktg}$

Rb = background count rate
tb = background count time
tg = sample count time
K = efficiency

# ATTACHMENT 12.2

## LEHR SPECIAL BIOASSAY PROGRAM SPECIFICATIONS AND DOSE ESTIMATES FOR DECLARED PREGNANT WORKERS

# LEHR SPECIAL BIOASSAY PROGRAM SPECIFICATIONS AND DOSE ESTIMATES FOR DECLARED PREGNANT WORKERS

| Radionuclide | Lung Class | Derived Investigation Levels pCi/sample to give 100 mrem CEDE | | | Dose estimates for Declared Pregnant Workers | | |
|---|---|---|---|---|---|---|---|
| | | Monthly Urine | Quarterly Urine | Semiannual Urine | Dose (mrem) to embryo/fetus per microcurie of inhalation intake to mother[6] | CEDE (mrem) to mother to give 50 mrem to embryo/fetus | CEDE (mrem) to mother to give 200 mrem to embryo/fetus |
| Sr-90 | D | 2.5E+02 | 5.4E+1 | 3.4E+1 | 5 | 5E+02 | 2E+03 |
| Ra-226 | W | 3.8E-01 | 1.8E-01 | 7.0E-02 | 300 | 1E+03 | 4E+03 |

[1] The Derived Investigation Level at time (t) post intake is given by DIL (t) = 0.02*ALI*IRF (t). IRF tables for Sr-90 and Ra-226 are reproduced in Attachment 8. IRFs for times not listed in the table can be obtained by interpolation.

[2] These data show the large intakes that would be required of the mother to approach the monitoring threshold for declared pregnant workers.

[6] Embryo/fetus doses taken from Appendices D and E of NUREG/CR-5631

# ATTACHMENT 12.3

## FIELD ESTIMATE OF INTERNAL EXPOSURE FORM

# FIELD ESTIMATE OF INTERNAL EXPOSURE

| Date | Individual | Employee # | Air Sample # | [1][2]DAC Fraction x Time (hrs) = DAC – hours | DAC – hours |
|---|---|---|---|---|---|
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
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| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |
| | | | | _____ x _____ = _____ / _____ = | |

Reviewed By: _____ Date: _____

[1] DAC Fraction = Measured Activity Concentration/DAC

[2] If mixture of radionuclides, the DAC Fraction must be a summation of all applicable DAC Fractions.

# ATTACHMENT 12.4

## BIOASSAY LOGS

# BIOASSAY SAMPLE NUMBER LOG

| NAME | DATE SAMPLE RECEIVED | SAMPLE NUMBER | INITIAL/DATE SENT |
|---|---|---|---|
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RSO REVIEW _____ DATE_____

# WHOLE-BODY SCREENING LOG

| NAME | DATE OF WHOLE-BODY SCREENING | INITIAL |
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RSO REVIEW _____ DATE_____

# ATTACHMENT 12.5

## BIOASSAY CHAIN-OF-CUSTODY ADDENDUM

# BIOASSAY CHAIN-OF-CUSTODY ADDENDUM

Project Name/Number: _____ Page_____ of_____

Quantity shipped:_____ Date Shipped:_____ via _____

Special Instructions _____

| NAME LAST, FIRST MI. | EMPLOYEE # | SAMPLE NUMBER | START DATE | START TIME | STOP DATE | STOP TIME | ANALYSIS REQUESTED | TYPE | PURPOSE |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
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**ANALYSIS REQUESTED**
Specify radionuclide(s) of concern or refer to Chain-of-Custody Control Number _____ ;

**SAMPLE TYPE**
Urine = UR; Feces = FC; Nasal swipe = NS; Other = OT;

**PURPOSE**
Baseline Bioassay = BL; Termination = TN; Routine = RT; Resample = RS; Special = SP (Is an incident report required?)

REVIEWED BY: _____ Date _____

# ATTACHMENT 12.6

## BIOASSAY RESULTS LOG

# BIOASSAY RESULTS LOG

| NAME | BIOASSAY COLLECTION DATE | RADIONUCLIDE(S) | RESULTS (UNITS) | DECISION LEVEL | DERIVED REPORTING LEVEL[1] |
|---|---|---|---|---|---|
| | | | | | |
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[1]The Derived dose reporting level for annual bioassay is given in Attachment 12.1.

RSO review: _____ Date: _____

# ATTACHMENT 12.7

## CORRECTIVE ACTIONS BASED ON URINARY RESULTS

## CORRECTIVE ACTIONS BASED ON URINARY RESULTS

| Urinary Result | Interpretation | Actions |
|---|---|---|
| Less than 1 DIL* | Radionuclide confinement and air sampling capabilities are adequate. | None |
| 1 to 2 DIL* | Radionuclide confinement and perhaps air sampling capabilities may not provide an adequate margin of safety. | 1. Confirm results (repeat urinalysis).<br>2. Determine why air samples were not representative and did not warn of excessive concentrations of airborne radionuclides. Make corrections.<br>3. Identify the cause of airborne radionuclides and initiate additional control measures.<br>4. Determine whether other workers could have been exposed and perform bioassay measurements for them.<br>5. Consider work assignment limitations for the worker. |
| Greater than 2 DIL* | Radionuclide air sampling and respiratory protection probably not adequate. | 1. Perform above actions and notify the HP.<br>2. Start daily urine sample collection.<br>3. Establish work restrictions for affected employees. |

* The DILs for the routine annual monitoring program for Sr-90 and Ra-226 are given in Attachment 12.1. DILs for some special bioassay frequencies are found in Attachment 2. IRFs for 24 hour urine for D class Sr-90 and W class Ra-226 are reproduced in Attachment 3. DILs for different sampling times and/or different radionuclides must be calculated using the IRF values in NUREG/CR –4884.

# ATTACHMENT 12.8

## INTAKE RETENTION FUNCTIONS

# INTAKE RETENTION FUNCTIONS

**Inhalation Intake Retention Function (IRF) for Class D Strontium 90 AMAD = 1 micron**

| Time after single intake Days | Fraction of initial intake in 24-hour urine |
|---|---|
| 1 | 8.57E-02 |
| 2 | 4.63E-02 |
| 3 | 3.69E-02 |
| 4 | 2.98E-02 |
| 5 | 2.45E-02 |
| 6 | 2.03E-02 |
| 7 | 1.71E-02 |
| 8 | 1.44E-02 |
| 9 | 1.22E-02 |
| 10 | 1.04E-02 |
| 20 | 2.26E-03 |
| 30 | 6.21E-04 |
| 40 | 2.75E-04 |
| 50 | 1.94E-04 |
| 60 | 1.68E-04 |
| 70 | 1.54E-04 |
| 80 | 1.43E-04 |
| 90 | 1.34E-04 |
| 100 | 1.26E-04 |
| 200 | 7.42E-05 |
| 300 | 5.04E-05 |
| 400 | 3.71E-05 |
| 500 | 2.86E-05 |
| 600 | 2.27E-05 |
| 700 | 1.86E-05 |
| 800 | 1.55E-05 |
| 900 | 1.33E-05 |
| 1000 | 1.16E-05 |
| 2000 | 5.85E-06 |
| 4000 | 2.94E-06 |
| 8000 | 9.81E-07 |
| 10000 | 6.33E-07 |
| 20000 | 1.16E-07 |

Data from NUREG/CR-4884, page B-77

**Inhalation Intake Retention Function (IRF) for Class W Radium 226 AMAD = 1 micron**

| Time after single intake Days | Fraction of initial intake in 24-hour urine |
|---|---|
| 1 | 4.01E-03 |
| 2 | 1.22E-03 |
| 3 | 6.70E-04 |
| 4 | 4.29E-04 |
| 5 | 3.03E-04 |
| 6 | 2.29E-04 |
| 7 | 1.83E-04 |
| 8 | 1.52E-04 |
| 9 | 1.30E-04 |
| 10 | 1.13E-04 |
| 20 | 4.62E-05 |
| 30 | 3.16E-05 |
| 40 | 2.64E-05 |
| 50 | 2.33E-05 |
| 60 | 2.08E-05 |
| 70 | 1.86E-05 |
| 80 | 1.66E-05 |
| 90 | 1.48E-05 |
| 100 | 1.33E-05 |
| 200 | 4.23E-06 |
| 300 | 1.38E-06 |
| 400 | 4.96E-07 |
| 500 | 2.21E-07 |
| 600 | 1.28E-07 |
| 700 | 9.05E-08 |
| 800 | 7.17E-08 |
| 900 | 5.98E-08 |
| 1000 | 5.14E-08 |
| 2000 | 2.16E-08 |
| 3000 | 1.41E-08 |
| 4000 | 1.03E-08 |

Data from NUREG/CR-4884, page B-324

# ATTACHMENT 12.9

## FAILURE TO PROVIDE BIOASSAY LETTERS (FIRST AND SECOND INSTANCE)

# LEHR PROJECT

**FIRST INSTANCE**

**TO:** **[ Project Manager ]**

**FROM:** [ Name ] **RCM/RSO**

**DATE:**

**SUBJECT:** Failure to Comply With Bioassay Program Requirements

Individuals Name: _____Company: _____

A bioassay sample container was issued to the individual above on (date) _____. This bioassay sample container was issued with instructions to return a full liter urine sample within two (2) days after issuance. The employee failed to comply with the requirements as instructed.

This is the first instance of non-compliance with bioassay sample submittal requirements by this employee while working on the LEHR project.

This letter documents that the person's radiation worker training is considered void as of this date. This person's dosimetry will be withheld. This person will not be allowed access to the LEHR radiological controlled areas until retrained as a radiation worker.

There were no extenuating circumstances, nor were allowances made with or approved by the RCM/RSO for variance from the requirements of the bioassay program.

The bioassay program is a cornerstone of our radiation protection program. This program protects the contractor, our customers, and subcontractors from future liability due to unquantified radiation exposure. Please notify the employee's company of this employee's situation and the importance of this program.

Please contact me if you have any questions.

cc: Project file

Individuals file

Employees company representative

# LEHR PROJECT

**SECOND INSTANCE**

**TO:** **[ Project Manager ]**

**FROM:** [ Name ] **RCM/RSO**

**DATE:**

**SUBJECT:** Permanent Disqualification for Failure to Comply With Bioassay Program Requirements

Individuals Name: _____Company: _____

A bioassay sample container was issued to the individual above on (date) _____. This bioassay sample container was issued with instructions to return a full liter urine sample within two (2) days after issuance. The employee failed to comply with the requirements as instructed.

This is the second time the employee has failed to comply with the bioassay sample submittal requirements while working on the LEHR project. The employee also failed to comply previously on (date of first letter) _____ and radiation worker training was voided at that time. The employee was subsequently retrained as a radiation worker.

In accordance with HSP 16.1, Internal Safety Procedures, I recommend that this employee be permanently disqualified as a radiation worker and be permanently restricted from all LEHR radiological controlled areas.

There were no extenuating circumstances, nor were allowances made with or approved by the RCS/RSO for variance from the requirements of the bioassay program.

The bioassay program is a cornerstone of our radiation protection program. This program protects the contractor, our customers, and subcontractors from future liability due to unquantified radiation exposure. Please notify the employee's company of this employee's situation and the importance of this program.

Please contact me if you have any questions.

cc: Project file
Individuals file
Employees company representative

# ATTACHMENT 12.10

# INTERPRETATION OF BIOASSAY

# INTERPRETATION OF BIOASSAY

| | |
|---|---|
| Subject: | Route of Intake: |
| Date of Sample Collection: | Annual Limit on Intake: |
| Radionuclide: | Dose Conversion Factor: |
| Solubility Class: Θ D Θ W Θ Y | |

| 1.t (days) | 2.Volume (liters) | 3.Activity (pCi/l or pCi/sample) | 4. Corrected Activity (pCi) | 5. IRF | 6. Corrected Activity/IRF (needed only for least squares fit) | 7. IRF[2] (needed only for least squares fit) | 8. Intake |
|---|---|---|---|---|---|---|---|
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| | | | | | 9. | 10. | |

11.
Intake = Average of (8) =

**or**

12.
Intake = (9)/(10) =

13
$H_{E,50}$ = (8, 11 or 12)/(ALI) x 5 =

**or:**

14.
$H_{E,50}$ = (8, 11 or 12) x DCF =

Dosimetrist_____ Date

* Needed only if least-squares fit is required.

# INTERPRETATION OF BIOASSAY (cont'd)

## Instructions for the Completion of Interpretation of Bioassay Form

1. The value listed for "t" should be the number of days between the suspected date of intake and the date of sample collection for indirect bioassay, or the date of measurement for direct bioassay. If the suspected date of intake is unknown it is assumed that the intake occurred midway between the last sample and the current one.

2. Value for "Volume" are applicable to indirect bioassay measurements only.

3. The "Activity" should be the actual activity reported from the bioassay measurement.

4. Corrected activity is the activity value corrected to reflect the appropriate units of activity in the applicable bioassay compartment. For example, a single 200 ml urine sample is analyzed and found to contain 25 pCi of "Activity". This value must be corrected to reflect the activity in a twenty-four-hour void. Therefore, "O(corrected)" is equal to (25 pCi H 1400 ml) 200 ml, or 175 pCi.

