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DOE STANDARD
RADIOLOGICAL CONTROL

U.S. Department of Energy

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Foreword

The Department of Energy (DOE) has developed this Standard to assist line managers in meeting their responsibilities for implementing occupational radiological control programs.

DOE has established regulatory requirements for occupational radiation protection in Title 10 of the Code of Federal Regulations, Part 835 (10 CFR 835), *Occupational Radiation Protection*, amended 2011. Failure to comply with these requirements may lead to appropriate enforcement actions as authorized under the Price Anderson Amendments Act (PAAA). While this Standard does not establish requirements, it does restate, paraphrase, or cite many (but not all) of the requirements of 10 CFR 835 and related documents (e.g., occupational safety and health, hazardous materials transportation, and environmental protection standards). Because of the wide range of activities undertaken by DOE and the varying requirements affecting these activities, DOE does not believe that it would be practical or useful to identify and reproduce the entire range of health and safety requirements in this Standard and therefore has not done so. In all cases, DOE cautions the user to review any underlying regulatory and contractual requirements and the primary guidance documents in their original context to ensure that the site program is adequate to ensure continuing compliance with the applicable requirements.

To assist its operating entities in achieving and maintaining compliance with the requirements of 10 CFR 835, DOE has established its primary regulatory guidance in the DOE G 441.1-1C Guide, *Radiation Protection Programs Guide for use with Title 10, Code of Federal Regulations, Part 835, Occupational Radiation Protection*. The Guide is structured to assist radiation protection professionals in developing the documented radiation protection program required by 10 CFR 835.101 and the supporting site- and facility-specific policies, programs, and procedures that are necessary to ensure compliance with the related regulatory requirements. The Guide establishes a macroscopic view of the various elements of a comprehensive radiation protection program and discusses concepts that the cognizant professionals should consider in developing and implementing the site- and facility-specific programs.

This Standard complements DOE G 441.1-1C and serves as a secondary source of guidance for achieving compliance with 10 CFR 835. While there is significant overlap between DOE G 441.1-1C and this Standard, this Standard differs from the Guide in both intent and detail. In contrast to the macroscopic view adopted by the Guide, this Standard discusses specific measures that should be implemented by affected line managers, workers, and support staff to ensure proper fulfillment of their radiological control responsibilities. DOE expects that each site will identify the provisions of this Standard that support its efforts to implement an effective radiological control program and incorporate these provisions, as appropriate, into the site-specific radiological control manual, site procedures, training, or other administrative instruments that are used to guide employee activities. The specific administrative instruments used at DOE sites vary widely, as would be expected given the varying nature of DOE facilities and activities and their associated hazards.

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PART 1 Department of Energy (DOE) Radiological Control Standard

111 Radiological Health and Safety Principles

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

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

The Department of Energy is committed to having high-quality radiological control programs. This commitment is reflected in the following DOE Radiological Health and Safety Principles:

- **Establish and maintain a system of regulatory policy and guidance reflective of national and international radiation protection standards and recommendations.**
- **Ensure personnel responsible for performing radiological work activities are appropriately trained.**
- **Ensure the technical competence of personnel responsible for implementing and overseeing the radiological control program.**
- **Establish and maintain, at all levels, line management involvement and accountability for departmental radiological safety performance.**
- **Ensure radiological measurements, analyses, worker monitoring results and estimates of public exposures are accurate and appropriately made.**
- **Conduct radiological operations in a manner that controls the spread of radioactive materials and reduces exposure to the workforce and the general public and that utilizes a process that seeks exposure levels as low as reasonably achievable.**
- **Incorporate features that minimize dose, contamination, and waste into the design of new facilities and significant modifications to existing facilities in the earliest planning stages.**
- **Evaluate Radiological Safety performance, by evaluating incident reports; using environment, safety, and health performance measures; and assessing the conduct of radiological protection programs and operations.**

112 Standard Applicability and Control

DOE has established basic standards for occupational radiation protection in Federal regulation Title 10 Code of Federal Regulations Part 835, *Occupational Radiation Protection* (10 CFR 835). Section 835.101 of 10 CFR 835 requires affected DOE activities to be conducted in compliance with a documented radiation protection program (RPP) that addresses each requirement of that regulation. DOE G 441.1-1C provides guidance for developing and implementing an RPP sufficient to ensure compliance with 10 CFR 835. DOE G 441.1-1C is primarily directed toward radiological control organization professionals who are responsible for developing programs that will ensure regulatory compliance. The Guide therefore tends to provide flexibility for the use of professional judgment and is more technical and general in nature than this Standard. This Standard is also directed toward line management; it therefore discusses specific, detailed measures that should be implemented by line managers as they discharge their

radiological control responsibilities. However, because both DOE G 441.1-1C and this Standard discuss development and implementation of appropriate radiological controls, there are necessarily many overlaps. As a result, in the documented RPPs developed to ensure compliance with 10 CFR 835, most DOE facilities have committed to implementation of certain provisions of this Standard or its predecessor, the DOE Radiological Control Manual.

The radiological control program discussed in this Standard goes beyond the scope of, and includes more details than, the documented RPP required by 10 CFR 835. To ensure implementation of a comprehensive and coherent radiological control program that exceeds basic requirements and provides a substantial safety margin, DOE encourages its contractors to implement the provisions of this Standard to the extent appropriate to facility hazards and operations, consistent with DOE's Integrated Safety Management Program. Should any conflicts arise between the site-specific radiological control manual (based on this Standard, see Article 114), and the documented RPP, the requirements of the documented RPP should take precedence. Such conflicts should be expeditiously resolved.

The Standard is not a substitute for regulations; it is intended to be consistent with all relevant statutory and regulatory requirements and will be revised whenever necessary to ensure such consistency. Some of the Standard provisions, however, challenge the user to go well beyond minimum requirements.

113 Implementation

1. This Standard sets forth DOE's views on the proper course of action in the area of occupational radiological control within the scope of DOE-sponsored activities. The words "shall" and "should" have the meaning below when used in this Standard.

2. The word "shall" identifies those elements and requirements that DOE has considered and found to be mandatory due to their derivation from related regulatory requirements found in 10 CFR 835 or other regulations or DOE Orders. These requirements are indicated by a bracketed reference following the related Standard provision (e.g., [see 835.XXX]). For purposes of regulatory and contractual compliance, DOE encourages users of the Standard to refer to the source document to view the requirement in context and to determine the applicability of the requirement to the specific facility operations and hazards. Federal regulation 10 CFR 820, *Procedural Rules for DOE Nuclear Activities*, establishes requirements for obtaining exemptions from 10 CFR 835. Due to its primary focus on line management implementation strategies, the Standard does not address all of the requirements of 10 CFR 835.

3. The word "should" means DOE has evaluated the provision and found that it is a proven practice or remedy that supports compliance with the basic requirements found in applicable regulations or DOE Orders or their underlying basis documents for occupational radiation protection. The use of the word "should" recognizes that: 1) there may be site- or facility-specific attributes that warrant special treatment; 2) the safety benefit derived from implementation of the provision may not in all cases be commensurate with the associated detriments (e.g., financial cost, worker discomfort, schedule impacts); or 3) literal compliance with the provision may not achieve the desired level of radiological control performance. Although a contractor may decide to follow an alternative technique, approach, or method in lieu of the "should" provision, DOE encourages implementation of these provisions to ensure compliance with the underlying basic requirements.

4. The term "Article" is used to reference portions or sections of this document. For ease of communications, portions of this document should be referred to as Articles. For example, the appropriate reference to this Article is Article 113.4.

114 Site-Specific Manual

1. The contractor senior site executive should issue and endorse a site-specific radiological control manual that invokes the applicable provisions of this Standard. The site-specific radiological control manual does not require review or approval by DOE's Office of Environment, Health, Safety and Security. One approach in the development of site-specific radiological control manuals is to invoke the applicable provisions of this Standard as written with site specific additions, supplements, and clarifications clearly indicated, included in the appropriate chapters, and directly referenced to the corresponding article. The provisions of specific articles may be changed from "should" to "shall" on a site-specific basis as necessary to emphasize those measures that are deemed necessary for compliance or to ensure the desired level of safety. Additions and supplements to address unique situations or to provide more detailed or prescriptive direction may be included.

2. Management policies, requirements, expectations, and objectives for the site radiological control program should be clearly and unambiguously stated.

3. The site-specific manual should be kept current and entered into the contractor document control system.

4. If a site has multiple facilities, there should be one manual for the site and one radiological control organization. If a prime contractor manages several DOE sites, efforts should be made to have one corporate radiological control manual that applies to all of that prime contractor's DOE sites. For a site that has multiple prime contractors, a common manual, with facility-, contractor-, or building-specific guidance to accommodate unique considerations, should be issued and endorsed by each contractor's senior site executive. For prime contractors who manage several sites but who also operate sites with more than one prime contractor, the site manual should take precedence over the corporate radiological control manual.

5. Subcontractors are not expected to develop their own radiological control manuals; rather they should comply with the site-specific radiological control manual.

6. Where DOE employees are conducting the transport of nuclear devices or components, a program-specific radiological control manual should be issued and approved by the DOE Operations Office Manager, the Service Center Manager, the DOE Project Office Manager or the DOE Site Manager, as appropriate. Controlled copies of such manuals should be provided to the Secretarial Officer having primary responsibility for operations at the site.

115 Application of Provisions

1. It is not the intent of this Standard to create unnecessary new or separate organizations if those functions can be incorporated into existing ones. Existing organizational and committee charters should be revised to reflect the provisions and emphasis of this Standard. Similarly, titles such as "radiological control manager" and "radiological control technician" that are used in the Standard may locally be designated differently. Position descriptions and organizational charts should be revised to accurately reflect required radiological control responsibilities.

2. The degree of program formality and extent of the associated administrative process should be commensurate with the extent of existing and potential radiological hazards. For example, a site with an annual collective total effective dose of one person-rem or less, that works with small quantities of unsealed radioactive material, would not be expected to have a radiological control program as complex as one required at higher hazard sites. At lower hazard sites, some program elements may be satisfied by brief policy statements.