5. Values for "IRF" shall be selected from those contained in NUREG/CR-4884. Interpolate to obtain values not in the tables.

6. For a single bioassay result intake is obtained by solving the equation: "corrected activity" / "IRF" and entered in column 8.

7. To obtain the average intake from multiple bioassay results , the average of the column (8) values is computed and entered in slot (11) .

8. To obtain a least-squares fit for multiple bioassay data:

   8.1 Columns labeled (6) and (7) should be completed, with the totals for each column entered in slots (9) and (10), respectively.

   87.2The best estimate of intake should be obtained by solving for (9) ) (10), and entering the result in (12).

9. An estimate of Committed Effective Dose Equivalent, or "$H_{E,50}$", in units of rem, should be obtained by one of the following means:

   9.1 Divide the value entered in either (8), (11), or (12) by the ALI, multiply the result by 5, and enter the result in (13).

   9.2 Multiply the value entered in either (8), (11), or (12) by an appropriate Dose Conversion Factor (Federal Guidance Report #11), and enter the result in (14).

9. Since the $H_{E,50}$ is assigned in the year in which the dose is received, the value of (13) or (14) can be added to the external dose for that year and compared directly to administrative or legal dose limits in order to guide follow-up actions.

# HAZARDOUS WORK PERMITS

HEALTH AND SAFETY PROCEDURE

## 1.0 PURPOSE

This procedure describes how hazardous work permits (HWPs) are used to identify and plan mitigation of radiological, chemical, and biological hazards, such as when HWPs are initiated; how radiological, industrial hygiene, and other safety hazard control conditions are specified; HWP review, approval, and termination; and HWP distribution and record keeping.

An HWP is a document used solely for the purpose of informing workers of task hazards, radiological conditions, required personal protective equipment (PPE), and special instructions to be followed during the conduct of the work. This document should not be used as a substitute for a task-specific work plan or work document. The "Scope of Work" should be a brief (i.e., two to three lines of text that provides a general overview of the work to be accomplished and refers to the task-specific work plan, if applicable). "Authorized Activities" should be brief statements of task activities, such as: soil sampling, trenching, packaging of waste, waste inventory, etc. Routine monitoring and survey activities will not be included in the scope of work or authorized activities blocks.

## 2.0 REFERENCES

### *2.1 10 CFR 835, "Occupational Radiation Protection"*

### *2.2 Final Project Health and Safety Plan*

### *2.3 Final Hazardous Waste Permit Implementation Guide*

## 3.0 DEFINITIONS

### *3.1 Confined or Enclosed Space*

Any space that is large enough for an employee to enter, has a limited means of egress, and is not designed for continuous occupancy. Confined or enclosed spaces include, but are not limited to, storage tanks, process vessels, bins, boilers, ventilation or exhaust ducts, sewers, underground utility vaults, tunnels, pipelines, and open spaces more than four feet in depth such as pits, tubs, trenches, and vessels.

### *3.2 Controlled Area*

Any area to which access is managed by or for DOE to protect individuals from exposure to radiation, and/or radioactive material, and any other hazards requiring special health and safety controls.

## 4.0 RESPONSIBILITIES

### *4.1 Field Coordinator*

The Field Coordinator implements the tasks in the field.

### *4.2 Project Manager*

The Project Manager is responsible for the safe and effective implementation of this procedure.

### *4.3 Project Task Leader*

The Project Task Leader is responsible for ensuring that an HWP is prepared for field activities, as required.

### *4.4 Radiological Control Manager*

The Radiological Control Manager (RCM) will review and approve all HWPs.

### *4.5 Radiation Safety Officer*

The Radiation Safety Officer is responsible for ensuring that all aspects of the HWP and work covered by the HWP are in compliance with the Radiation Protection Program.

### *4.6 Radiological Worker and/or General Employee*

The radiological worker and/or general employee is responsible for reading and understanding the HWP prior entry to a HWP controlled area. This individual is also responsible for signing and documenting the time on the HWP sign-in log each time an entry and exit are made into the HWP controlled area.

### *4.7 Site Health and Safety Officer*

The Site Health and Safety Officer (SHSO) is responsible for reviewing and prior to work and signing the HWP when work is completed.

The SHSO is responsible for ensuring that all work involving radioactive materials, chemical or biological deficiencies, or other safety hazards is conducted under an approved HWP. The SHSO is also responsible for reviewing and signing all HWPs.

# 5.0 SAFETY PRECAUTIONS/PREREQUISITES

None.

# 6.0 PROCEDURE

An approved HWP shall be required to conduct any field work that involves entry into areas with the following conditions:

- Chemical exposure;
- Oxygen deficiency;
- Exposure to ionizing and non-ionizing radiation, including entry into:
  - Radiation, high radiation or very high radiation areas;
  - Airborne radioactivity areas; and,
  - Contamination or high contamination areas;
- Biological hazards; and,
- Other hazards determined to require an HWP by the RCM, RSO or SHSO.

The only exception to the above is emergency response when serious impacts could result if time were taken for HWP preparation and approval. This procedure allows for written procedures to meet requirements prescribed in 10 CFR 835 (Reference 2.1).

## *6.1 Hazardous Work Permits*

At a minimum, an HWP shall include the following:

1. Description of work to be performed;
2. Map of work area identifying the locations of potential hazards;
3. Work area radiological or other hazardous conditions;
4. Dosimetry requirements;
5. Special instructions / pre-job briefings;
6. Training requirements;
7. Any required documented reading;

8. Radiological control or health and safety coverage or controls;
9. Any limiting conditions that would void the HWP;
10. Any required engineered controls;
11. HWP identification number;
12. Requested, issued, effective for and expiration dates; and,
13. Authorizing signatures.

## *6.2 Job-Specific Hazardous Work Permits*

Job-specific HWPs shall be used to control non-routine operations or work in areas with potential for changing radiological conditions. A job-specific HWP shall remain in effect only for the duration of that particular job.

## *6.3 General Hazardous Work Permits*

General HWPs are used to control routine activities such as inspections, routine survey activities, or minor work activities in areas where radiological conditions are not likely to change. General HWPs shall be valid for no longer than one year.

HWPs shall be compared against updated survey data to verify adequacy of all requirements (i.e., PPE, monitoring, radiological information, special instructions, etc.).

HWPs shall be located at control points in the applicable radiological areas, or areas that are deemed hazardous for other than radiological reasons.

Radiological workers and/or general employees shall acknowledge by signature that they have read, understand and will comply with all requirements of an HWP by signing the HWP sign-in log prior to entry or exit of a controlled area.

## *6.4 Initiation of a Hazardous Work Permit*

The instructions in this section may vary during routing and authorization for the HWP but are presented to facilitate rapid approval of a properly completed HWP.

6.4.1 The PTL initiates an HWP for a field task.

6.4.2 The HWP routing sequence is addressed in the HWP Implementation Guide.

6.4.3 Fieldwork commences when the HWP has all required review signatures.

## *6.5 Hazardous Work Permit Close Out*

An HWP will be terminated if any of the following occur:

- Completion of field work;
- Attainment of the expiration date;
- Hazards encountered that are outside the scope of work or are greater than the scope of work, such as high contamination, airborne contaminants, dose rates greater than anticipated; and/or,
- Replacement by a new, approved HWP.

### *6.6 Completed Field Work*

The Field Coordinator, SHSO and RCM sign off on the HWP when the field task is completed.

### *6.7 Changes to a Hazardous Work Permit*

The RCM will determine if changes to an HWP are necessary.

## 7.0 DOCUMENTATION/RECORDS

### *7.1 Active Hazardous Work Permits*

See the HWP Implementation Guide.

### *7.2 Completed Hazardous Work Permits*

All terminated HWPs are retained in the project files.

## 8.0 ATTACHMENTS

### *8.1 Hazardous Work Permit Form*

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# ATTACHMENT 8.1

## HAZARDOUS WORK PERMIT FORM

# HAZARDOUS WORK PERMIT (HWP)

| | | |
|---|---|---|
| Work Location: LEHR | HWP Number: | Effective |
| Requested By: | If scope of work changes, See Revision: | From: To: |
| Requested Date: | | |

**SCOPE OF WORK:**

| **AUTHORIZED ACTIVITIES:** | **HAZARDOUS CONDITIONS:** |
|---|---|
| | |

## RADIOLOGICAL CONDITIONS

| Dose Rate | | Loose Contamination | Air Sample Results | Fixed Contamination |
|---|---|---|---|---|
| Contact: TR/hr | 30 cm : TR/hr | dpm/100 $cm^2$ $\beta\gamma$ | µCi/ml gross $\beta\gamma$ | dpm/probe area $\beta\gamma$ |
| Gamma | Gamma | dpm/100 $cm^2$ $\alpha$ | µCi/ml gross $\alpha$ | dpm/probe area $\alpha$ |
| Beta | Beta | | | |

**RADIONUCLIDES:**

## REQUIRED PERSONNEL PROTECTIVE EQUIPMENT

| Hands | Feet | Head/Eyes | Body | Respiratory |
|---|---|---|---|---|
| **Gloves:** | Rubber Shoe Covers | Safety Glasses | **Coveralls:** | Half-Face Neg. Press |
| Cotton | Plastic Boots | Goggles | Cotton | Full-Face Neg. Press |
| Latex | Hip Waders | Face Shield | Tyvek | Powered Air Purifying |
| Rubber | Steel Toe Shoes | Hard Hat | Special: | specify cartridge ( ) |
| Neoprene | Disp. Shoe Covers | Hearing Protection | Poly Tyvek | |
| Nitrile | | | Poly Apron | Supplied Air Hood |
| Work | | | Rain Suit | Supp. Air Full-Face |
| Polycoated | | | Moon Suit | Sandblast Hood |
| Arm Sleeves | | | Rubber Suit | Self-Contained (SCBA) |
| | | | Acid Suit | |

| Miscellaneous | | Dosimetry |
|---|---|---|
| Tape Gloves and Boots to Coveralls | Other | TLD Badge |
| Life Lines | | Finger Ring |
| Safety Belts | | Other |

| SPECIAL INSTRUCTIONS | | | ENVIRONMENT (IH) MONITORING |
|---|---|---|---|
| Watchman | **General Site Training:** | | **Airborne Radioactivity Monitoring:** |
| Electrical Tagout | Emergency Response | | Breathing Zone (BZ) |
| Pre-entry Monitoring | Site Specific Orientation | | General Area (GA) |
| Buddy System in effect | Work Plan, PHSP, QAPP | | Perimeter / boundary |
| Job Coverage by Safety Professional | Read & Sign Tailgate | | **P.I.D. Monitoring :** |
| First Aid Kit | Work Plan & Pre- Job Briefing | | Pre-job |
| Portable Eye Wash Station | **Rad Training:** | | On-going |
| Fire Extinguisher | Rad Worker I | | **L.E.L. Monitoring :** |
| Emergency Air Horn | Rad Worker II | | Pre-job |
| Portable Radio | Other | | On-going |

**Additional Instructions:**

## APPROVAL SIGNATURES

| WORK COMMENCEMENT | | WORK COMPLETION | |
|---|---|---|---|
| Project H&S Manager: | Date: | Project H&S Manager: | Date: |
| e H&S Officer: | Date: | Site H&S Officer: | Date: |
| ield Coordinator: | Date: | Field Coordinator: | Date: |

# PERSONNEL CONTAMINATION

HEALTH AND SAFETY PROCEDURE

## 1.0 PURPOSE

This procedure describes the requirements for recording personnel contaminations (clothing or skin), decontaminating of radioactive contaminants, and for estimating personnel skin (shallow) dose equivalent due to skin contamination. This procedure is applicable to field investigation and decommissioning and decontamination activities at LEHR.

## 2.0 REFERENCES

*2.1* *10 CFR 835, "Occupational Radiation Protection"*

*2.2* *SOP 32.1, "Contamination Control"*

*2.3* *SOP 25.1, "Radiological Surveys and Instrumentation"*

*2.4* *SOP 20.1, "Employee and Subcontractor Training Requirements"*

## 3.0 DEFINITIONS

### *3.1 Contamination*

The presence of radioactivity in unwanted areas (i.e., surfaces of structures, objects, areas, or personnel).

### *3.2 Decontamination Agent*

Solutions used to decontaminate personnel, usually warm water and soap.

## 4.0 RESPONSIBILITIES

### *4.1 Project Manager (PM)*

The PM is responsible for the safe and effective implementation of this procedure.

### *4.2 Radiological Control Manager (RCM)*

The RCM is responsible for approving all skin dose estimates and for reporting all personnel contaminations to DOE Oakland as required by DOE Order 5000.3a "Occurrence Reporting and Processing of Operations Information," May 30, 1990.

### *4.3 Radiation Safety Officer (RSO)*

The RSO ensures that all Radiological Control Technicians (RCTs) and project personnel are trained on this procedure and understand its requirements. The RSO is responsible for reviewing all Personnel Contamination Reports (PCRs) (Attachment 8.1) and performing field estimates of external dose when such dose assessment is required. The RSO is also responsible for having all dose assessments reviewed by a Health Physicist prior to submitting the dose estimate to the RCM.

### *4.4 Radiological Control Technicians (RCT)*

The RCTs are responsible for overseeing decontamination of personnel and for filling out a PCR.

### *4.5 Site Health and Safety Officer (SHSO)*

The SHSO ensures that all PCRs and substantiating data are properly filed and that any skin (shallow) dose calculated is properly entered into project personnel dose records.

## 5.0 SAFETY PRECAUTIONS/PREREQUISITES

### *5.1 Monitoring Equipment*

All monitoring equipment (instrumentation) shall be in current calibration and shall meet the requirements of SOP 25.1 (Reference 2.3). Instruments shall be selected based on the type of radionuclides expected and the efficiencies shall be determined prior to use.

### *5.2 Personnel*

Personnel shall be trained in the use of surveying (frisking) equipment, and shall be Rad Worker II trained per HSP 20.1 (Reference 2.4).

## 6.0 PROCEDURE

### *6.1 Instructions*

6.1.1 All personnel exiting a posted contamination area shall monitor themselves for radioactive contamination.

**Note:** Personnel are considered contaminated when measurements of the skin reach or exceed 200 disintegrations per minute (dpm)/100 $cm^2$ beta-gamma or 20 dpm/100 $cm^2$ alpha activity.

6.1.2 If an individual determines that they are potentially contaminated, they must:

- Notify an RCT or the RSO immediately
- Remain at the location where the contamination was identified, and
- Isolate the area to prevent further spread of contamination (i.e, taping the area off or covering the affected area with a plastic bag, etc.).

6.1.3 Upon notification, the RCT or RSO shall resurvey the individual and initiate a PCR (Attachment 8.1) if clothing or skin contamination is present.

## *6.2 Decontamination of Personnel*

6.2.1 The RCT or RSO shall oversee the decontamination of the affected person. Decontamination of clothing may be as aggressive as necessary, and may include use of tape, vacuum, brushing, on-site washing of clothing, etc. Decontamination procedures for skin (arranged in a progressive order) may include:

- Wash contaminated area with warm water and hand soap
- Wash contaminated area with warm water and laundry detergent
- Wrap contaminated area with plastic to cause sweating
- Other measures taken only under the direction of the RSO.

**CAUTION:** Decontamination procedures for personnel shall never result in reddening or abrasion of the skin nor involve cutting or shaving of hair unless specifically authorized by the RSO.

6.2.2 Decontamination of the eyes shall be restricted to flushing with water. More aggressive measures should only be performed under medical supervision.

6.2.3 Decontamination of the nasal passages shall be restricted to nose blowing and nasal swabs.

6.2.4 Decontamination procedures may be conducted in the field using decontamination kits, at the Health Physics office, or at site showers.

## *6.3 Documentation and Reporting of a Personnel Skin Contamination*

6.3.1 The RSO shall ensure all personnel skin or clothing contaminations are documented on a PCR and that all pertinent reports and substantiating data are passed on to the SHSO for inclusion in project files.

6.3.2 The RSO shall report all personnel skin or clothing contaminations to the RCM.

6.3.3 The RSO shall notify the Project Manager prior to letting any individual leave the job site or facility with contaminated skin. This should only happen after decontamination has been done, and no loose contamination above limits remains.

## *6.4 Assessment of Skin Dose*

6.4.1 The RSO shall make a dose assessment of non-uniform exposures of the skin from x-rays, beta radiation, and/or radioactive material for each skin contamination when it is anticipated that the dose would be >50 mrem under any of the following conditions:

- When the area of skin is 100 $cm^2$ the maximum value of dose averaged over any area of >100 $cm^2$ is to be assessed, recorded, and included with any uniform dose equivalent also recorded by the skin in the annual skin (shallow) dose equivalent to any extremity or skin for the year.
- When the area of skin exposed is $\geq$10 $cm^2$ but <100 $cm^2$ the dose equivalent to that tissue is to be determined by:

$$H = f\,D$$

where:

f = Fraction of skin exposed compared to 100 $cm^2$ (in no case shall f <0.1)
D = Maximum dose averaged over a 1 $cm^2$ of skin

The calculated dose is to be recorded and included in the annual skin (shallow) dose equivalent.

- When the area of skin exposed is <10 $cm^2$ the maximum value of dose averaged over any 1 $cm^2$ is to be assessed and recorded in the individual's occupational exposure history as a special entry but is not to be included in the annual skin (shallow) dose equivalent to any extremity or skin recorded as the dose equivalent for the year.

6.4.2 To calculate skin dose, the RSO may use the following techniques:

- Thumb Rule: 5,000 dpm-hours equals 1 mrem based on the limiting isotope Sr/Y-90. (Note: This thumb rule is only good for contamination <50,000 dpm-hours.)
- Dose conversion factors may be used whenever more accurate calculations are necessary or the levels exceed those allowable for the thumb rule.
  - Dose conversion factors may be obtained from MIRD 11, ORNL 5000, Kocher, etc.
  - Isotopic ratios and information may be obtained from data on facility history, waste stream, smears, or from samples collected during decontamination.

- The VARSKIN computer program (includes revisions and updates) may be used whenever more accurate calculations are necessary or the levels exceed those allowable for thumb rules.

6.4.3 Information used to calculate skin doses and the calculations should be attached to the PCR.

6.4.4 The RSO shall have all skin (shallow) dose assessments reviewed by a Health Physicist.

# 7.0 DOCUMENTATION/RECORDS

## *7.1 Records*

All records pertinent to this procedure shall be maintained by the SHSO.

## *7.2 Shallow Dose*

Shallow dose calculated for a person shall be entered and maintained in their personal exposure history by the SHSO.

# 8.0 ATTACHMENTS

## *8.1 Personnel Contamination Report*

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# ATTACHMENT 8.1

## PERSONNEL CONTAMINATION REPORT

# Personnel Contamination Report

**PERSONNEL CONTAMINATION REPORT**

No. _____

Name:

Employee No.: SSN:

Date/Time of Incident:

Location of Incident:

Describe and number locations of contamination (*include estimate of surface area involved*):

| Location of Contamination | Initial Contamination Levels/Time | Levels after Decon 1/Time | Levels after Decon 2/Time | Levels after Decon 3/Time |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

Name of RCT performing decontamination:

Instrument Used: Cal. Due Date:

Dose Assessment (for skin contamination):

| | | | |
|---|---|---|---|
| Total dpm-hours at each locations: | (1) | (2) | (3) |
| Skin Dose at each location: | (1) | (2) | (3) |

Name of RSO performing skin dose assessment?

Reviewed by:

Approved by:

Skin Dose Assigned by:

Date Assigned:

## Instructions for Completing the Personnel Contamination Report

1. Personnel Contamination Report No. - Insert the next sequential number obtained from the Personnel Contamination Log maintained by the LEHR RSO.

2. Name of Individual - Insert the first name/middle initial/last name of the contaminated individual.

3. Employee No./SSN - Insert the 5 digit Employee ID Number and the 9 digit Social Security Number of the individual.

4. Date/Time of Incident - Insert the date the incident occurred and the estimated time of contamination.

5. Location of Incident - Describe the location where the contamination occurred including site, building number, and room number, etc.

6. Mark and Number Locations of Contamination - On the figures shown mark where the contamination has been found and number the separate locations. The size of the area contaminated shall be estimated also and shown. Examples follow:

   (a) 100 $cm^2$ on elbow area (b) 50 $cm^2$ on thigh

7. Initial Contamination Levels/Time - Insert the highest contamination level (in dpm) found at each location and denote the time when the contamination may have occurred.

8. Levels after Decon 1, 2, 3 - Insert the highest contamination level found at each location after the appropriate decontamination effort. In addition, denote the time that the decontamination effort occurred.

9. Name of Radiation Control Technician performing decontamination - The RCT responsible for performing the decontamination shall insert their first name/middle initial/last name.

10. Instrument used - Insert the type of instrument used by the Technician to measure the contamination including manufacturer, model number, probe type, and probe number.

11. Cal. Due Date - Insert the date when the next calibration is due.

12. Total dpm-hours at each location - Calculate dpm-hours by multiplying the contamination level (dpm) and the time (hours) it was present on the individual. This shall be completed for each location through each decontamination effort and then totaled and inserted here.

13. Skin dose at each location - Insert the skin dose (in mrem) for each location.

14. Name of LEHR Radiation Safety Officer performing skin dose assessment - The RSO who performed the skin dose assessment shall insert their first name/middle initial/last name.

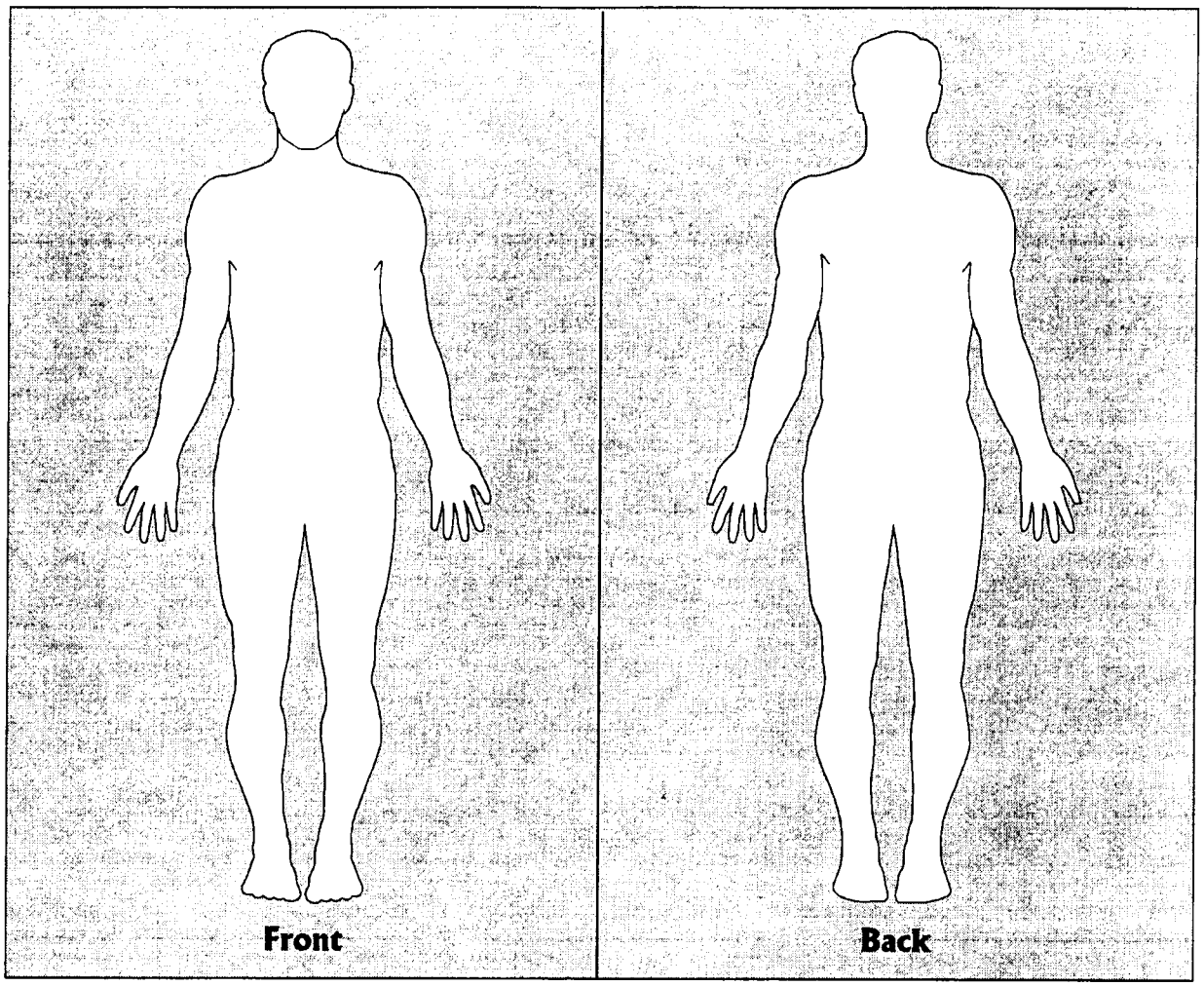
15. Reviewed by - The PCR shall be reviewed by an independent Health Physicist who shall place their signature in this space.

16. Approved by - The PCR shall be approved by the Radiological Control Manager, who shall place his signature in this space.

17. Skin Dose Assigned by - The LEHR RSO shall assign the highest skin dose value (from a contamination area greater than 10 $cm^2$) to the individual. The individual who assigns the dose shall sign in this space.