116 User Groups

DOE encourages its contractors to establish informal working associations or user groups that promote dialogue among the radiological control organizations from similar or comparable facilities. User Groups should include representation from various contractors.

117 The "As Low As Is Reasonably Achievable" Process

10 CFR 835 requires DOE activities to develop and implement plans and measures to maintain occupational radiation exposures as low as is reasonably achievable (ALARA) [see 10 CFR 835.101 and 835.1001]. As applied to occupational radiation exposure, the ALARA process does not require that exposures to radiological hazards be minimized without further consideration, but that such exposures be optimized, taking into account both the benefits arising out of the activity and the detriments arising from the resultant radiation exposures and the controls to be implemented.

An effective ALARA process includes effective consideration, planning, and implementation of both engineered controls and administrative controls to balance the risks of occupational radiation exposure against the benefits arising out of the authorized activity. While beyond the scope of this Technical Standard, an effective ALARA process also balances risks of exposures to the public and releases to the environment Lessons learned are documented, institutionalized, and considered in planning and executing subsequent activities to further the goals of the ALARA process and to optimize employee protection.

While most or all of the provisions of this Standard support the ALARA process, the provisions of Chapter 3 are specifically directed toward the planning and execution of work, physical design features and administrative controls, and efforts to implement work controls commensurate with the radiological hazards.

118 Integrated Safety Management

DOE requires its contractors to develop and implement an Integrated Safety Management (ISM) system that integrates safety (including radiological safety) into management and work practices at all levels. (See DOE Policy 450.4A *Integrated Safety Management Policy* and DOE Order 450.2, *Integrated Safety Management*, and associated guidance documents.). DOE intends for the provisions of this Standard to be consistent with, and to complement implementation of, ISM. This Standard supports ISM by providing a system of radiological controls that can be implemented on a site-wide basis and tailored to meet facility-and hazard-specific needs. This Standard also provides guidance for increasing worker involvement in identification and implementation of appropriate controls. Like the ALARA process, an effective integrated safety management system emphasizes the development and implementation of controls that are commensurate with the hazards associated with any specified activity.

1. Under ISM, both DOE and DOE-contractor line managers are charged with responsibility for integrating safety measures into all facets of work planning and execution. Line managers should use their site-specific radiological control manual as a guide to integrating radiological control measures into work planning and execution.

2. This Standard supports the ISM guiding principles as follows:

    - Line Management Responsibility - This Standard clearly indicates that line management is responsible for ensuring adequate implementation of the radiological control program.
    - Clear Roles and Responsibilities - This Standard establishes clear roles and responsibilities for DOE and contractor line management and for the radiological control organization.

- Competence Commensurate with Responsibilities - This Standard provides guidance for providing classroom and on-the-job training so that individuals may gain and maintain the appropriate competence.
- Identification of Safety Standards and Requirements - This Standard provides cross-references to other DOE, Federal Agency, scientific, and consensus standards that are important to developing and implementing an effective and comprehensive radiological control program.
- Hazard Controls Tailored to Work Being Performed - This Standard provides guidance for implementing a program that establishes radiological controls that are commensurate with the hazards and that provide flexibility for consideration of other hazards (e.g., industrial safety, industrial hygiene, environmental hazards).

The concepts of Balanced Priorities and Operations Authorization are outside the scope of this Standard.

3. Both the ISM and ALARA processes require hazard controls to be tailored to the work being performed. In addition to establishing basic radiological safety standards that must be observed, 10 CFR 835 establishes requirements that provide significant flexibility so that individual activities may implement compliance measures in a manner that is commensurate with specific hazards and work activities. This Standard provides guidance for implementing radiological controls that DOE has evaluated and found to meet the requirements of 10 CFR 835 and to be consistent with the specified conditions and activities. For example:

   - Chapter 3 of this Standard provides guidance for implementing access and egress controls for areas having specific radiological conditions and hazards.
   - Chapter 4 of this Standard provides guidance for implementing specific controls over radioactive materials.
   - Chapter 5 of this Standard provides guidance for performing radiological monitoring at specified frequencies consistent with known and likely radiological hazards.
   - Chapter 6 of this Standard provides guidance for providing training to ensure that individuals are able to discharge their responsibilities related to the radiological control program.

4. Radiation protection is only one area of safety and health covered by DOE's comprehensive system of safety management programs. Accordingly, when applying the radiological controls specified in the Standard to a planned DOE activity, familiarity and coordination with other safety programs existing on the DOE site is necessary to avoid duplicative or conflicting safety measures. Such programs and their primary associated directive or regulation include:

   - Worker safety and health (contractors) 10 CFR 851
   - Worker safety and health (Federal employees) DOE O 440.1B
   - Nuclear safety 10 CFR 830
   - Facility Safety DOE O 420.1C
   - Radiation protection of the public and the environment DOE O 458.1
   - Radioactive material transportation and packaging DOE O 460.1C
   - Radioactive waste management DOE O 435.1

PART 2 Superior Performance in Radiological Control

To achieve superior, consistent performance, qualified individuals need to follow approved procedures and practices, and management needs to actively monitor the workplace and assess ongoing activities. Such ongoing activities include, but are not limited to, operations, remediation, laboratory work, research and development, and cleanup. Constant review and informed interest by senior management are required to achieve a superior radiological control program. Management at all levels should emphasize the need for high standards for radiological control through direct communication, instruction, and inspection of the workplace. The DOE field office manager and the contractor senior site executive responsible for the site should have a basic knowledge of radiation, its effects, and radiological control requirements. The DOE field office manager and the contractor senior site executive should also be familiar with the current radiological control performance record. This chapter provides key principles that foster the attitude and commitment common to a successful, well-managed radiological control program.

121 Senior Management Commitment

1. Senior managers should establish high standards for radiological control performance and frequently communicate these standards and management expectations to the work force.

2. Senior managers should state in writing their firm commitment to a high-quality radiological control program. Management should demonstrate commitment and support, in part, by allocating sufficient resources, including personnel, and providing for training to ensure workers are always qualified for their assigned duties.

3. Managers should ensure that orientation, training, mentoring and critiques reinforce rules and guidelines for each worker to control radiation exposure and radiological conditions.

4. Managers should hold workers and their supervisors accountable for radiological control performance. Relevant knowledge and performance should be assessed as a specific part of each individual's performance evaluation. This assessment should not be limited to those who perform radiological work, since many other workers have an impact on the radiological control program.

5. Senior managers should solicit feedback from their radiological control professionals, line management, and workers on radiological control performance.

6. Senior managers should encourage initiatives to identify concerns at an early stage, to prevent radiological conditions from deteriorating, and to promote doing the right job correctly the first time.

7. Prevention of the spread of radioactive material is usually less costly than remediation. Management should implement cost effective modifications that improve radiological control performance.

8. The authority and responsibility to establish a comprehensive and effective radiological control training program should be assigned to line managers and their subordinates. Dedicated training organizations should provide training, in most cases, but the responsibility for quality and effectiveness rests with line management.

9. Senior managers should encourage minimizing the generation of radioactive waste and discharges to the environment, controlling contamination at its source, and minimizing radiation dose to workers and the public.

10. The manager is responsible for fixing or mitigating a radiological problem, regardless of whether it has been reported to a superior (contractor or DOE).

122 Worker Attitude

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

1. Each worker should understand that proper radiological control is an integral part of one's daily duties.

2. Training programs should support a positive attitude towards radiological control in the work force. Training instructors should be knowledgeable about the work environment and those aspects of radiological control that are important to developing a positive worker attitude and perspective.

3. Cooperation between the work force and the radiological control organization should be developed and fostered. The worker should not look upon radiological controls as hurdles or restrictions to be bypassed.

4. Radiological control organization personnel should be helpful in showing workers how to follow the rules. This spirit of cooperation should be developed without subverting the control functions of the radiological control technicians.

5. A situation in which radiological controls are left solely to the radiological control organization is unacceptable.

123 Worker Responsibilities

Trained individuals should recognize that their actions directly affect contamination control, personnel radiation exposure, and the overall radiological environment associated with their work. The following radiological controls should be included in training, as appropriate to the type of work conducted at the site. Management should consider displaying a poster that outlines basic worker responsibilities, such as those listed below, at appropriate access points and work areas.

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

OBEY

- Posted, written, and oral radiological control instructions and procedures, including instructions on radiological work permits.
- "Evacuate" and "stop work" orders from radiological control personnel promptly.

DO NOT

- Loiter in radiation areas.
- Smoke, eat, drink, or chew in a contamination area, high contamination area, or airborne radioactivity area. (Drinking may be allowed in a contamination area under certain circumstances.)

BE SURE TO

- Wear personnel monitoring devices where required by radiological work permits, signs, procedures, or by radiological control personnel. Report immediately the loss, damage, or unexpected exposure of personnel monitoring devices or off-scale readings of self-reading dosimeters to the radiological control organization.
- Keep track of your radiation dose and avoid exceeding radiological administrative control levels.
- Wear personal protective equipment and clothing properly whenever required by radiological work permits or postings.
- Minimize the spread of potential radioactive spills and promptly notify the appropriate personnel of all spills.
- Avoid contact of skin, clothing, and equipment with contaminated surfaces.
- Place contaminated tools, equipment, and solid waste items on disposable surfaces, such as plastic sheets, when not in use.
- Notify radiological control personnel of alarming or faulty radiological control equipment.
- Notify radiological control personnel of off-site occupational radiation exposures so that worker dosimetry records can be updated. Notify radiological control personnel of any medical use of radioactive material, which could interfere with personnel contamination controls.

PRIOR TO ENTERING AREA

- Assure that you are mentally alert and in physically sound condition.
- Limit the amount of non-contaminated material taken into contaminated areas to minimize radioactive waste and future decontamination.
- Have necessary materials and equipment on hand to complete your task, thereby minimizing time and exposure.
- Notify radiological control personnel of the presence of open wounds, sores or rashes before entering an area where contamination exists and exit immediately if a wound occurs while in such an area.