18. Date Assigned - The LEHR RSO shall insert the date that the dose was assigned.

# Personnel Contamination Report




**Notes:** _____

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lhall (09-02-97)

# EMBRYO-FETUS PROTECTION PROGRAM

**HEALTH AND SAFETY PROCEDURE**

## 1.0 PURPOSE

This procedure describes the embryo-fetus protection program requirements for environmental assessment and decontamination and decommissioning activities at LEHR. This procedure is not for the purpose of monitoring individuals to demonstrate compliance with 10 CFR 835.402(a) or (c).

## 2.0 REFERENCES

*2.1 10 CFR 835, "Occupational Radiation Protection Program"*

*2.2 Regulatory Guide 8.13 "Instruction Concerning Prenatal Radiation Exposure"*

## 3.0 DEFINITIONS

### *3.1 Embryo*

The developing unborn baby during the first eight weeks of pregnancy.

### *3.2 Fetus*

The developing unborn baby after the first eight weeks of pregnancy.

### *3.3 Declared Pregnant Worker*

A woman who has voluntarily declared to her employer, in writing, her pregnancy for the purpose of being subject to the occupational dose limits to the embryo/fetus as provided in § 835.206. This declaration may be revoked, in writing, at any time by the declared pregnant worker.

### *3.4 Records Inventory and Disposition Schedule (RIDS)*

The LEHR Record Keeping System

# 4.0 RESPONSIBILITIES

## *4.1 Project Manager (PM)*

The PM is responsible for ensuring this policy is implemented.

## *4.2 Radiological Control Manager (RCM)*

The RCM is responsible for the issuance, revision, maintenance, and safe and effective implementation of this procedure.

## *4.3 Site Health and Safety Officer (SHSO)*

The SHSO is responsible for placing completed forms in the correct general employee and/or radiological worker's personnel file, for arranging transfers as discussed in Section 6.2 of this procedure, and for conducting briefings and workplace evaluations as discussed in Sections 6.1 and 6.2 of this procedure.

## *4.4 General Employees or Radiological Workers*

General employees and/or radiological workers are responsible for attending briefings, completing applicable forms and for requesting accommodations/transfers. A more detailed discussion is provided in Section 6.2 of this procedure.

# 5.0 SAFETY PRECAUTIONS/PREREQUISITES

None.

# 6.0 PROCEDURE

## *6.1 Training*

6.1.1 The SHSO or designee at the LEHR facility shall provide instruction to all general employees and/or radiological workers about this procedure and the risk of radiological and chemical exposure inside and outside the workplace during pregnancy in accordance to the requirements of 10 CFR 835 (Reference 2.1).

6.1.2 All general employees and/or radiological workers will complete an Embryo-Fetus Protection Form to acknowledge being informed about these risks and the LEHR procedures for protection.

6.1.3 The SHSO or designated trainer shall obtain a completed Embryo-Fetus Protection Form from the general employee and/or radiological worker. The Embryo-Fetus Protection Form will be retained in the personnel section of the RIDS (LEHR Project files).

## *6.2 Protective Measures*

General employees and/or radiological workers are strongly urged to inform their supervisor when pregnancy (self or spouse) is imminently planned, suspected, or confirmed. No supervisor is authorized to take any action that would violate an general employee and/or radiological worker's right to continue normal duties while pregnant or attempting pregnancy. All information will be kept strictly confidential.

6.2.1 Any general employee and/or radiological worker whose duties involve exposure to radioactive materials or chemical handling, and who plans, suspects, or has confirmed pregnancy may request that the SHSO assess the job requirements and working conditions for exposure to hazardous materials. This request is made by filling out the appropriate section of a Declaration of Attempt or Pregnancy Form and submitting it to the RCM, SHSO, or Radiation Safety Officer (RSO).

6.2.2 The SHSO shall retain the completed forms in the applicable folder of the Personnel Section in the RIDS (LEHR Project files).

6.2.3 The SHSO and RSO are responsible for conducting the requested assessment and making this determination regarding the potential for exposure within a few days of the request. The RCM and/or SHSO is responsible for the final determination regarding the potential for exposure to hazardous chemicals. The RSO is responsible for the final determination regarding the potential for exposure to radiation.

6.2.4 The results of the assessment will be documented by the SHSO using an Area Assessment for Declaration of Attempt or Pregnancy Form. Assessment results will be shared with the general employee and/or radiological worker. The general employee and/or radiological worker may discuss the results with the SHSO and/or the Radiation Safety Officer (RSO), and/or the RCM. After the discussion, the general employee and/or radiological worker may request a job accommodation or transfer to alternate duties not involving handling of or exposure to hazardous materials.

6.2.5 A transfer shall continue for the duration of the pregnancy for women. Transfer for men shall continue until spousal pregnancy is confirmed or for a reasonable period while attempting pregnancy. Any general employee and/or radiological worker transferring to alternate duties during pregnancy shall continue to receive his or her normal rate of pay. Seniority of the transferring general employee and/or radiological worker in their position shall be fully protected throughout the transfer duration.

6.2.6 Any general employee and/or radiological worker may rescind the declaration of pregnancy by filling out a Declaration of Attempt or Pregnancy Termination Form and submitting it to the SHSO.

6.2.7 The SHSO shall retain the completed form in the applicable folder of the Personnel Section of the RIDS (LEHR Project files) and inform the RCM and RSO of the general employee and/or radiological worker's change in status.

## *6.3 Hazards Affecting the Embryo-Fetus*

To assist general employees and/or radiological workers in deciding whether to continue normal duties or request a pregnancy-related transfer, a list of chemicals believed to be capable of embryo-fetal damage has been compiled. This list (Section 6.3.1) is based upon the best information available, but should not be considered comprehensive due to the limited body of research knowledge available. Additionally, information pertinent to radiation effects has been included in Section 6.3.2. Any general employee and/or radiological worker who suspects or has confirmed pregnancy should consult her personal physician.

6.3.1 List of Chemicals/Substances Believed to be Reproductive Toxins

| | |
|---|---|
| 2-Acetylamino/Fluorene | 4-Dimethylaminoazobenzene |
| Acrylonitrile | Dimethylformamide |
| Ammonium chloride | Dimethylsulvoxide |
| Arsenic | Dinitrotoluene |
| Benzene | EDB (ethylene dibromide) |
| Cadmium | Epichlorophydrin |
| Carbon disulfide | 2-Ethoxyethanol |
| Cellosolve solvents | Ethylene glycol monoethyl ether |
| Chloroform | Ethylene glycol monomethyl ether |
| Chloropropene | Ethylene oxide |
| DBCP (dibromochloropropane) | Ethylene thiourea |
| 1,2-Dimethoxyethane | Fluorocarbon-22 |
| Dimethyl acetamide | Formamide |
| Glycidyl Ethers | Organophosphate pesticides |
| Hexafluoroacetone | Polychlorinated biphenyl |
| Inorganic lead | Styrene |
| Ionizing radiation (Attachment ) | TCDD (dioxin) |
| Karathene | TCDF (fura) |
| Lead | Tetramethyluea |
| Magnesium sulfate | TOK herbicide |
| Mercury, all forms | Vinyl chloride |
| 2-Methoxyethanol | Waste anesthetic gases and vapors |

Any chemical whose Material Safety Data Sheet lists possible embryo-fetus toxicity shall be acknowledged as a hazardous substance for the purposes of embryo-fetus protection.

6.3.2 Radiological Hazards for the Embryo-Fetus

The U.S. Nuclear Regulatory Commission (NRC) provides Regulatory Guide 8.13, "Instructions Concerning Prenatal Radiation Exposure" (Reference 2.2). The regulatory guide takes into consideration a proposed revision to the Code of Federal Regulations, Title 10, Part 20, which incorporates the radiation protection guidance for the embryo-fetus approved by the President of the United States in January 1987. The aforementioned code of federal regulations requires that all individuals working in or frequenting any portion of a radiologically posted area be instructed in the health protection problems associated with exposure to radioactive materials or radiation, in precautions or procedures to minimize exposure, and in the regulations that they are expected to observe. At the completion of such training, workers are required to read and sign the Embryo-Fetus Protection Form (Attachment 8.1).

The NRC's present limit on the radiation dose that can be received by the unborn child is 500 millirems for the entire pregnancy. This dose limit is stated in 10 CFR 835.206a. This dose is only implemented for a declared pregnancy as defined in Section 3.3 of this procedure. General employees and/or radiological workers who do not declare a pregnancy, as defined in Section 3.3 of this procedure, are covered by the dose for a radiation worker, 5 rem per year or the LEHR administration limit of 500 mrem per year.

The DOE has codified these dose limits for the unborn child in 10 CFR 835.

Substantial variation above a uniform exposure rate of 0.5 rem shall be avoided.

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

# 7.0 DOCUMENTATION/RECORDS

Attached are the Embryo-Fetus Protection Form (Attachment 8.1), Declaration of Attempt or Pregnancy Form (Attachment 8.2), Area Assessment for Declaration of Attempt or Pregnancy Form (Attachment 8.3), and the Declaration of Attempt or Pregnancy Termination Form (Attachment 8.4). Each completed form will be placed by the SHSO into the affected general employee and/or radiological worker's personnel file in RIDS (LEHR Project files).

# 8.0 ATTACHMENTS

## *8.1 Embryo-Fetus Protection Form*

## *8.2 Declaration of Attempt or Pregnancy*

## *8.3 Area Assessment for Declaration of Attempt or Pregnancy*

## *8.4 Declaration of Attempt or Pregnancy Termination*

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# ATTACHMENT 8.1

## EMBRYO-FETUS PROTECTION FORM

# ATTACHMENT 8.1

## EMBRYO/FETUS PROTECTION FORM

I acknowledge that I have received embryo-fetus protection training according to 10 CFR 835 and understand that the dose limits for the embryo-fetus of a declared pregnant worker is 500 mrem for the entire pregnancy, preferably no more than 50 mrem per month. I also understand that male and female workers who are attempting pregnancy may request a temporary work station relocation if the working environment is determined by the worker's supervisor to pose a possible threat to the reproductive organs. I also understand that a female worker must declare the pregnancy in writing for the embryo-fetus dose limit to apply. I understand that a declared pregnant worker may request or be assigned to a temporary work station. I understand that the employer must provide the option of a mutually agreeable assignment of work tasks, with no loss of pay or promotional opportunity for the declared pregnant worker. I understand also that if the pregnancy is not declared in writing, the embryo-fetus dose limit does not apply.

Name _____ Date _____

Signature _____ SSN _____

# ATTACHMENT 8.2

## DECLARATION OF ATTEMPT OR PREGNANCY

# ATTACHMENT 8.2

## DECLARATION OF ATTEMPT OR PREGNANCY

**Part I.** *I, the undersigned, do hereby declare my intent to become pregnant or to father a child.* I understand that my workplace will be assessed to determine if there is any reasonable possibility that circumstances (radiological or chemical) exist that would have detrimental effects on an unborn child during this time of attempted pregnancy. If such circumstances exist in my workplace that would cause the aforementioned detrimental effects, I understand that the employer must provide the option of a mutually agreeable assignment of work tasks, with no loss of pay or promotional opportunity, for a reasonable time to attempt pregnancy. I also understand that I must inform the employer upon confirmation of pregnancy. I understand that female workers who declare a pregnancy shall receive no more than 500 millirem of radiation for the duration of pregnancy. I understand that I will, upon confirmation of pregnancy or within a reasonable time of unsuccessful attempt at pregnancy, return to the workplace and work tasks assessed to have detrimental effects on an unborn child.

Name _____ Date _____

Signature _____ SSN _____

---

**Part II.** *I, the undersigned, do hereby declare that I am pregnant.* I understand that in declaring this pregnancy I am accepting the U.S. Nuclear Regulatory Commission 500 millirem dose limit to the embryo-fetus for the entire pregnancy. I also understand that my workplace will be assessed to determine if there is any reasonable possibility that the aforementioned dose limit will be exceeded or if there are any chemical toxins known or suspected to have detrimental effects on an unborn child. If such circumstances exist in my workplace that would cause the aforementioned detrimental effects, I understand that the employer must provide the option of a mutually agreeable assignment of work tasks, with no loss of pay or promotional opportunity.

Name _____ Date _____

Signature _____ SSN _____

Assumed date of conception _____

# ATTACHMENT 8.3

## AREA ASSESSMENT FOR DECLARATION OF ATTEMPT OR PREGNANCY

# ATTACHMENT 8.3

# AREA ASSESSMENT FOR DECLARATION OF ATTEMPT OR PREGNANCY

Officer (RSO) upon completion of the workplace and work activity assessment for declaration of attempt or pregnancy. The assessment is to follow the employee's completion of either Part I or Part II of a Declaration of Attempt or Pregnancy Form.

The workplace and work activity assessment for employee _____ _____ is complete. The Site Health and Safety Officer finds the workplace and work activity:

*does not* propose chemical hazards to the unborn child. Therefore, the employee may continue to work in this area and perform regular activities without endangering the unborn child.

*does* propose chemical hazards to the unborn child. Therefore, the employee may not continue to work in this area and perform regular activities due to the endangerment of the unborn child.

The Radiation Safety Officer finds the work place and work activity:

*does not* propose radiological hazards to the unborn child. Therefore, the employee may continue to work in this area and perform regular activities without endangering the unborn child.