UPON LEAVING AREA

- Properly remove personal protective equipment and clothing to minimize the spread of contamination.
- Frisk or be frisked for contamination when entering an uncontaminated area after exiting contamination, high contamination, or airborne radioactivity areas and associated radiological buffer areas, and notify radiological control personnel when contamination is found.

124 Radiation and Risk Communications

Many people have concerns related to low radiation exposure and health impacts. Accordingly, managers and first line supervisors should employ the following training and counseling to correct misinformation and appropriately inform and assist workers in understanding radiation risks:

1. Appropriate training in accordance with Article 651 is helpful in dealing with workers who have anxiety about radiation.

2. Some individuals, such as those who have had internal depositions of radionuclides, may be concerned about future doses. Counseling with such individuals is the preferred way to consider relevant factors. In some cases, special control levels as described in Article 216 might be appropriate.

3. Some individuals who have just received internal depositions of radionuclides may have concerns about medical intervention to reduce their future radiation dose. Counseling with site and personal physicians, coupled with guidance from REAC/TS personnel when appropriate, is the preferred way for these individuals to consider relevant factors and determine when intervention is necessary.

125 Conduct of Radiological Operations

1. This Standard is consistent with the provisions of DOE O 422.1, *Conduct of Operations*. The concepts of all chapters of DOE O 422.1 are applicable to the conduct of radiological control activities.

2. Managers should ensure radiological safety is not compromised to achieve production, remediation, or research objectives.

3. Supervisors should enhance their effectiveness by being be technically knowledgeable, inquisitive and asking questions of the work force concerning radiological work details to verify worker comprehension.

4. Line managers should periodically monitor work areas to observe personnel at work in order to identify good radiological work practices, radiological control deficiencies and concerns. Frequent inspections and walk-throughs, including off-hours and weekends (where appropriate), reinforce management expectations to the work force.

5. Written procedures for performing radiological work should be clear and accurate. If during the use of procedures workers cannot responsibly follow a written requirement, the work should stop and guidance obtained.

6. Supervisors and managers should encourage the workers to identify radiological control deficiencies and concerns, and should take prompt appropriate action to address identified issues and prevent their recurrence. Training, indoctrination, and procedure review are useful in addressing these issues.

7. Managers and supervisors should establish working conditions that enhance radiological control. This includes temperature, humidity, and lighting as well as the more difficult considerations of accessibility. Work conditions should be considered in planning work.

8. Cleanliness and good housekeeping are essential to a robust radiological control program. Workers should routinely clean up after operations.

9. Subcontractors and subcontracted employees should be treated the same as facility staff in the area of radiological control matters, shall have comparable radiation safety training [see 835.901], and should meet the same requirements and expectations.

10. Conditions that could cause or promote the spread of contamination, such as a leaking roof or piping, should be identified and corrected on a priority basis.

126 Worker Awareness of Radiological Conditions

In performing assigned duties within radiological areas, workers should be familiar with the area radiological conditions, be aware of the possibility that unforeseen changes may occur, and believe indicators that radiological control limiting conditions have been exceeded. Although the conduct of radiological surveys is viewed as a traditional role of radiological control technicians, properly trained and qualified workers should perform supplemental radiological surveys in the course of work thus potentially reducing radiological exposure and improving contamination control.

Specific examples of surveys that workers may effectively perform and that result in exposure reductions include self-monitoring of dose rates during high radiation area entries and monitoring of tools and equipment for contamination as a qualitative check during work in contamination areas. The performance of legal record surveys, such as release surveys, should remain the responsibility of the radiological control organization.

127 Critiques

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

A formal critique process should be established to obtain pertinent facts following an unusual radiological situation or at the satisfactory conclusion of a new or unusual operation involving radiological controls. This process complements the Occurrence Reporting and Processing System (ORPS) of DOE O 232.2, *Occurrence Reporting and*

Processing of Operations Information. The process, as described in Article 351, is used to quickly establish facts in chronological order so that the underlying reasons or causes for the success or failure are well understood.

An informal critique process can be established for a less severe event.

128 Facility Modifications and Radiological Design Considerations

Radiological control performance is affected by human performance and engineered design features. This Standard primarily addresses the way individuals operate and use existing facilities and sites. General design criteria for new facilities and major modifications to existing facilities are provided in 10 CFR 835 and DOE O 420.1C, *Facility Safety*. Additional design criteria are provided in Chapter 3 and in DOE Guide 441.1-1C.

PART 3 Improving and Assessing Radiological Control Performance

131 Radiological Performance Goals

Managers and supervisors should establish goals to focus worker attention in specific areas. Following are goals that may be effective for reinforcing important elements of the radiological control program:

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

2. Skin and Personal Clothing Contamination Occurrences (number): Personnel contaminations may indicate a breakdown of controls intended to prevent the spread of contamination.

3. Intakes of Radioactive Material (number): Management should focus attention on any failure of the controls that results in unplanned intakes.

4. Contaminated Area within Buildings (square feet): Operating with a smaller contaminated area may result in less radioactive waste, fewer personnel contaminations, and improved productivity. The reduction of existing contaminated areas should be balanced by the recognition that this generates radioactive waste. Goals for both should be correlated.

5. Radioactive Waste (cubic feet): Minimizing the generation of radioactive waste reduces the environmental impact of DOE operations, helps reduce personnel exposure, and reduces costs associated with handling, packaging, and disposal. (These goals may not be applicable to decontaminations and decommissioning operations)

6. Liquid and Airborne Radioactivity Released (curies): Minimizing effluents reduces the environmental impact of DOE operations and reduces the costs associated with remediation.

132 Management of Radiological Control Goals and Performance Indicators

1. The contractor senior management should establish, approve, and maintain a radiological control goals and performance indicator program.

2. The radiological control goals should be measurable, achievable, auditable, and meaningful in promoting a sound radiological control program.

3. Radiological control goals should be reviewed at least annually and revised as appropriate.

133 Radiological Control Performance Reports

1. The radiological control manager or designee should provide a periodic summary report to the contractor senior management for sites that exceed an annual collective dose of one person-rem. This report should include feedback on the radiological control goals established in accordance with Article 131. Examples of performance indicators that provide a more detailed analysis of performance are identified in Table 1-1. The periodic report should provide current performance indicators, as well as tracking and trending for the prior twelve-month period.

2. The radiological control manager should provide appropriate performance indicator information to supervisors and managers often enough to allow reasonable management of radiological control performance. The frequency should be consistent with the nature of the workload and as well as in support of achieving the established goals.

3. To promote worker awareness of radiological control performance, supervisors should consider posting selected indicators related to their work group in the workplace.

Table 1-1: Suggested Radiological Control Performance Indicators

Exposure control a. Collective dose in person-rem b. Average worker dose in rem c. Maximum dose to a worker in rem d. Number of unplanned exposures resulting in doses greater than the facility administrative control level e. Number of dose assessments for lost or damaged dosimeters
Personnel contamination a. Number of skin and personal clothing contaminations (may be normalized to the number of entries) b. Number of contaminated wounds c. Number of facial contaminations
Control of internal exposure a. Number of unplanned intakes b. Number of airborne events c. Number of alarms on airborne radioactivity monitors (actual and false) d. Number of airborne radioactivity areas e. Area of airborne radioactivity areas in square feet f. Number of respirators used in a year
Control of contaminated areas in operational areas a. Number of contamination and high contamination areas b. Area of contamination areas in square feet c. Area of high contamination areas in square feet d. Number of spills requiring posting of an area e Number of contaminated items found outside of contaminated areas
Minimization of radioactive waste a. Volume and activity of radioactive waste in cubic feet and curies, respectively b. Number of cubic feet not subject to volume reduction by incineration, compaction, or other means
Control of radioactive discharges a. Activity of liquid radioactivity discharges in curies b. Activity of airborne radioactivity discharges in curies
Administrative Radiological Controls a. Number of RWP violations

134 Assessments

Assessment, as used in this Standard, refers to the process of providing independent feedback to senior line managers to indicate the adequacy of the radiological control program.

1. Inspections, audits, reviews, investigations, and self-assessments are part of the numerous checks and balances needed in a good radiological control program. Internal audits, preferably as management or independent assessments, of the radiation protection program shall be conducted such that over a 36-month period, all functional elements are assessed [see 835.102]. To the extent possible, functional element assessments should be distributed evenly over the 36 month period. The scope of these audits should include implementation of and compliance with radiological control program requirements, as well as adequacy of the technical basis supporting the program. Personnel performing the audits should have the necessary qualifications and experience to assess effectively program adequacy and compliance. To the extent possible, the audits should be conducted in an independent manner. If radiological control program personnel are used to perform the audits, they should be restricted from auditing program areas or procedures for which they have responsibility. In those instances where internal radiological control program personnel are used to conduct 10 CFR 835 triennial audits, DOE encourages the use of qualified personnel from outside the radiological control organization as auditors to supplement the radiological control program conducted audits and provide a clear measure of independence.

2. Identification of the functional elements of the program depends upon many site-specific factors. Based upon the contents of 10 CFR 835, the following functional elements should be considered for inclusion in the assessment program:

   - Personnel dosimetry and dose assessment
   - Portable and fixed instrumentation
   - Contamination control
   - Radiological monitoring (area and item monitoring)
   - ALARA program
   - Accident and emergency dose controls
   - Radioactive material control, including sealed radioactive source control and material release
   - Entry controls
   - Training
   - Posting and labeling
   - Records and reports
   - Radiological design and administrative controls

   The assessment program shall also include subcontracted services supporting the radiological control program [see 830.122].

3. Results of assessments should be incorporated into the ongoing process of improving radiological control performance.

4. Managers should encourage the positive view that identifying even minor deficiencies represents an opportunity for further improvement. The number of deficiencies does not in itself measure the overall quality of the radiological control program. A prioritization system to implement actions for resolving the deficiencies should be implemented.

5. In developing corrective action plans for assessment activities, managers should address root causes for the identified deficiencies or concerns, not just the specific symptoms identified by the reviewer.

6. Feedback on findings from assessments, root-cause analyses, status of corrective actions, and adherence to action plan schedules should periodically be provided to management.

135 Workplace Awareness

1. DOE encourages management initiatives to facilitate the expression of concerns on the part of the work force, to address such concerns, and to solve them to ensure the proper respect for and understanding of radiation.

2. Management should establish and support a radiological awareness reporting system. To enhance work force awareness, the program should encourage continuous evaluation and improvements, track resolution of concerns, provide feedback to employees, and post results and trends. This system may be integrated with similar reporting systems for non-radiological concerns.

136 Internal Exposures

Control and prevention of internal exposure, particularly from long-lived radionuclides in the workplace, present special challenges to a radiological control program that warrant particular attention. Factors requiring management attention include the following:

- Workers may be exposed to unanticipated levels of elevated airborne radioactivity. The time required to collect representative airborne radioactivity samples and to determine the airborne concentration of radionuclides may contribute to worker intakes of radioactivity.

- If controls fail, internal depositions of radionuclides can occur in a short period of time.

- The continued exposure of workers to airborne radioactivity over extended periods of time can create worker concerns.

- Doses from some radionuclides taken into the body are difficult to measure. Although some radionuclides, such as cesium and tritium, can be readily measured at levels that produce only a few millirem, some long-lived radionuclides, such as plutonium, may require years for reliable measurements of hundreds of millirem.

- Medical intervention, such as the administration of blocking and chelating agents, to mitigate internal deposition may generate worker concerns over possible health effects related to the medical procedure's associated risks.

- Sampling of body excretions and whole body or organ counting techniques may encourage worker perceptions of internal exposure significance.

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

- Use of respiratory protection devices imposes additional physical stresses upon participating workers.

- Overall optimization of total dose – sum of both external and internal.

The hierarchy of radiological controls for internal exposures is provided in Article 316.

137 Neutron Exposures

Neutron exposures have the following characteristics that require attention:

- The specific biological effects of neutrons vary with energy.
- Neutron dose is more difficult to measure than gamma dose.

138 ALARA Committee

The ALARA process of managing radiation exposures is a fundamental requirement of every radiological control program. An ALARA Committee provides a useful forum for reviewing radiological control plans and performance and focusing management resources on radiological control issues. The goal of the ALARA Committee should be to promote the optimization of personnel exposure to workers and the public, and to reduce radiological releases to the environment.

1. An ALARA Committee should be established. The membership should include managers and workers from the line, the technical support organization, and the radiological control organization. It is more effective if a line manager, such as Director of Operations, Research, or Maintenance serves as the Chair. This Committee may be part of a general safety or radiation safety committee whose functions include ALARA activities. It may be combined with other committees at smaller facilities.

2. The ALARA Committee should make recommendations to management to improve progress toward controlling radiation exposure and radioactive releases. The Committee should evaluate items such as construction and design of facilities and systems, planned major modifications or work activities, and experimental test plans for exposure, waste, and release controls. The Committee should also receive, as a minimum, the results of all radiological control program assessments, both internal and external, and should review the overall conduct of the radiological control program.

PART 4 Contractor Radiological Control Organization

141 Radiological Control Organization

1. A radiological control organization should be established to provide relevant support to line managers and workers. To function effectively, the radiological control organization should be independent of the line organizational element responsible for production, operation, or research activities and should have an equivalent reporting level. A single, dedicated radiological control organization for the site is sufficient. At larger DOE sites where facilities, buildings, or work areas are dispersed, an approach that provides site-wide consistency and individual facility radiological control support is recommended. The senior line manager responsible for operations at a facility should have assigned radiological control personnel dedicated to the facility. Consistency of radiological control is critical. It is not the intent of this Standard to duplicate organizations but to use personnel in an effective manner in workplace situations.

2. Radiological control personnel should monitor adherence to 10 CFR 835 requirements and to the site-specific radiological control manual and be available to the facility line manager for radiological support to the work force. To function effectively in this capacity, they should receive their day-to-day priorities from facility managers. To ensure independence in making correct radiological control decisions, the radiological control organization should be accountable to the radiological control manager.

3. The radiological control manager heads the radiological control organization and is responsible for and should establish a high quality radiological control program.

4. The radiological control manager should have access to the contractor senior management for radiological control matters.

142 Radiological Control Manager Qualifications

1. The radiological control manager should be an experienced radiological control professional and be familiar with the design features and operations of the facility that affect radiological hazards.

2. The radiological control manager should have the technical competence and experience to establish radiological control programs and the supervisory capability to direct the implementation and maintenance of radiological control programs.

3. The radiological control manager should have a minimum of a bachelor's degree or the equivalent in science or engineering, including some formal training in radiological control. Certification by the American Board of Health Physics provides equivalency to the above. The radiological control manager should have at least three years of professional experience in applied radiological control work. Advanced academic degrees can count as one year of experience where course work related to radiological control is involved. Radiological control manager qualifications should be consistent with the guidelines provided in DOE-STD-1107-97, *Knowledge, Skills, and Abilities for Key Radiation Protection Positions at DOE Facilities*.

4. If the most effective manager for this position does not satisfy the above qualifications, the assignment of a deputy with the requisite expertise and qualifications can satisfy the requirement until the manager obtains the necessary qualifications. The education, training, and skills requirements of 10 CFR 835.103 would apply to both individuals to the extent that their responsibilities address programs to ensure compliance with 10 CFR 835.

5. Management should provide persons assigned to or being considered for the radiological control manager position a structured program leading to certification by the American Board of Health Physics.

143 Radiological Control Organization Functions and Staffing

1. The senior staff of the radiological control organization should include health physicists and other professionals with bachelor degrees in science or engineering. A continuing training program should be established. DOE encourages pursuit of certification by the American Board of Health Physics for senior and professional staff members. Training and education provisions for these individuals are established in Article 654.

2. Radiological support personnel provide health physics and radiological engineering, dosimetry, bioassay, independent oversight, instrumentation, and calibration functions. Training and education provisions for these individuals are established in Article 654.

3. Appropriate standards for the education and training of radiological control organization senior staff and support personnel are provided in DOE-STD-1107-97, *Knowledge, Skills, and Abilities for Key Radiation Protection Positions at DOE Facilities.*

144 Relationship between Radiological Control Technicians and Workers

Radiological control technicians (RCTs) and their supervisors perform the functions of assisting and guiding workers in the radiological aspects of the job.

1. Radiological workers should have sufficient training to recognize questionable or deteriorating radiological conditions and seek advice from radiological control technicians and their supervisors.

2. RCTs and their supervisors have the responsibility and authority to stop work or mitigate the effect of an activity in accordance with Article 345.

3. The actions or presence of radiological control personnel does not absolve the workers of their responsibility for properly conducting radiological control aspects of the job.

145 Marginal Radiological Control Performance

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

2. If the work force does not have the required level of sensitivity for radiological work practices, additional management attention is needed to assure the proper outcome. Line management should be held accountable for implementation of the radiological control program. Corrective actions that should be considered include:

    a. More direct line supervision in the workplace
    b. Curtailment of work schedules
    c. Deferral of work
    d. Addition of extra radiological control personnel
    e. Conduct of additional training.

3. When radiological control performance is less than adequate, line management should consider the above corrective actions.

PART 5 DOE Management

151 Program Office

1. Secretarial Officers are responsible for the establishment and maintenance of radiological control programs for activities under their cognizance, and are accountable for the quality and performance of radiological work conducted at their assigned sites.

2. Each Secretarial Officer should designate an individual to be the Program Office focal point on radiological control matters with the DOE Operations Offices and applicable Field Organization Managers, counterparts within DOE, and the contractor organizations. This individual is referred to in this Standard as the Radiological Control Program Advisor.

152 Operations Offices and Applicable Field Offices

1. Field Office Managers are responsible for the line management function of conducting day-to-day management of contractor activities, including monitoring the quality and performance of radiological work.

2. Field Office Managers should designate an individual with responsibility for the following functions:

    a. Providing radiological control program assessments,
    b. Interacting routinely with the Radiological Control Program Advisors of the affected DOE Program Offices,
    c. Assisting the DOE field line organization in the use of this Standard, and
    d. Interacting on a periodic basis with counterparts at other sites.

153 Department Policy

The Office of Environment, Health, Safety and Security (AU) is responsible for promulgating and maintaining the overall DOE policy and standards with respect to radiological health and safety. AU is also responsible for periodically revising the Standard to make corrections or improvements to the document. Other DOE elements should rely upon subject matter experts within AU for assistance on issues involving topics such as radiological health effects, health physics, dosimetry, instrumentation, training, and radiological controls.

154 Department Independent Radiological Control Performance Oversight

AU carries out its responsibility to provide independent radiological control performance oversight, on behalf of the Secretary of Energy, through various means, including the following:

1. Evaluating radiological control performance using 10 CFR 835 as its primary basis document. To the extent that a DOE activity's documented Radiation Protection Program establishes commitments to the use of specific guidance documents, such as the Guide for use with 10 CFR 835 (DOE G 441.1-1C), this Standard, or consensus standards, to achieve compliance, these documents should also be used as basis documents.

2. Assessing DOE Program, Operations, and applicable field organization performance of their line management responsibilities for implementing and maintaining radiological controls as detailed in the basis document(s).

155 Radiological Control Coordinating Committee (RCCC)

1. The RCCC, as a minimum, consists of the Radiological Control Program Advisors from the Offices of the National Nuclear Security Administration, Science, Environmental Management, Legacy Management and Nuclear Energy, and representatives from AU, and selected Operations Offices and Field Organizations.

2. The RCCC functions in a collective manner to promote a consistent and uniform emphasis in the direction and implementation of radiation protection programs at DOE sites. Communications with the RCCC should follow standard administrative and reporting channels. The RCCC is expected to receive and review suggestions, concerns, and comments from its individual members, Operations Offices, and contractors.

3. The RCCC should meet at least quarterly and more frequently during periods of transition (i.e., when developing or implementing significant new or revised complex-wide programs).

4. RCCC meetings should include representatives from Operations Offices and Field Organizations and recognized industry experts from outside DOE. The interaction with non-DOE professionals enhances the awareness of state-of-the-art technology and practices.