*does* propose radiological hazards to the unborn child. Therefore, the employee may not continue to work in this area and perform regular activities due to the endangerment of the unborn child.

SHSO _____ SSN _____

Signature_____ Date _____

RSO _____ SSN _____

Signature_____ Date _____

# ATTACHMENT 8.4

## DECLARATION OF ATTEMPT OR PREGNANCY TERMINATION

# ATTACHMENT 8.4

## DECLARATION OF ATTEMPT OR PREGNANCY TERMINATION

I, the undersigned, do hereby declare that I am no longer pregnant or no longer attempting to become pregnant or no longer attempting to father a child. I understand that I will return to the workplace and work tasks assessed to have detrimental effects on an unborn child. I also understand that my radiation dose limit will be 5 rem per year.

Name _____ Date _____

Signature_____ SSN _____

Date pregnancy ended (female worker) _____

# EMPLOYEE AND SUBCONTRACTOR TRAINING REQUIREMENTS

HEALTH AND SAFETY PROCEDURE

## 1.0 PURPOSE

This procedure sets forth training requirements for LEHR employees and subcontractors. Training requirements are established for tasks or types of work to be executed at LEHR during environmental investigation and decontamination and decommissioning activities.

## 2.0 REFERENCES

*2.1* *10 CFR 835, "Occupational Radiation Protection"*

*2.2* *29 CFR 1910, "Occupational Safety and Health Standards, Labor"*

*2.3* *29 CFR 1926, "Safety and Health Regulations for Construction"*

*2.4* *SQP 3.2, "Indoctrination and Training"*

## 3.0 DEFINITIONS

### *3.1 Annual Refresher*

Abbreviated training on a required subject for the purpose of repeating information that may have been updated or is worthy of formally reminding the employees annually.

### *3.2 Attendant*

One who monitors those who enter a permit-required confined space.

### *3.3 Employee*

Any person employed by the prime contractor or any subcontractor working at the LEHR site.

### *3.4 Escort*

An individual with the prerequisite training necessary for unescorted access to the area(s) where the escort activities will be performed who is authorized to accompany and ensure the safety of individuals who lack such training.

### *3.5 Hazardous Materials*

Anything defined by the U.S. Department of Transportation (DOT) or the U.S. Environmental Protection Agency (EPA) as hazardous materials. This term includes hazardous materials, substances, and wastes in any quantity.

### *3.6 Radiological Worker*

A general employee whose job assignment involves operation of radiation producing devices or working with radioactive materials, or who is likely to be routinely occupationally exposed above 0.1 rem (0.001 sievert) per year total effective dose equivalent.

### *3.7 Radiological Control Technicians*

Radiological Control Technicians perform the functions of assisting and guiding workers in the radiological aspects of the job in order to ensure compliance with the project radiological protection program.

### *3.8 Radiological Worker*$^{+}$

A Radiological Worker who has specialized training to perform specific RCT type tasks after approval from the RSO.

### *3.9 General Employee*

A General Employee is an individual who is either a DOE or 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.

## 4.0 RESPONSIBILITIES

### *4.1 Project Manager (PM)*

The PM is responsible for the implementation of this procedure.

### *4.2 Radiological Control Manager (RCM)*

The RCM is responsible to identify all training requirements pertinent to work activities involved at LEHR. The RCM is responsible for ensuring all personnel working at the LEHR project have received the required training and for the issuance, revision, maintenance, and compliance of this procedure.

### *4.3 Site Health and Safety Officer (SHSO)*

The SHSO is responsible for verifying training status of all employees, and for identifying training and refresher training needs to the appropriate Subcontractor Health and Safety Coordinator(s).

### *4.4 Subcontractor Health and Safety Coordinator (SHSC)*

The SHSC is responsible for ensuring all company employees are trained to the applicable training requirements of this procedure, and for scheduling refresher training as required.

### *4.5 Employees*

All employees are responsible for providing training certificates to their SHSC or to the SHSO, and for attending required training.

### *4.6 Escorts*

An escort is responsible for ensuring that all escorted individuals comply with the documented Radiation Protection Program and notifying and obtaining direction from the RSO for specific escort requirements prior to acting in that capacity.

## 5.0 SAFETY PRECAUTIONS/PREREQUISITES

No employee shall perform work for the contracted scope of work at LEHR until they comply with the training requirements of this procedure. Training certificates are accepted as proof of prior training.

## 6.0 PROCEDURE

### *6.1 Minimum Training Requirements*

Training requirements presented in this section focus primarily on regulatory training. Each site employee will be properly trained (off-site and on-site), as necessary, to meet regulatory requirements. Each employee will undergo training prior to initial assignment, and periodically throughout the project. In some circumstances, initial training will be accomplished concurrent with a task if the individual is accompanied by and under direct supervision of a trained individual. The

level of training is to be commensurate with each worker's assignment. Retraining will generally be provided when there is a significant change to policies or procedures, but generally at intervals not to exceed a 24 month period. Training will be conducted under the procedures presented in the QAPP, SQP 3.2, "Indoctrination Training." No employee shall be permitted to engage in work activities without the necessary regulatory training and proper documentation thereof.

6.1.1 This procedure establishes the minimum LEHR employee training requirements. Additional training requirements may be established by state or local authorities as well as by the Occupational Safety and Health Administration (OSHA) regulations. The training program shall be established, as necessary, to ensure 10 CFR 835 (Reference 2.1) compliance.

6.1.2 The RCM/SHSO shall ensure that training complies with applicable regulatory requirements. Monitoring shall be performed by trained and qualified personnel.

6.1.3 Documentation of prior outside training may be accepted by the SHSO as essentially equivalent to some LEHR sessions. To expedite this process, the employee requesting such acceptance shall provide copies of all certificates to the SHSO. The SHSO may request supporting data for any supplied documentation. The RCM shall approve use of outside training resources for radiation training.

6.1.4 Radiation safety training shall include the following topics, to the extent appropriate to each individual's prior training, potential assignments, and degree of exposure to potential radiological hazards:

- Risks of exposure to radiation and radioactive materials, including prenatal radiation exposure;
- Basic radiological fundamentals and radiation protection concepts;
- Physical design features, administrative controls, limits, policies, procedures, alarms, and other measures implemented at the facility to manage doses and maintain doses ALARA, including both routine and emergency actions;
- Individual rights and responsibilities as related to implementation of the facility radiation protection program;
- Individual responsibilities for implementing ALARA measures required by 10CFR835 (Reference 2.1); and,
- Individual exposure reports that may be requested in accordance with 10CFR835.

Prior to permitting an individual to enter a radiological area unescorted, perform unescorted radiological work, training commensurate with the hazard in the area and the required controls shall be completed. Examinations for Radiological Worker training and Radiological Control Technician qualification shall be used to demonstrate satisfactory completion of theoretical and applied material. Examinations should consist of written examinations and performance demonstrations. The examination process should require:

- That true/false questions not be included;

- Use of questions randomly selected from the DOE supplied question bank;
- Acknowledgement by signature that the student participated in a post-examination review;
- That competence in required skills be measured using performance- based examinations;
- Remedial actions for failure to meet the minimum score;
- That the question bank contain questions that test what the student is expected to remember months after the training rather than to test short term memory of theoretical material; and,
- The practical examination be commensurate with the type of work to be performed.

Training should address both normal and abnormal situations in radiological control. Changes to the radiological control program shall be incorporated as they are identified and a decision made if retraining prior to the 24 month period is needed.

6.1.5 General Employees

- All general employees shall be trained in radiation safety prior to receiving occupational dose during unescorted access to controlled areas at a DOE site or facility. Training shall address the radiation safety training topics in 6.1.4. to the extent appropriate for the degree of exposure to radiological hazards that may be encountered and the required controls.
- Allowance may be made for previous DOE training on generic radiation safety topics (i.e., those not specific to a site or facility), provide the training was received at another DOE site or facility within the past 24 months.
- Documentation of the previous training shall clearly identify the individual's name, date of training, topics covered, and name of the certifying individual.
- General employees shall not be permitted unescorted access to any radiological area without appropriate training and examination.
- The knowledge of radiation safety possessed by general employees shall be verified by examination.
- Retraining shall be provided when there is a significant change to radiation protection policies and procedures that affect general employees and shall be conducted at intervals not to exceed 24 months.

6.1.6 Radiological Workers

- Each radiological worker shall demonstrate knowledge of the radiation safety training topics in Section 6.1.4, commensurate with the hazards in the area and required controls, by successful completion of an examination and performance demonstrations:

  - before being permitted unescorted access to radiological areas
  - before performing unescorted assignments as a radiological worker
- Radiological worker training not specific to a given site or facility may be waived provided that:
  - this training has been received at another DOE site or facility within the past 24 months
  - there is provision of proof-of-training in the form of a certification document containing the individual's name, date of training, and specific topics covered
  - an appropriate official has certified the training of the individual
- The knowledge of radiation safety possessed by radiological workers shall be verified by examination and performance demonstrations prior to an unsupervised assignment
- The training (radiological worker) shall include procedures specific to an individual's job assignment
- The level of training (radiological worker) is to be commensurate with each worker's assignment
- Radiological worker training programs and retraining shall be established and conducted at intervals not to exceed s 24 month period to familiarize the worker with topics indicated in Section 6.1.4
- Training shall include both classroom and applied training
- Training shall either precede assignment as a radiological worker or be concurrent with assignment as a radiological worker if the worker is accompanied by and under the direct supervision of a training radiological worker (acting as an escort)

6.1.7 Radiological Worker$^+$

- Radiological Worker$^+$ will have the same level of training as a radiological worker (See Section 6.16)
- The knowledge of radiation safety as it applies to specialized assignment or task verified by examination prior to an unsupervised assignment
- The training shall include procedures specific to an individual's job assignment
- The level of training is to be commensurate with each worker's assignment
- Radiological Worker$^+$ training programs and retraining for specialized assignments or tasks shall be established and conducted at intervals not to exceed a 24 month period to familiarize the worker with the fundamentals of radiation protection and the ALARA process for the specialized assignment or task
- Training shall include both classroom and applied training

- Training on the specialized assignment or tasks precede assignment as a Radiological Worker[+]

6.1.8 Radiological Control Technician

- Each Radiological Control Technician shall demonstrate knowledge of the radiation safety training topics in Section 6.1.4, commensurate with the hazards in the area and required controls, by successful completion of an examination and performance demonstrations:
  - before being permitted unescorted access to radiological areas
  - before performing unescorted assignments as a Radiological Control Technician
- Training and retraining programs for radiological control technicians shall be established and conducted at intervals not to exceed a 24 month period.
- This program shall include both classroom and applied training
- The training shall either precede performance of tasks assigned to radiological control technicians or be concurrent with such task assignments if the individual is accompanied by and under the direct supervision of a trained individual (acting as an escort).
- The required level of knowledge of radiation safety possessed by radiological control technicians shall be verified by examination and performance demonstrations including demonstrations of qualifications of critical areas prior to any unsupervised work assignment.
- The training program shall include plans and procedures specific to the site or facility where the technician is assigned.
- The level of training shall be commensurate with the technician's assignment.
- Allowance may be made for previous DOE training on generic radiation safety topics (i.e., those not specific to a site or facility), provided the training was received with the past 24 months. Site specific training shall be required.
- Documentation of the previous training shall clearly identify the individual's name, date of training, topics covered, and name of the certifying individual.
- Before performing a job function without direct supervision, a trainee with partially completed qualifications shall have completed the qualifications for that task.

6.1.9 Escorts

When an escort is used in lieu of training, the escort shall:

- Have completed radiation safety training, examinations; and performance demonstrations required for entry to the area and performance of the work

- Ensure that all escorted individuals comply with the documented radiation protection program
- Obtain direction from the RSO for specific escorting requirements prior to acting in that capacity

6.1.10 Subcontracted Employees

Subcontractors and subcontracted employees should be treated the same as facility staff in the area of radiological matters, shall have comparable radiation safety training, and should meet the same requirements and expectations.

6.1.11 Individuals ensuring compliance with training requirements mandated by 10 CFR 835 shall have the appropriate education, training, and skills to discharge these responsibilities.

## *6.2 OSHA Training Requirements*

6.2.1 Site-specific training shall cover the site-specific and job-specific elements that necessarily cannot be covered in standardized formal training sessions.

6.2.2 Hazard Communication Training shall cover all employees dealing with hazardous chemicals used on site and reading and understanding of Material Safety Data Sheets. Course content shall address the requirements of 29 CFR 1910.120 (Reference 2.2).

6.2.3 Hazards and Protection Limited Training shall cover all employees with potential exposure to physical or health hazards beyond those normal to the office environment, but not subject to training under 29 CFR 1910.120 or 1926.65 (Reference 2.3).

6.2.4 40-Hour or HAZWOPER Training shall cover all employees with duties on 29 CFR 1910.120- or 1926.65-regulated sites in other than the support zone and must complete initial and annual training commonly referred to as 40-hour or HAZWOPER. Persons who clearly meet criteria of 29 CFR 1910.20/1926.65 (e)(3)(ii) or (iii) may be approved by the SHSO responsible for the Site following provisions documented in the LEHR PHSP.