156 DOE Employees in the Workplace

DOE employees at a DOE site or facility are subject to and should adhere to the provisions of the contractor's site-specific radiological control manual.

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CHAPTER 2 RADIOLOGICAL STANDARDS

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PART 1 Administrative Control Levels and Dose Limits

To accomplish DOE's objective of maintaining individual doses well below regulatory limits, challenging numerical administrative control levels should be established below the regulatory limits to administratively control and help minimize individual and collective radiation dose. These control levels should be multi-tiered with increasing levels of authority required to approve higher administrative control levels.

Unless otherwise indicated, administrative, lifetime, and special control levels and dose limits are stated in terms of the total effective dose, which is the sum of the doses received from internal and external sources.

211 Administrative Control Level

1. Approval by the appropriate Secretarial Officer or designee should be required prior to allowing an individual to exceed 2,000 millirem in a year.

2. Facility management should establish an annual facility administrative control level based upon an evaluation of historical and projected radiation exposures, work load, and mission. This control level should be reevaluated annually. The choice of a low level for one year does not preclude choosing either a higher or lower level in a subsequent year. The facility administrative control level should be approved by the contractor senior site management.

3. When there is wide variation in the expected doses to the various work groups at a single facility, facility management should develop work group-specific administrative control levels to control worker doses below the regulatory limits.

4. No individual should be allowed to exceed the facility administrative control level without the prior written approval of the radiological control organization and cognizant facility management. Authorization by the contractor senior management is recommended.

212 Lifetime Control Level

1. Efforts should be made to control each individual's lifetime occupational dose below a lifetime control level of N rem where N is the age of the individual in years. Article 216 discusses special control levels for radiological workers who have doses exceeding N rem. This is applicable only to radiological workers because they are the only individuals expected to receive greater than 100 mrem in a year; see Article 721 for supporting information.

2. To ensure compliance with the lifetime control level, efforts should be made to determine the lifetime occupational dose of individuals expected to receive more than 1 rem in a year. The lifetime occupational dose is determined by summing all occupational internal and external doses received during the individual's lifetime.

3. The internal contribution to lifetime occupational dose from intakes prior to January 1, 1989, may be calculated in terms of either cumulative annual effective dose or committed effective dose equivalent. The committed effective dose equivalent should be used to the extent that adequate data are available to calculate doses in these terms.

213 Occupational Dose Limits

1. Occupational dose limits are provided in Table 2-1 and shall not be exceeded [see 835.202(a)(1)-(4)]. All occupational dose received during the current year, (including that received from accidents and non DOE employment), except the dose resulting from planned special exposures and emergency exposures shall be included when demonstrating compliance with Table 2-1 limits [see 835.202(b) & 702(d)]. If formal records of an individual's prior occupational dose during the year cannot be obtained, a written estimate signed by the individual may be accepted [see 835.702(d)]. Written estimates should not be used as a basis for authorizing planned special exposures or emergency exposures.

2. In the following exceptional situations, a radiological worker may be authorized to receive a dose in excess of the values of the limits specified in Table 2-1:

    a. Planned special exposures may be authorized for an individual to receive doses in addition to and accounted for separately from doses received under the Table 2-1 limits [see 10 CFR 835.204].
    b. Under emergency conditions, individuals may be authorized to receive doses that exceed the limits established in Table 2-1 [see 835.1301 & 1302]. The provisions of this Standard do not limit actions necessary to protect health and safety under these conditions [see 10 CFR 835.3(d)].

    DOE believes that: (1) there are few situations in which conducting a planned special exposure or emergency exposure constitutes a best management practice and (2) proper implementation of the provisions of this Standard will prevent the need for conducting these operations. Therefore, this Standard does not contain specific guidance for conducting these operations. Requirements for authorizing, conducting, recording, and reporting these operations are provided in 10 CFR 835. In addition, guidance for response to emergency exposures, is contained in DOE Emergency Management Guide, DOE G 151.1-4 *Response Elements*, Sections 7.4.3 and 7.4.4.

3. The occupational dose limits provided in Table 2-1 apply to all general employees. However, general employees who have not completed appropriate training and examinations are not permitted unescorted access to any radiological area [see 10 CFR 835.901(b)].

214 Member of the Public Dose Limit

Members of the public permitted access to the controlled area at DOE sites shall be limited to an annual radiation dose of 100 millirem from the sum of doses received from internal and external radiation sources [see 10 CFR 835.208].

215 Embryo/Fetus Dose Controls

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

1. The employer should provide the option of a mutually agreeable assignment of work tasks, without loss of pay or promotional opportunity, such that further occupational radiation exposure during the remainder of the gestation period is unlikely.

2. For a declared pregnant worker who chooses to continue work involving occupational exposure:

    a. The dose limit for the embryo/fetus from conception to birth (entire gestation period) as a result of the occupational exposure of the declared pregnant worker is 500 millirem [see 10 CFR 835.206(a)]. The dose to the embryo/fetus is equal to the sum of doses received from external doses, sources inside the mother, and sources inside the embryo/fetus. The dose limit to the fetus is the equivalent dose.
    b. Measures shall be taken to avoid substantial variation above the uniform exposure rate necessary to meet the 500 millirem limit for the gestation period [see 10 CFR 835.206(b)]. Efforts should be made to avoid exceeding 50 millirem per month to the declared pregnant worker.

3. If the dose to the embryo/fetus is determined to have already exceeded 500 millirem when a worker notifies her employer of her pregnancy, the worker shall not be assigned to tasks where additional occupational radiation exposure is likely during the remainder of the gestation period [see 10 CFR 835.206(c)].

Table 2-1: Summary of Occupational Dose Limits

TYPE OF EXPOSURE	LIMIT
General Employee: Whole Body (internal + external) (TED)	5 rem/year
General Employee: Lens of the Eye (external)	15 rem/year
General Employee: Skin and extremities (external dose to the skin or extremities + internal dose resulting in dose to the skin)	50 rem/year
General Employee: Any organ or tissue (other than lens of eye) (internal + external)	50 rem/year
Declared Pregnant Worker: Embryo/Fetus (internal + external)	0.5 rem/ gestation period
Minors: Whole Body (internal + external) (TED)	0.1 rem/year
Minors: Lens of the eye, skin, and extremities	10% of General Employee limits

Notes:

- The weighting factors in Appendix 2C shall be used in converting organ equivalent dose to effective dose for the whole body dose [see 835.203(b)].
- The annual limit of dose to "any organ or tissue" is based on the committed equivalent dose to that organ or tissue resulting from internally deposited radionuclides over a 50-year period after intake plus any equivalent dose to that organ from external exposures during the year[see 835.202(a)(2)].
- Exposures due to background radiation, as a patient undergoing therapeutic and diagnostic medical procedures, and participation as a subject in medical research programs shall not be included in either personnel radiation dose records or assessment of dose against the limits in this Table [see 835.202(c)].
- See Appendix 2D for provision on assessing and recording doses from non-uniform exposure of the skin.
- Whole body dose (total effective dose [TED]) = effective dose from external exposures + committed effective dose from internal exposures [see 835.2(b)].
- Lens of the eye equivalent dose = equivalent dose from external exposure determined at a tissue depth of 0.3 cm [see 835.2(b)].
- Equivalent dose to the skin = equivalent dose from external exposure determined at a tissue depth of 0.007 cm [see 835.2(b)].

216 Special Control Levels

Certain situations may require lower individual exposure control levels. In addition to considering recommendations from senior radiological control and medical officials, the contractor senior site executive should obtain advice from professionals in other disciplines such as human resources and legal in establishing special control levels. The contractor senior site executive may wish to establish these special control levels using a radiological health advisory group.

1. A special control level of 5000 millirem in a year for equivalent dose to the lens of the eye should be considered for radiological workers performing work in non-uniform radiation fields where the maximum exposure is to the worker's head. Of particular interest are non-uniform x ray and beta exposures to the head. When this special control level is implemented in conjunction with the 2000 millirem administrative control level, the equivalent dose to the lens of the eye will not exceed 5000 millirem in a year. (*Note that in April 2011, ICRP recommended lowering the limit on the equivalent dose to the lens of the eye (EqD-Eye) from 15 rem/year to 10 rem in 5 years with the dose in any single year limited to 5 rem. The ICRP based this recommendation on a review of information they interpreted as indicating that the threshold for radiation-induced effects in the lens of the eye was significantly lower than previously expected.)*

2. A special control level for annual occupational exposure should be offered to each radiological worker with a lifetime occupational dose exceeding N rem, where N is the age of the individual in years. The special control level should allow the individual's lifetime occupational dose to approach and, if practicable, fall below N rem during ensuing years as additional occupational dose is received.

3. An employer should be attentive to special circumstances of employees, such as those undergoing radiation therapy, and offer to establish special control levels, at the employee's discretion, as appropriate.

4. Special controls on an individual dose should not be implemented in a manner that interferes with that individual's right to work. If reasonable efforts to implement the special control level below 1 rem per year threaten to restrict the individual's right to work or are otherwise unsuccessful, the contractor senior site executive should authorize any doses in excess of the special control level, but not to exceed the regulatory dose limits.

PART 2 Contamination Control and Control Levels

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

221 Personnel Contamination Control

1. Article 338 provides personnel contamination monitoring requirements and guidance. This guidance is not relevant to individuals exiting areas containing only radionuclides, such as tritium, that cannot be detected using hand-held or automatic frisking equipment.

2. Monitoring for contamination should be performed using frisking equipment that can detect total contamination at or below the values specified in Table 2-2. DOE encourages the use of automatic monitoring units that meet the above requirements.

3. Individuals found with detectable contamination on their skin or personal clothing, other than noble gases, radon progeny, or natural background radioactivity, should be promptly decontaminated as described in Article 541.

222 Contamination Control Levels

1. A surface is considered contaminated if either the removable or total surface contamination is detected above the levels in Table 2-2. Controls shall be implemented for these surfaces commensurate with the nature of the contaminant and level of contamination [see 10 CFR 835.1102(b)]. Appropriate postings and controls are established in Chapters 2, 3, and 4 of this Standard.

2. Surfaces exceeding the values of Table 2-2 for total contamination may be covered with a fixative coating to prevent the spread of contamination. However, reasonable efforts should be made to decontaminate an area before a coating is applied. A fixative coating should not be applied without the approval of the radiological control manager or designee.

3. Appropriate controls for areas of fixed contamination are provided in Article 224.

4. For areas with contaminated soil that is not releasable in accordance with the requirements in DOE O 458.1, a soil contamination area should be considered that:

    a. Is posted as specified in Article 238.
    b. Meets the requirements of Article 231.1 through 231.8.

5. Soil contamination areas may be located outside a controlled area (including a radiological buffer area).

6. Radioactive material, equipment and real property, on a DOE site, that have been documented to meet the conditions for their release specified in a DOE authorized limit approved by a Secretarial Officer in consultation with the Chief Health, Safety and Security Officer, are not subject to the values in Table 2-2 [see §§835.1(b)(6) and 835.2(a)].

223 Airborne Radioactivity Control Levels

1. Use of engineered and administrative controls to reduce the potential for internal exposure should be evaluated before allowing individuals, with or without respiratory protection, to enter airborne radioactivity areas.

2. Posting requirements for airborne radioactivity areas are specified in Article 235. Values of Derived Air Concentrations are provided in 10 CFR 835.

224 Areas of Fixed Contamination

Due to reduced concerns regarding contamination spread, areas having only fixed contamination may not warrant the full range of entry controls established for areas having removable contamination levels exceeding the Table 2-2 values. Areas located outside of radiological areas having measured total contamination exceeding the total surface contamination values specified in Table 2-2 (removable contamination levels below Table 2-2 values) are subject to the following controls:

1. Periodic surveys shall be conducted to ensure the surface contamination remains fixed to the surface and removable surface contamination levels remain below Table 2-2 values [see 10 CFR 835.1102(c)(1)].

2. Markings indicating the status of the area shall be applied [see 10 CFR 835.1102(c)(2)]. These markings should be applied directly to the surface (or at the access points) to provide appropriate warning. These markings may also provide appropriate instructions to individuals entering the area or contacting the surface (i.e., "Fixed Contamination" or "Fixed Contamination, Notify Radiological Control Personnel Prior to Removing Paint"). Signs, stencils, or other appropriate markings may be used.

3. Markings and postings should be maintained in a legible condition.

4. Appropriate written procedures should be implemented to prevent unplanned or uncontrolled removal of the contamination. These procedures should address issues such as access controls and fixative coatings, if needed, survey techniques and frequency, area tracking and maintenance, and required markings.

5. If surveys indicate that contamination is likely to be transferred from the area, fixative coatings should be applied. When paint is used as a fixative coating, it should consist of two layers having contrasting colors, to provide indication of erosion of the top layer. Other fixative coatings, such as strippable coatings and applied plastics and foams, should be periodically evaluated for evidence of degradation. Removable contamination should be reduced to the minimum practicable level before application of fixative coatings.

6. Areas meeting these requirements are exempt from the posting requirements of Articles 232 - 238 and the entry and exit requirements of Chapter 3.

Table 2-2: Summary of Surface Contamination Values [see 835 Appendix D]

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	1,000[7]	5,000[7]
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 STCs [6]	10,000	See Footnote 6

Footnotes:

1. The values in this appendix, with the exception noted in footnote 6 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 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 cm2 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 cm2 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 including special tritium compounds (STCs) 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. In certain cases, a “Total” value of 10,000 dpm/100 cm2 may be applicable either to metals of the types from which insoluble special tritium compounds are formed, that have been exposed to tritium, or to bulk materials to which insoluble special tritium compound particles are fixed to a surface.
7. These limits apply only to the alpha emitters within the respective decay series.

PART 3 Posting

231 General Posting Provisions

1. Radiological postings are intended to alert individuals to the presence of radiation and radioactive materials and to aid them in controlling exposures and preventing the spread of contamination. Boundaries used for radiological control purposes are depicted in Figure 2-1.

2. Signs shall contain the standard radiation symbol (radiation warning trefoil) colored magenta or black on a yellow background [see 10 CFR 835.601(a)]. Lettering should be either magenta or black. Magenta is the preferred color. Standardized signs, as described in DOE's core training and the 10 CFR 835 Guide, should be used where practicable.

3. Signs shall be conspicuously posted at each access point [see 835.601, 603], clearly worded, and, where appropriate, may include radiological control instructions [see 835.601(b)]. Radiological postings should be displayed only to signify actual or potential radiological conditions. Signs used for training should be clearly marked, such as "For Training Purposes Only."

4. Posted areas should be as small as practicable for efficiency.

5. Postings should be maintained in a legible condition and updated based upon the results of the most recent surveys.

6. If more than one radiological condition (such as contamination and high radiation) exists in the same area, each condition shall be identified [see 835.603].

7. In areas of ongoing work activities, the dose rate and contamination level or range of each should be included on or in conjunction with each posting as applicable.

8. Postings at entrance points to areas of ongoing work activities controlled for radiological purposes should state basic entry requirements, such as dosimetry, radiological work permit (RWP) or other written authorization, and respiratory protection requirements.

9. Rope, tape, chain, and similar barriers used to designate the boundaries of posted areas should be distinctive (e.g., yellow and magenta or yellow and black in color).

10. Physical barriers should be placed so that they are clearly visible from all directions and at various elevations. They should not be easily walked over or under, except at identified access points. These barriers shall be set up such that they do not impede the intended use of emergency exits or evacuation routes [see 835.501(e), 502(d)].

11. Areas shall be clearly and conspicuously posted [see 835.601(b)]. Posting of doors should be such that the postings remain visible when doors are open or closed.

12. A radiological posting that signifies the presence of an intermittent radiological condition should include a statement specifying when the radiation is present, such as "CAUTION: RADIATION AREA WHEN RED LIGHT IS ON."

13. Accessible areas may be excepted from the radiological area posting requirements:

    a. During transient radiological conditions of less than 8 continuous hours duration when posting is not practical, such as radioactive material transfers. Under these conditions, the area shall be placed under the continuous observation and control of individuals who are knowledgeable of and empowered to implement required access and exposure control measures [see 835.604(a)]. These individuals should be stationed to provide line of sight surveillance and verbal warnings.
    b. When the area contains only packages of radioactive material received from transportation while awaiting survey in accordance with Articles 552 and 554 [see 835.604(c)].

    The exceptions discussed above apply only to radiological area and radioactive material area posting requirements and do not apply to the entry control requirements established in 10 CFR 835.501 and 835.502.

232 Posting Controlled Areas

Controlled areas are established and posted to warn individuals that they are entering areas controlled for radiation protection purposes. Individuals who enter only the controlled area without entering radiological areas or radioactive material areas are not expected to receive a total effective dose exceeding 100 millirem in a year.

1. Each access point to a controlled area shall be posted whenever radiological areas or radioactive material areas may be present in the area [see 835.602(a)].

2. The contractor may select the type of sign (colors and words) used to avoid conflict with local security requirements [see 835.602(b)]. This selection should be approved by the contractor senior site executive.

233 Posting Radiological Buffer Areas

Radiological buffer areas are intended to provide boundaries to minimize the spread of contamination and to limit doses to general employees who have not been trained as radiological workers.

1. A radiological buffer area should be established for contamination control adjacent to any entrance to or exit from a contamination, high contamination, or airborne radioactivity area. The size of the radiological buffer area should be commensurate with the potential for the spread of contamination. A radiological buffer area may also be established in areas such as Change Rooms, where low-level contamination may be present, but where radioactive material handling is not specifically authorized. Radiological buffer areas established for contamination control should be located within controlled areas.

2. A radiological buffer area should be established as needed for exposure control. The boundary for the radiological buffer area should be established to limit radiation doses (TED) to general employees to less than 100 millirem in a year or as needed to keep radiation doses to general employees ALARA.

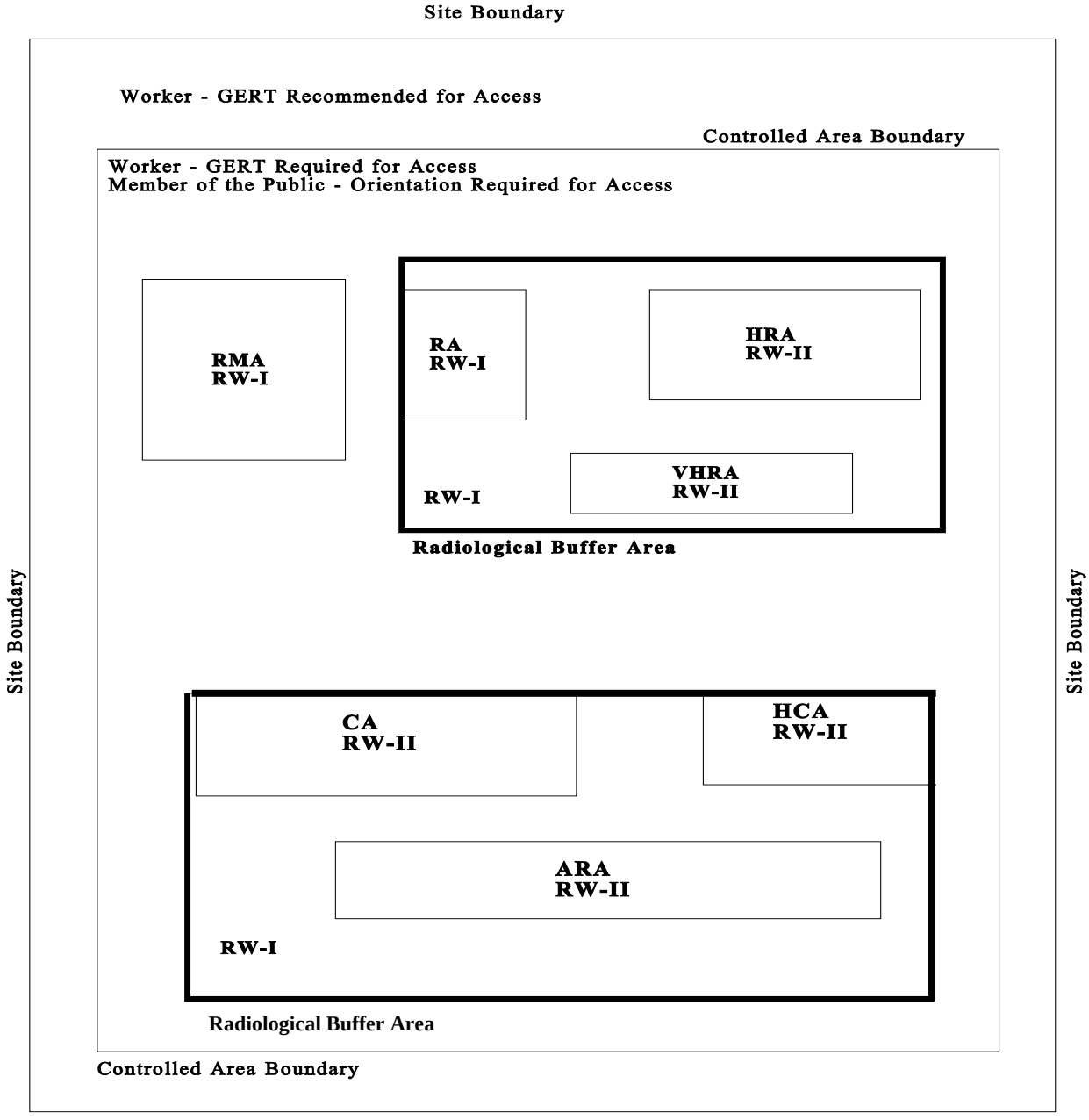
3. A radiological buffer area is not warranted for:

    a. High contamination or airborne radioactivity areas that are completely within contamination areas
    b. Inactive contamination, high contamination, or airborne radioactivity areas (i.e., areas to which entry has been prohibited by posting or barricades)
    c. Exposure control, if other posted boundaries or controls provide equivalent employee protection
    d. Exposure control, if general employees who are not trained as radiological workers are restricted from unescorted entry to controlled areas.
    e. Exposure control, if general employees who are not trained as radiological workers are unlikely to be present in the area long enough to receive 100 mrem in a year.

4. The need for radiological buffer areas around radioactive material areas, soil contamination areas, and underground radioactive material areas should be determined by the Radiological Control Organization (RCO) based upon the potential for exposure of unmonitored individuals and the spread of contamination.

5. Posting of radiological buffer areas should be in accordance with Article 231 and contain the wording "CAUTION, RADIOLOGICAL BUFFER AREA."

Figure 2-1
Establishing Posted Areas



GERT; General Employee Radiological Training
RW-I; Radiological Worker I Training
RW-II; Radiological Worker II Training
RMA; Radioactive Material Area
RA: Radiation Area
HRA; High Radiation Area
VHRA; Very High Radiation Area
CA; Contamination Area
HCA; High Contamination Area
ARA: Airborne Radioactivity Area

234 Posting Radiation Areas

1. Areas shall be posted to alert individuals to the presence of external radiation in accordance with Table 2-3 [see 835.601, 603]. In addition to the 'required posting' contractors may add supplemental information; examples of typical supplemental information are shown in Table 2-3. In addition, hot spots should be labeled as described below to provide warning of discrete radiation sources.

2. Radiation areas and high radiation areas shall be identified based on the dose rates at a distance of 30 centimeters either from the source or from any surface penetrated by the radiation [see 835.2(a), radiation area and high radiation area]. Very high radiation areas shall be identified based on the dose rate at a distance of 100 centimeters either from the source or from any surface penetrated by the radiation [see 835.2(a), very high radiation area].

3. Hot spots are localized sources of radiation, normally located within piping or components, with contact radiation levels greater than 100 millirem per hour (penetrating radiation dose) and more than 5 times greater than the general area dose rate. Contact readings should be used to determine the need for labeling hot spots. Measures taken to identify sources of elevated general area radiation levels while conducting routine radiation surveys should be sufficient to identify hot spot locations. Special surveys for the sole purpose of identifying hot spots are not required.

4. A label reading "Caution, Hot Spot" and marking the location of the hot spot should be placed on or as near the spot as practicable. The provisions of Article 231.7 through 231.11 do not apply to the hot spot labeling. Labeling of hot spots is not required in areas with general area dose rates greater than 1 rem/hr. However, the locations of such hot spots should be noted on area surveys and discussed in pre-job briefings.

5. Dose received in an hour may be used as the criterion for posting (Column 2 of Table 2-3). Very high dose rates (such as those in very high radiation areas) shall be recorded in units of “rads” rather than “rem” in an hour [see 835.2].

Table 2-3: Criteria for Posting Radiation Areas

AREA	CRITERIA	REQUIRED POSTING	SUPPLEMENTAL POSTING
Radiation Area	Radiation levels could result in an individual receiving > 0.005 rem in 1 hour at 30 cm	"CAUTION, RADIATION AREA" [see 835.603(a)]	"RWP AND PERSONNEL DOSIMETER REQUIRED FOR ENTRY"
High Radiation Area	Radiation levels could result in an individual receiving > 0.1 rem in 1 hour at 30 cm	"CAUTION" or "DANGER," "HIGH RADIATION AREA" [see 835.603(b)]	"PERSONNEL DOSIMETER, SUPPLEMENTAL DOSIMETER, AND RWP REQUIRED FOR ENTRY"[1]
Very High Radiation Area	Radiation levels could result in an individual receiving > 500 rad in 1 hour at 100 cm	"GRAVE DANGER, VERY HIGH RADIATION AREA" [see 835.603(c)]	"SPECIAL CONTROLS REQUIRED FOR ENTRY"[1]

Footnote:
1. Access requirements may be deleted or modified if personnel access is specifically prohibited.

235 Posting Contamination, High Contamination, and Airborne Radioactivity Areas

1. Areas shall be posted to alert individuals to the presence (or likely presence) of removable surface contamination and airborne radioactivity in accordance with Table 2-4 [see 835.603].

2. Derived Air Concentration (DAC) values found in 10 CFR 835 shall be used in posting airborne radioactivity areas in accordance with Table 2-4 [see 835.209(a)].

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

AREA	CRITERIA	REQUIRED POSTING	SUPPLEMENTAL POSTING
Contamination Area	Removable contamination levels (dpm/100 cm^2) > Table 2-2 values[1] but ≤ 100 x Table 2-2 values	"CAUTION, CONTAMINATION AREA" [see 835.603(e)]	"RWP AND PROTECTIVE CLOTHING REQUIRED FOR ENTRY"
High Contamination Area	Removable contamination levels (dpm/100 cm^2) > 100 x Table 2-2 values[1]	"CAUTION" or "DANGER," "HIGH CONTAMINATION AREA" [see 835.603(f)]	"RWP AND PROTECTIVE CLOTHING REQUIRED FOR ENTRY"
Airborne Radioactivity Area	Airborne concentrations (μCi/ml) above background: 1) are > the applicable DAC values[1]; or 2) could result in an individual (w/o respirator) receiving an intake > 12 DAC-hrs in a week	"CAUTION" or "DANGER," AIRBORNE RADIOACTIVITY AREA" [see 835.603(d)]	"RWP AND PROTECTIVE CLOTHING REQUIRED FOR ENTRY"

Footnote:
1. Levels exceed or are likely to exceed the listed values

236 Posting Radioactive Material Areas

1. Accessible areas where items or containers of radioactive material in quantities exceeding the values provided in Appendix E of 10 CFR 835 are used, handled, or stored shall be posted "CAUTION or DANGER, RADIOACTIVE MATERIAL" [see 835.603(g)].

2. Radioactive material areas shall be within a controlled area [see 835.2(a), radioactive material area].

3. Radioactive material areas may be excepted from the posting requirements when:

   a. The area is posted as a radiological area in accordance with Article 234 or 235 [see 835.604(b)(1)]; or
   b. Each item or container of radioactive material in the area is clearly labeled to warn individuals of the hazards [see 835.604(b)(2)]; or
   c. The radioactive material of concern consists solely of structures or installed components which have been activated (such as by exposure to neutron radiation or particles produced in an accelerator); or
   d. The area contains only packages of radioactive material received from radioactive material transportation while awaiting monitoring in accordance with Articles 552 and 554 [see 835.604(c)]; or
   e. For periods of eight continuous hours or less, the area is under the continuous observation and control of an individual knowledgeable of, and empowered to implement, required access and exposure control measures [see 835.604(a)].

4. Provisions for labeling radioactive material are specified in Chapter 4.

237 Posting Underground Radioactive Material Areas

1. Underground radioactive material areas should be established to indicate the presence of underground items that contain radioactive materials, such as pipelines, radioactive cribs, covered ponds, covered ditches, catch tanks, inactive burial grounds, and sites of known, covered, unplanned releases (spills).

2. Underground radioactive material areas should be posted "UNDERGROUND RADIOACTIVE MATERIAL." Posting should include instructions or special warnings to workers such as "Consult Radiological Control Organization before Digging" or "Subsurface Contamination Exists." The posting should meet the applicable requirements of Article 231. Underground radioactive material areas need not be posted if physical or administrative controls are implemented to ensure appropriate radiological controls are established prior to excavating, penetrating, or otherwise disturbing underground radioactive materials.

3. Underground radioactive material areas may be located outside controlled areas unless access is likely to result in individual doses (total effective dose) greater than 100 millirem in a year from underground radioactive material.

4. Underground radioactive material areas are exempt from the entry and exit requirements of Chapter 3 when access is not likely to result in individual doses greater than 100 millirem in a year. Article 333.1 provides entry provisions for instances in which access is likely to result in individual doses greater than 100 millirem in a year.