6.2.5 Hazardous Waste Supervisor Training shall cover all employees who supervise or manage (on-site or off-site) jobs regulated by 29 CFR 1910.120 or 1926.65 and must complete Hazardous Waste Supervisor Training.

6.2.6 Project Health and Safety Plan Training shall cover all employees who work at the LEHR project site to familiarize them with the content of the health and safety plan, hazards found at the site, protective clothing requirements, and emergency response actions.

6.2.7 Contingency Plan and General Emergency Response Training shall be given for all employees at the LEHR project site to familiarize them with the emergency response actions and contingency plans for handling emergencies at the site.

6.2.8 Hazardous Work Permit Training shall be given for all employees at the LEHR project site to familiarize them with the requirements of HSP 17.1 "Hazardous Work Permits," and the use of these permits at LEHR.

6.2.9 Respirator Training shall cover all employees at LEHR who are required to wear respiratory protection during the conduct of their work. This training shall be consistent with the requirements of the 29 CFR 1910.134.

6.2.10 Heavy Equipment and Forklift Training shall cover all employees who are required to operate heavy equipment and forklifts during the conduct of their work at LEHR as required in 29 CFR 1910 and 1926.

6.2.11 California Illness and Injury Prevention Program Training shall cover all subcontractors to their employees prior to initiating any work at the LEHR facility.

6.2.12 Health Hazard Training shall cover all employees whose work involves the potential for exposure to the specific materials listed below. With the exception of asbestos, this training shall be conducted or arranged by the RCM or designee in accordance with the listed OSHA regulation, LEHR procedure, and applicable State regulation. The training must be conducted prior to work with the below-listed materials, and annual refresher training is generally required by OSHA. The substance-specific regulation should be consulted to verify the correct application and currency:

| | |
|---|---|
| 1,2-dibromo-3-chloropropane (DBCP) | bis-Chloromethyl ether |
| 2-acetylaminofluorene | bloodborne pathogens* |
| 3,3'-dichlorobenzidine (and its salts) | coke oven emissions |
| 4-aminodiphenyl | cotton dust |
| 4-dimethylaminoazobenzene | Dioxin |
| 4-nitrobiphenyl | Ethyleneimine |
| Acrylonitrile | ethylene oxide |
| alpha-Naphtylamine | Formaldehyde |
| Arsenic | Lead |
| Benzene | methyl chloromethyl ether |
| Benzidine | N-nitrosodimethylamine |
| Beryllium | polychlorinated biphenyls |
| beta-Naphthylamine | vinyl chloride |
| beta-Propiolactone | |

* Includes other potentially infectious materials.

6.2.13 Competent Person Training shall cover those employees who supervise the entry of personnel into an excavation to enable them to recognize unsafe conditions in and around the excavation.

6.2.14 First-Aid or CPR Providers/Bloodborne Pathogen Training shall cover those employees who perform First-Aid or CPR. These employees must have a current certification card and must have completed Bloodborne Pathogen Training.

### *6.3 DOE 10 CFR 835 Training Requirements*

6.3.1 General Employee Radiation Training shall be given to all employees with unescorted access to radiological control areas of the site, excluding access to radiologically restricted areas. These employees may encounter radiological hazards as a result of their job description or work location, but who are not considered to be radiation workers.

6.3.2 Radiation Worker Training shall be given to all individuals that are unescorted and permitted access to radiological areas and unescorted assignment as a radiological worker.

6.3.3 ALARA Training shall be given to all employees whose work involves entry into radiologically posted areas. This training shall familiarize employees with techniques that can be used to reduce their dose to ALARA.

6.3.4 Embryo-Fetus Protection Training shall be given to all employees and include the risks of chemical and radiation exposure to the unborn. This training shall be given annually and may be included in GERT.

6.3.5 Escorts shall:

- Have completed radiation safety training, examinations, and performance demonstrations required for entry to the area and performance of the work
- Ensure that all escorted individuals comply with the documented radiation protection program
- Obtain direction from the RSO for specific escorting requirements prior to acting in that capacity

### *6.4 Site-Specific Training Requirements*

6.4.1 Quality Assurance Training shall be given to all employees and covers the requirements of the Site Quality Plan, Standard Operations Procedures, and Project Health and Safety Plan.

6.4.2 Other Training may be given on planning documents or other standard operating procedures, insofar as these procedures impact health, safety, and radiation protection.

## 7.0 RECORDS

The training records documenting satisfactorily completion of training for LEHR employees shall be maintained in the project files to demonstrate compliance with this procedure.

# 8.0 ATTACHMENTS

None.

A form referenced or attached to this procedure may be replaced with a substitute form, with the approval of the RCM or RSO, if the substitute form contains equivalent information as the referenced form.

# U.S. Department of Energy

Oakland Operations Office, Oakland, California

# FINAL
# AS LOW AS REASONABLY ACHIEVABLE PLAN

for the:

## LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH
## UNIVERSITY OF CALIFORNIA, DAVIS

*Submitted to:*
**Weiss Associates**
5801 Christie Avenue, Suite 600
Emeryville, California 94608

*Prepared by:*
**Environmental Management Services, Inc.**
3075 Citrus Circle, Ste. 175
Walnut Creek, California 94518

February 12, 2001
Rev. 4

DOE Oakland Operations Contract DE-AC03-96SF20686

Weiss Associates
Environmental Science, Engineering and Management

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Issued To: _____ Date: _____

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Approvals Page

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Figure 1-2. Site Location Map

Figure 5-1. Project Organization Chart

Figure 5-2. LEHR Radiological Control Organization Chart

# TABLE

Table 6-1. LEHR Administrative Control Levels and Goals

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ALARA | As Low As Reasonably Achievable |
| CFR | Code of Federal Regulations |
| DOE | U.S. Department of Energy |
| DOE-OAK | U.S. Department of Energy Oakland Operation Office |
| EPA | U.S. Environmental Protection Agency |
| FFA | Federal Facility Agreement |
| LEHR | Laboratory for Energy-Related Health Research |
| mrem/yr | millirem per year |
| RCM | Radiological Control Manager |
| ROD | Record of Decision |
| RPP | Radiological Protection Program |
| RSO | Radiological Safety Officer |
| WA | Weiss Associates |

# RECORD OF REVISIONS

| Revision Number | Description | Date |
|---|---|---|
| 1 | Final As Low as Reasonably Achievable Program, Rev. 0 | July 11, 1997 |
| 2 | Final As Low as Reasonably Achievable Program, Rev. 1 | N/A |
| 3 | Final As Low as Reasonably Achievable Program, Rev. 2 | June 27, 1997 |
| 4 | Final As Low as Reasonably Achievable Program, Rev. 3 | July 20, 1999 |
| 5 | Final As Low as Reasonably Achievable Program, Rev. 4 | February 12, 2001 |

# 1. INTRODUCTION

## 1.1 Objectives

This document describes the Laboratory for Energy-Related Health Research (LEHR or the Site) As Low As Reasonably Achievable (ALARA) Plan for U.S. Department of Energy (DOE) operations and activities at LEHR that have the potential to cause radiation exposures to workers, the public, and the environment. This policy/Plan document addresses potential radiological impacts of environmental restoration and waste management activities which are the sole extent of the DOE activities at the Site.

ALARA is the approach to radiation protection to manage, control, and minimize exposures (both individual and collective) to the work force and to the general public to ALARA, taking into account social, technical, economic, practical, and public policy considerations. It is not a dose limit, but a process which has the objective of reducing dose as far below the applicable dose limits of 10 CFR 835 as is reasonably achievable. The ALARA Plan is an integral part of the LEHR Radiological Protection Program (RPP) for minimizing or eliminating occupational doses, public doses, and releases of radioactivity to the environment.

### *1.1.1 Document Preparation*

This document was prepared by Environmental Management Services, Inc. for Weiss Associates (WA) at the request of the U.S. Department of Energy Oakland Operation Office under contract number DE-AC03-96SF20686.

### *1.1.2 Document Revision*

This document is a revision (Revision 4) to an earlier ALARA Plan document entitled "Laboratory for Energy-Related Health Research ALARA Policy for Radiation Protection of Workers, the Public and the Environment," Revision 3, 1999.

## 1.2 Site Background

LEHR was established in 1958 at the University of California at Davis, California (UC Davis) as a research laboratory. The DOE-funded research at LEHR focused on the health effects from chronic exposures to radionuclides, primarily Strontium-90 (Sr-90) and Radium-226 (Ra-226)

using primarily beagles to simulate radiation effects on humans. In a separate, but related project, research animals were exposed to gamma radiation to advance our knowledge of the effect of this type of radiation on development of cancers such as leukemia. DOE-funded research involving the use of small amounts of Plutonium-241 (Pu-241), Thorium-228 (Th-228), and other radioisotopes was also conducted at LEHR by University-employed scientists.

In 1988, pursuant to a Memorandum of Agreement between DOE and UC Davis, DOE's Office of Energy Research decided to close out the research program, remediate the site as required, and turn the facility and site over to UC Davis for unrestricted use. Site restoration activities, including decontamination and decommissioning of laboratory buildings, started in 1990. In 1994, DOE initiated a waste management program for the management of DOE legacy waste at the site. This program includes the management of various types of research materials and waste generated by researchers.

Also in 1994, as a result of ground water contamination detected during a preliminary investigation and the potential threat of contamination to public health and the environment, the U.S. Environmental Protection Agency (EPA) placed the LEHR site on the National Priority List (NPL).

Currently, DOE, EPA and the State of California are negotiating a Federal Facility Agreement (FFA) for site restoration. This FFA is expected to cover the performance of a CERCLA Remedial Investigation/Feasibility Study and possibly the completion of Record of Decision (ROD) for selected (DOE areas) operable units. Specific interim or removal actions may be implemented before the ROD.

## 1.3 Site Description

The 15-acre LEHR site is located about one and one-half miles south of the UC Davis Campus (Figure 1-1). The land is owned by the Regents of the University of California and leased to the DOE. All structures at the LEHR site are currently owned by the DOE. On-site facilities consist of 16 buildings, including two former animal hospitals, waste storage facilities, laboratory and support buildings, two sets of former dog pens, underground septic and domestic concrete tanks and numerous radioactive sources (Figure 1-2). Three inactive landfill units (operated by UC Davis from the 1940's until the mid 1960's) cover about six acres of the LEHR site.

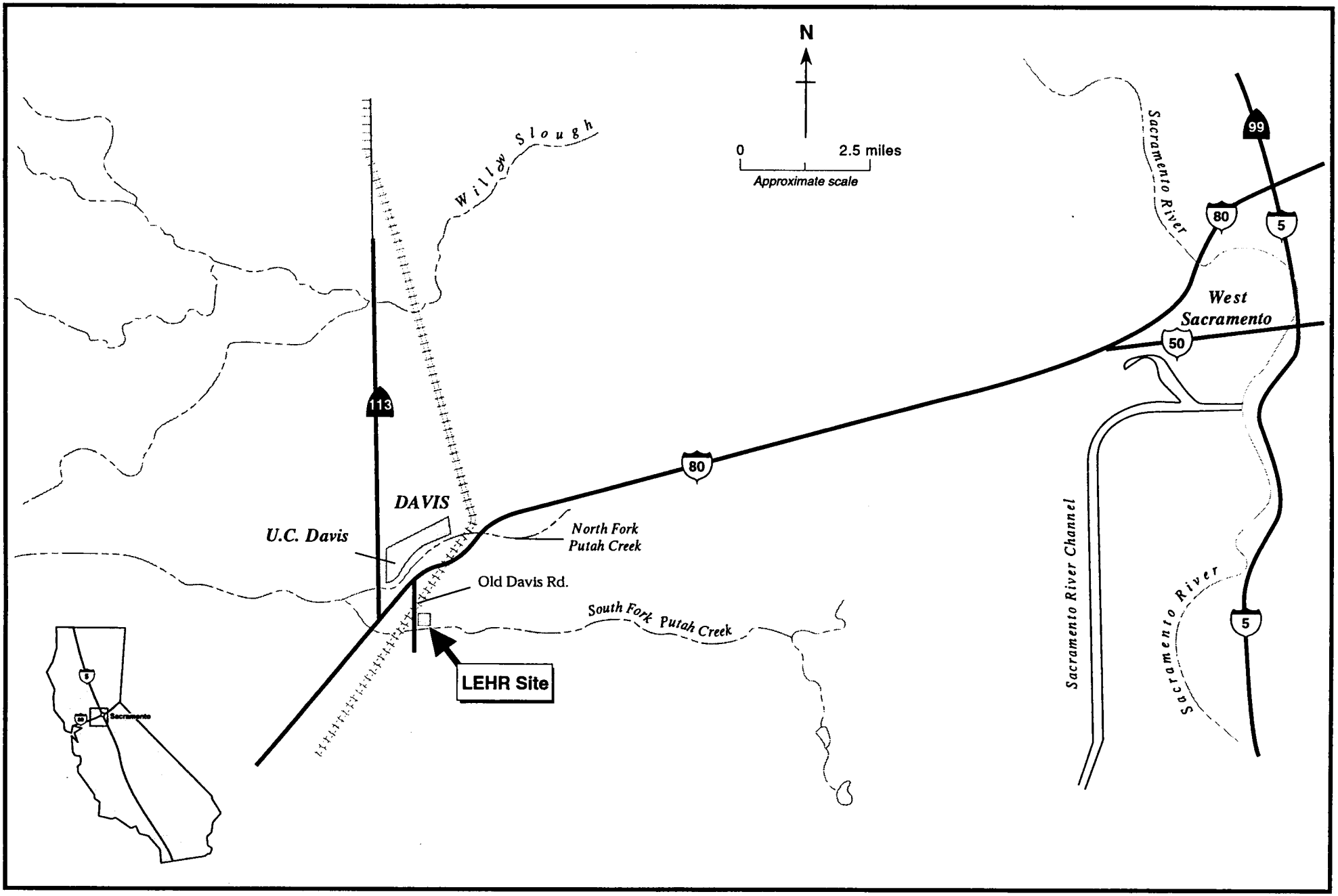


Figure 1-1. Location Map - LEHR Site, Davis, California

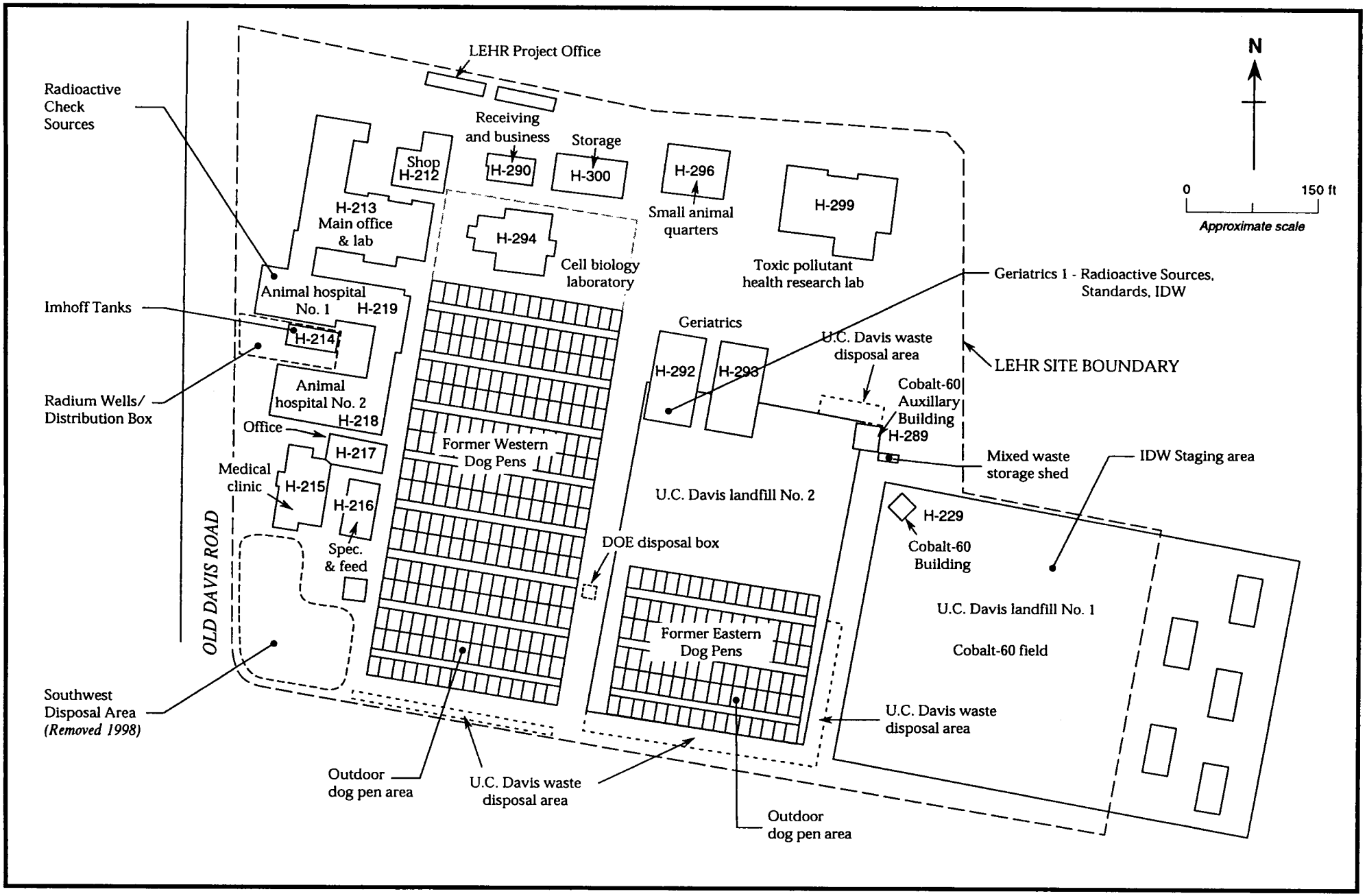


Figure 1-2. Site Location Map

4004-052.ai

# 2. SCOPE OF ACTIVITIES

The scope of DOE activities at the LEHR site includes investigation and assessment of soil contamination, remedial and/or removal actions, management of hazardous and radioactive waste, and verification sampling to ensure that remediation objectives are met.

# 3. ALARA POLICY AND MANAGEMENT COMMITMENTS

## 3.1 DOE ALARA Policy

The importance of the ALARA concept was stressed in DOE Policy P 441.1, DOE Radiological Health and Safety Policy (DOE, 1996), which states:

*It is the policy of the Department of Energy to conduct its radiological operations in a manner that ensures the health and safety of all its employees, contractors, and the general public. In achieving this objective, the Department shall ensure that radiation exposures to its workers and the public and releases of radioactivity to the environment are maintained below regulatory limits and deliberate efforts are taken to further reduce exposures and releases as low as reasonably achievable. The Department is fully committed to implementing a radiological control program of the highest quality that consistently reflects this policy.*

## 3.2 LEHR ALARA Policy

It is the policy of the LEHR Environmental Restoration/Waste Management Program to conduct the site activities in a manner to protect the health and safety of site workers and the public, and ensure compliance with applicable federal, state, and local laws and regulations concerning radiation protection of workers, the public, and the environment. The management team of WA (the LEHR prime contractor) and subcontractors are committed, in all its activities, to reduce any safety or health risks associated with radioactive materials ionizing radiation and exposures to the work force, general public, and the environment to levels that are ALARA taking into account social, technical, economic, practical, and public policy considerations.

The LEHR ALARA Plan is the formal Plan which management has the responsibility of implementing and maintaining to ensure that exposures to workers and the public are consistent with this policy.

## 3.3 Management Commitment

Management support and commitment to reducing individual and collective exposures and controlling radioactive contamination to further reduce external and internal exposures is critical to the success of the LEHR ALARA Plan. This commitment, which is an important part the Project Health and Safety Plan (WA, 2000a) and the LEHR 10 CFR 835 Radiological Protection Program (WA, 1999), is demonstrated by management's allocation of sufficient resources to ALARA Plan

activities (e.g., providing personnel, training, and material to ensure the implementation of the ALARA Plan).

# 4. REGULATORY AND PLAN REQUIREMENTS

Separate requirements relating to the ALARA Plan can be found for: 1) occupational radiation workers; and, 2) the public and environment. Current requirements for maintaining occupational radiation worker doses ALARA are found in the 10 CFR 835 Radiation Protection Regulations for Occupational Radiation Protection (DOE, 1998). Current regulations for maintaining public doses and environmental releases ALARA are found in DOE 5400.5 (DOE, 1990).

## 4.1 Occupational Workers

### *4.1.1 Radiological Protection Program*

The LEHR RPP references this ALARA Plan to meet the 10 CFR 835 requirements for ALARA. The following elements which have been met by this Plan constitute an acceptable occupational ALARA Plan which amplifies the regulatory requirements in 10 CFR 835:

| Required Elements of ALARA Plan | ALARA Plan Section that meets the requirements |
|---|---|
| Management Commitment | 3.0 |
| Assignment of Responsibility | 5.0 |
| Administrative Control Levels | 6.0 |
| Radiological Performance Goals | 6.0 |
| ALARA Training | 7.0 |
| Programs & Procedures | 10.0 |
| Internal Audits/Assessments | 8.0 |
| Optimization Methodology | 9.0 |
| Radiological Design Review | 10.0* |
| Radiological Work/Experiment Programming | 10.0 |
| Records | 11.0 |

**Note:**
*LEHR's Scope of Activities and Mission are such that there is limited design for radiological facilities. However, if circumstances warrant design, then work Plans will be developed that integrate ALARA into development & review of the designs.

10 CFR 835 stipulates that failure to implement one or more of the listed criteria would indicate an unacceptable ALARA Plan and could constitute a violation of 10 CFR 835.

## 4.2 Public and the Environment

### *4.2.1 DOE 5400.5*

As required by DOE 5400.5 potential exposures to members of the public should be as far below the regulatory limits as is reasonably achievable. To accomplish this objective, Field Operations Offices shall develop an ALARA Plan and shall require contractors to implement the ALARA process for all DOE activities and facilities that cause public dose. A quantitative cost-benefit analysis (optimization) generally is not needed. Therefore, except for meeting requirements of the National Environmental Policy Act, qualitative analyses are acceptable for ALARA judgments, particularly when the potential doses are well below the dose limit. The bases for such judgments should be documented. More detailed analyses should be considered if the decisions might result in doses that approach the limit.

# 5. LEHR PROJECT ORGANIZATION

Weiss Associates is managing the DOE environmental restoration and waste management program of the LEHR site for the DOE Oakland Operations Office (DOE-OAK). The overall Project organizational chart is shown in Figure 5-1, and the LEHR Radiological Control organization is shown in Figure 5-2. Due to the limited radiological activities conducted at the LEHR site, the ALARA Committee has been combined with the Radiological Control Committee. The WA Program Manager is responsible for ensuring that the authority, commitment, support, and resources are provided to implement the ALARA Plan. The WA Program Manager is responsible to the DOE-OAK Program Manager for implementing the ALARA Plan by achieving the assigned ALARA goals, and for providing technical support and assistance to task leaders with the tools and resources needed to implement and document the radiological design and operational control elements of the ALARA Plan.

The Radiological Control Manager (RCM) is responsible for interfacing with managers, project task leaders, and other support groups to ensure that the ALARA Plan is implemented and that the assigned ALARA goals are achieved. Additionally, this individual will assist in developing and reviewing pertinent procedures and will guide management and first line supervisors on administering the plan and achieving their ALARA goals. The RCM is also responsible for developing, maintaining, and providing training courses and mock-up facilities, if needed, to ensure that the facility staff are familiar with the ALARA plan and are aware of their respective responsibilities.

The Radiological Safety Officer (RSO) is responsible for field implementation of the LEHR RPP during all field activities. The RSO duties include: notify the RCM if any radiological work is not conducted in a manner consistent with the LEHR RPP or ALARA Plan; provide consultation to the project team during task planning in order that the ALARA Plan will be considered during all planning evolutions; and, participate in the radiological committee meetings.

Radiological Control Technicians and their supervisors have the responsibility and authority to stop work or mitigate the effect of an activity if they suspect that the initiation or continued performance of a job or test will result in the violation of radiological control standards, result in imminent danger or unacceptable risk, or cause the exposure and the spread of radioactive materials to levels that are not ALARA.

The Radiation Workers are responsible for reducing their exposure and the spread of radioactive materials and maintaining their exposure to levels that are ALARA by following all radiological safety requirements, reporting any radiological problems to their supervisors, and to the extent practicable, following established good work practices.

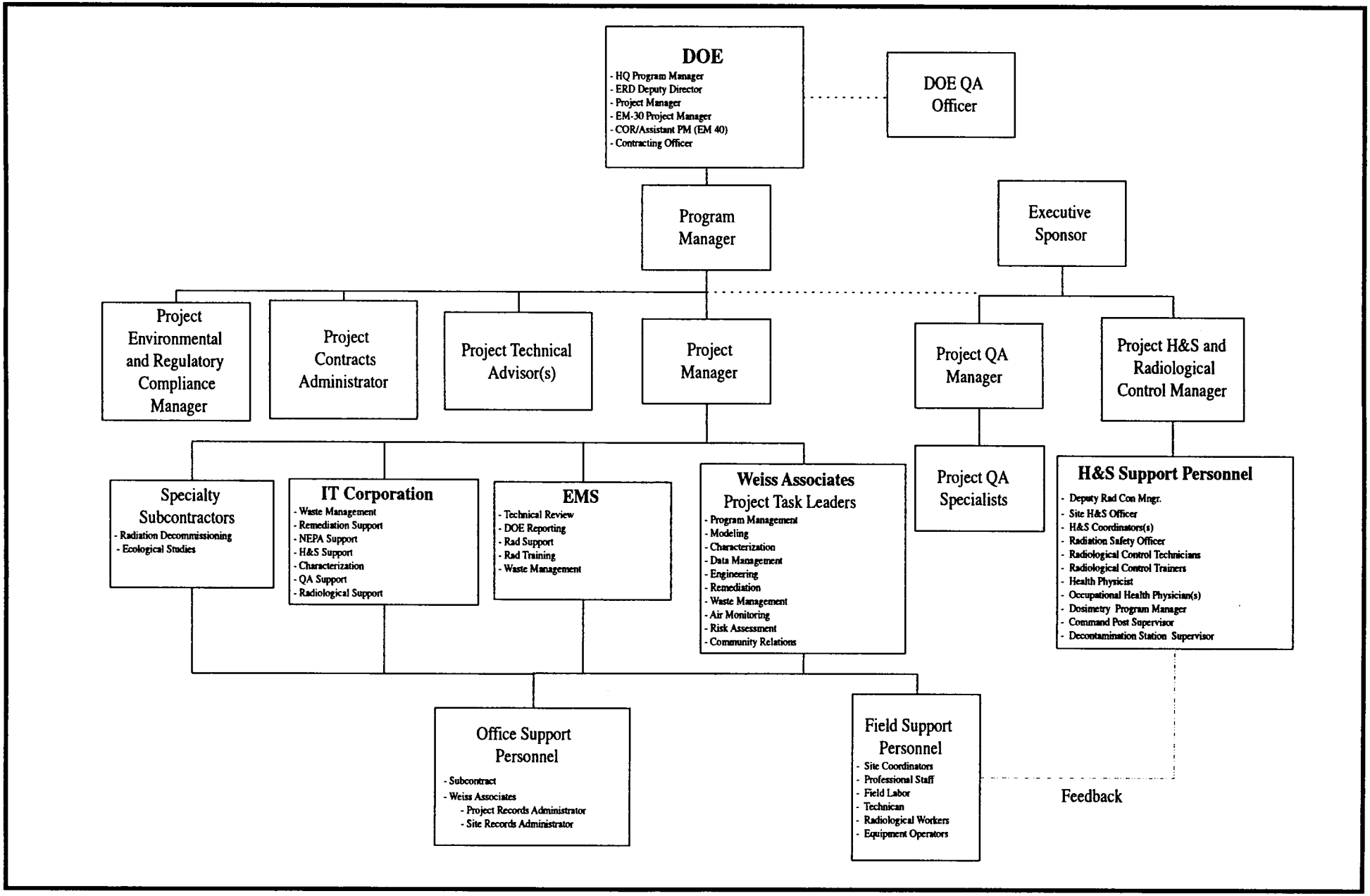


Figure 5-1. LEHR Project Organizational Chart

*Weiss Associates*

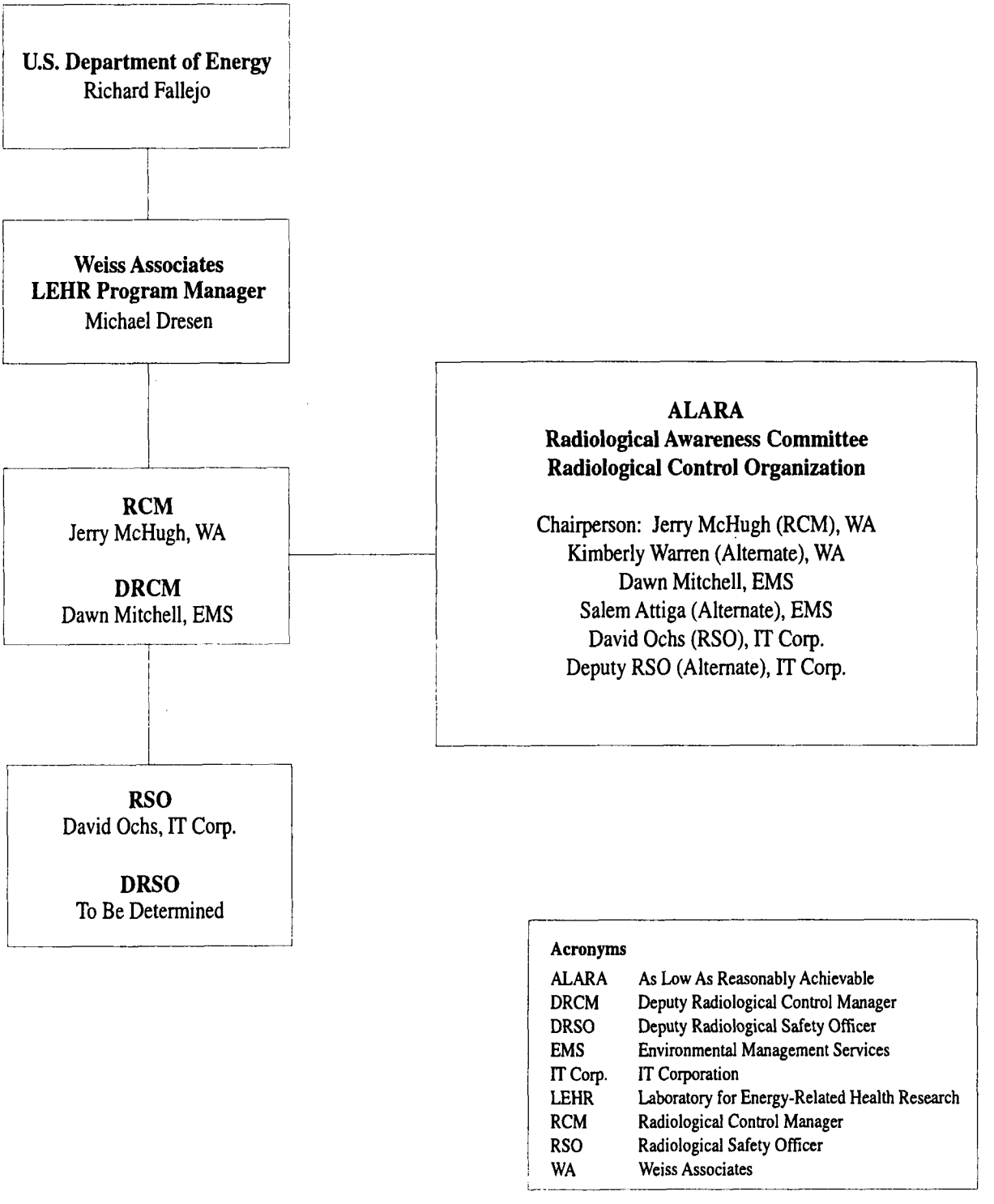


Figure 5-2. LEHR Radiological Control Organizational Chart

# 6. ADMINISTRATIVE CONTROL LEVELS AND GOALS

## 6.1 Administrative Control Levels

The LEHR Administrative Control Levels and ALARA Goals are indicated in Table 6-1. The levels indicated in Table 6-1 are only applicable when external and/or internal monitoring is being performed; otherwise, the dose is expected to be below 100 mrem/yr. These values are based on evaluation of historical and projected radiation exposures, work load, and mission. They are more restrictive than the DOE Administrative Control Level for Radiological workers of 2,000 mrem/yr. The LEHR ALARA Plan must ensure that work is conducted so that staff members' radiation doses are maintained ALARA and within or below the framework of the Administrative Control Levels.

Table 6-1. LEHR Administrative Control Levels and Goals

| Type of Exposure | Annual Limit (rem) | Administrative Control Level (rem) | ALARA Goals (rem) |
|---|---|---|---|
| Radiological Worker: Whole Body (internal + external) | 5 | 0.5 | 0.4 |
| Radiological Worker: Lens of Eye | 15 | 5 | 1 |
| Radiological Worker: Extremity (hands and arms below the elbow; feet and legs below the knees) | 50 | 15 | 10 |
| Radiological Worker: Any organ or tissue (other than lens of eye) and skin | 50 | 15 | 10 |
| Declared Pregnant Worker: Embryo/Fetus (per gestation period) | 0.5 | 0.4 | 0.2 |
| Visitors | 0.1 | 0.08 | 0.05 |

## 6.2 Setting and Evaluating Goals

The ALARA Committee will establish ALARA goals for LEHR environmental restoration activities. ALARA goals should be either quantitative or qualitative and be measurable, realistic, and have one or more clearly defined end points. Typical quantitative goals may include increasing the frequency of prejob briefings or reducing the number of hours workers spend in respiratory protection. Typical qualitative goals may include revising radiation work procedures or training procedures. Once goals are established, management will provide the manpower and financial

support necessary to ensure that the goals are obtained. The ALARA Committee should establish an appropriate frequency for evaluating the progress toward meeting goals.

# 7. TRAINING

ALARA training and retraining shall be documented, and conducted at a sufficient frequency (retraining shall be required every 2 years per 10 CFR 835.902) to ensure each contractor, subcontractor and individual involved in the site restoration and waste management activities is implementing the ALARA plan. The objectives and content of the training courses or modules shall be specific to the individual's job assignments, e.g., training for general employees, radiation workers, radiation protection technicians, engineers and programmers, managers and task leaders. The focus of these training programs shall be to heighten individual awareness of ALARA principle, principle of ALARA, basic ALARA techniques, dose and contamination reduction techniques, and to inform individuals of their responsibilities for implementing the program. Training shall, at a minimum, comply with the requirements set forth in the LEHR RPP.

# 8. AUDITS AND ASSESSMENTS

Periodic internal audits of the overall ALARA Plan will be performed, with audit results reported to LEHR's RCM (10 CFR 835.102). Decisions regarding corrective actions would be promptly rendered and followed by timely implementation. The LEHR RCM will be responsible for ensuring periodic internal audit(s) of the overall ALARA plan for the LEHR environmental restoration activities are conducted. Such audit(s) will be conducted on a schedule no less then every 36 months as required in the LEHR RPP. Audit findings will be tracked by management, and corrective actions will be implemented in a timely manner.

# 9. OPTIMIZATION METHODOLOGY

The 10 CFR 835 and LEHR RPP indicate that optimization techniques including cost-benefit analysis will be part of the ALARA Plan. Optimization of radiation protection is a process used to evaluate the optimal level of radiation protection that can be identified, effectively achieved, and measured. For major restoration activity and/or when activities could result in a dose above 100 mrem/yr, some of the following steps may be employed, when appropriate, to optimize the specific radiation protection activities that are part of the activity:

- Identify possible options for performing a particular activity.
- For each option, determine both the individual and collective dose equivalents that will result.
- For each variable option, identify all associated costs and determine the net cost for each option by summing the identified costs.
- Determine the cost-equivalent of the dose resulting from each option.
- Sum the costs from physical items and dose to determine the total net cost for each option.
- The option with the lowest total net cost and acceptable dose is the optimal option.
- Sensitivity analysis should be performed to determine how the solution depends on the assumptions that are required to perform the optimization analysis.

# 10. PLANNING AND OPERATIONS

Work Plans and procedures for conduct of environmental restoration/waste management activities will be prepared and include reference to ALARA considerations for minimizing doses to workers and the public. ALARA considerations include engineering controls (e.g., shielding), administrative controls (e.g., hazardous work permits), scheduling of work, briefing and debriefing of workers, and documenting and analyzing past work experiences. Such Plans or procedures will be approved, issued, and updated by LEHR management as needed. LEHR management will ensure that Plans or procedures are implemented so that ALARA considerations are optimized.

# 11. RECORD CONTROL

The management of radiological records is essential to the ALARA Plan, since the applicable records are maintained for accuracy and historical purposes. The required storage, retention, and records that are generated by the ALARA Plan are the same as health and safety-related records and should be managed in compliance with the Project Health and Safety Plan (WA, 2000a), the Quality Assurance Project Program (WA, 2000b), and the RPP (WA, 1999).

The records will include copies of all documentation used to justify ALARA decisions in the programming, design, and the cleanup phases of the project. Documentation of the ALARA committee meetings will also be maintained.

# 12. REFERENCES

WA, 1999, Final Radiological Protection Program for the Laboratory for Energy-Related Health Research, University of California at Davis, California, Weiss Associates, Rev. 3, November.

WA, 2000a, Final Project Health and Safety Plan for Environmental Restoration/Waste Management, Rev. 3, LEHR, University of California at Davis, California, Weiss Associates, June.

WA, 2000b, Final Quality Assurance Project Plan for Environmental Waste Management, LEHR, University of California at Davis, California, Weiss Associates, Rev. 3, June.

U.S. Department of Energy (DOE), 1990, Radiation Protection of the Public and Environment, DOE Order 5400.5, issued February 8, 1990, as amended through Change 2, issued January 7, 1993, DOE, Washington, D.C.

U.S. Department of Energy (DOE), 1996, Radiological Health and Safety Policy, DOE Policy P 441.1, April 26, 1996.

U.S. Department of Energy (DOE), 1998, Occupational Radiation Protection, Final Rule (10 CFR 835): Federal Register Vol. 63, No. 213, November 4, 1998.