238 Posting Soil Contamination Areas

1. For areas with contaminated soil that is not releasable in accordance with the requirements in DOE O 458.1, a soil contamination area should be established that is posted in accordance with the requirements in Article 231.1 through 231.8. Posting should include the words "Caution, Soil Contamination Area" and instructions or special warnings to workers, such as "Consult with Radiological Control Organization before Digging" or "Subsurface Contamination Exists."

2. Soil contamination areas may be located outside controlled areas if exposure to the material in the area is not likely to cause any individual to receive a total effective dose in excess of 100 millirem in a year.

3. If the contamination levels in the area exceed the values provided in Table 2-2 (as evidenced by the likelihood of tracking contamination out of the area at levels exceeding these values), then the area is a contamination area or high contamination area and shall be posted in accordance with Article 235 [see 835.2(a), contamination area and high contamination area and 835.603(d) and (e)].

Appendix 2A

[Reserved]

Appendix 2B

Radiation Weighting Factors[1], w_R

Type and energy range	Radiation Weighting factor, w_R
Photons, electrons and muons, all energies	1
Neutrons, energy < 10 keV[2, 3]	5
Neutrons, energy 10 keV to 100 keV[2, 3]	10
Neutrons, energy > 100 keV to 2 MeV[2, 3]	20
Neutrons, energy > 2 MeV to 20 MeV[2, 3]	10
Neutrons, energy > 20 MeV[2, 3]	5
Protons, other than recoil protons, energy > 2 MeV	5
Alpha particles, fission fragments, heavy nuclei, all energies	20

Footnotes:

1. All values relate to the radiation incident on the body or, for internal sources, emitted from the source.
2. When spectral data are insufficient to identify the energy of the neutrons, a radiation weighting factor of 20 shall be used.
3. When spectral data are sufficient to identify the energy of the neutrons, the following equation may be used to determine a neutron radiation weighting factor value:

$$w_R = 5 + 17 \exp\left[\frac{-(\ln(2E_n))^2}{6}\right]$$ Where E_n is the neutron energy in MeV.

Appendix 2C

Tissue Weighting Factors for Various Organs and Tissues, w_T

Organs or tissues, T	Tissue weighting Factor, w_T
Gonads	0.20
Red bone marrow	0.12
Colon	0.12
Lungs	0.12
Stomach	0.12
Bladder	0.05
Breast	0.05
Liver	0.05
Esophagus	0.05
Thyroid	0.05
Skin	0.01
Bone surfaces	0.01
Remainder[1]	0.05
Whole body[2]	1.00

Footnotes:

1 "Remainder" means the following additional tissues and organs and their masses, in grams, following parenthetically: adrenals (14), brain (1400), extrathoracic airways (15), small intestine (640), kidneys (310), muscle (28,000), pancreas (100), spleen (180), thymus (20), and uterus (80). The equivalent dose to the remainder tissues ($H_{remainder}$), is normally calculated as the mass-weighted mean dose to the preceding ten organs and tissues. In those cases in which the most highly irradiated remainder tissue or organ receives the highest equivalent dose of all the organs, a weighting factor of 0.025 (half of remainder) is applied to that tissue or organ and 0.025 (half of remainder) to the mass-weighted equivalent dose in the rest of the remainder tissues and organs to give the remainder equivalent dose.

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

Appendix 2D

Non-Uniform Exposure of the Skin

Non-uniform exposures of the skin from X-rays, beta radiation, and radioactive materials on the skin, including hot particles, shall be assessed and recorded as specified in the table below [see 835.205(b)].

AREA OF SKIN IRRADIATED	METHOD OF AVERAGING, ADDING TO OTHER DOSES RECEIVED, AND RECORDING NON-UNIFORM SKIN DOSE
$\geq$ 100 cm^2 [see 835.205(b)(1)]	Averaged over the 100 cm^2 of skin receiving the maximum dose Added to any uniform equivalent dose also received by the skin Recorded as the equivalent dose (H) to any extremity or skin for the year
$\geq$ 10 cm^2 and < 100 cm^2 [see 835.205(b)(2)]	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) Added to any uniform equivalent dose also received by the skin Recorded as the annual extremity or skin equivalent dose [1]
< 10 cm^2 [see 835.205(b)(3)]	Averaged over the 1 cm^2 of skin receiving the maximum dose Not added to any other equivalent dose, extremity or skin equivalent dose recorded for the annual equivalent dose Recorded in a individual's radiation dose record as a special entry[1]

Footnote:

1 Recording of the non -uniform equivalent dose to the skin is not required if the dose is less than 2 % of the limit specified for the skin at 835.202(a)(4).

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CHAPTER 3 CONDUCT OF RADIOLOGICAL WORK

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PART 1 Planning Radiological Work

311 General

1. DOE regulations for occupational radiation protection require written authorizations to control access to and work in radiological areas [see 835.501(d)]. The level of detail included in such authorizations is dependent upon facility hazards and the nature of the work force. Technical requirements for the conduct of work, including construction, modifications, operations, maintenance, and decommissioning, should incorporate radiological criteria to ensure safety and maintain radiation exposures ALARA. In general, efforts to reduce individual dose should not be allowed to cause a concurrent increase in collective dose.

2. The primary methods used to maintain exposures ALARA shall be facility and equipment physical design features [see 835.1001(a)]. Performance of some activiy, such as maintenance or modification, may render a permanently-installed physical design feature inadequate. In such an instance, a special subset of design features, often referred to as engineered controls (e.g., temporary shielding, containment devices, and filtered ventilation systems) should be used, as appropriate, to further control individual exposure. Design criteria are discussed in Part 8 of this Chapter.

3. When physical design features, including engineered controls, are impractical or inadequate, they shall be augmented by administrative controls [see 835.1001(a) & (b)]. To accomplish this, the design and planning processes should incorporate radiological control considerations in the early planning stages. The checklist in Appendix 3A is helpful in reducing occupational radiation exposure.

4. To ensure adequate protection of the work force, planning for radiological work should also include consideration of all other workplace hazards (e.g., industrial hygiene and safety, fire safety, electrical safety), consistent with the principles of Integrated Safety Management as discussed in Article 118.

312 Planning for Maintenance, Operations, and Modifications

1. Work plans and procedures should be reviewed to identify and incorporate radiological control requirements, such as engineered controls and dose and contamination reduction considerations. Performance of this review should be the responsibility of line management, with support and concurrence from the radiological control organization. Where multiple hazards are present, this review should be performed by the multi-disciplinary team which is preparing the work control procedure**.** An integrated set of controls for all hazards (e.g., radiological, chemical, and physical) should be developed from this review.

2. The radiological hazard assessment and control process should be integrated with the processes used to assess and control other workplace hazards.

    a. For Federal employees, DOE O 440.1B Change 2, *Worker Protection Program for DOE (including the National Nuclear Security Administration) Federal Employees*, and its associated guide, DOE G 440.1-1B Administrative Change 1, provide requirements and guidance, respectively, for performing hazards assessments and implementing associated controls. This Order applies only to Federal Employees.
    b. For contractors, Rule 10 CFR 851, *Worker Safety and Health Program*, and its associated guide, DOE G 440.1-1B Administrative Change 1, provide requirements and guidance, respectively, for performing hazards assessments and implementing associated controls. This Rule applies only to contractors.

3. For routine tasks, such as surveillance, tours, and minor maintenance, performance of the above review and documentation of identified radiological protection requirements may be conducted as part of the radiological work permit process (see Article 321) or other work authorization development process that may be required by 835.501(d).

4. The site-specific radiological control manual should establish trigger levels requiring formal radiological review of non-routine or complex work activities. The trigger levels should be based on actual or expected radiological conditions in the absence of the job-specific engineered and administrative controls. Following are example trigger levels; each site should select trigger levels that are appropriate to their operations.

    a. Estimated individual or collective dose greater than pre-established values (e.g., any individual likely to receive a dose exceeding 50% of the local administrative control level or collective dose likely to exceed 1 person-rem)
    b. Predicted airborne radioactivity concentrations in excess of pre-established values (e.g., greater than 10 times the applicable DAC value(s) provided in 10 CFR 835)
    c. Removable contamination on accessible surfaces greater than pre-established values (e.g., greater than 100 times the values in Table 2-2)
    d. Entry into areas where dose rates exceed 1 rem/hour
    e. Potential releases of radioactive material to the environment
    f. Encountering radioactive material in damaged packages or containers.

5. For non-routine or complex tasks at a minimum, the radiological review should consider the following:

    a. Inclusion of radiological control hold points in the technical work documents,
    b. Elimination or reduction of radioactivity through line flushing and decontamination,
    c. Use of work processes and special tooling to reduce time in the work area
    d. Use of engineered controls to minimize the spread of contamination and generation of airborne radioactivity
    e. Specification of special radiological training or monitoring requirements
    f. Use of mock-ups for high exposure or complex tasks
    g. Engineered, design, and use of temporary shielding to reduce radiation levels
    h. Walkdown or dry-run of the activity using applicable procedures
    i. Staging and preparation of necessary materials and special tools
    j. Maximization of prefabrication and shop work
    k. Review of abnormal and emergency procedures and plans
    l. Identification of points where signatures and second party or independent verifications are required
    m. Establishment of success or completion criteria, with contingency plans to anticipate difficulties
    n. Development of a pre-job estimate of collective dose to be incurred for the job
    o. Provisions for waste minimization and disposal
    p. Identification of potential environmental releases.

6. The extent of the radiological review should be commensurate with the expected and potential hazards and required controls.

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

    a. Line management and the radiological control organization should provide enhanced oversight during the initiation and conduct of the work.

8. The ALARA Committee should review and approve plans for radiological work anticipated to exceed site-specific individual or collective dose criteria.

9. Optimization techniques, such as cost-benefit analyses, represent a fundamental part of radiological design analysis and work review. For review of minor activities with low associated doses, a cost-benefit evaluation is an intrinsic part of the design review process and a detailed evaluation is not necessary. For review and planning of major tasks involving higher collective dose expenditures, a detailed and documented evaluation should be performed.

313 Infrequent or First-Time Activities

In addition to the planning provisions of Article 312, special management attention should be directed to radiological activities that are infrequently conducted (i.e., activities for which there is insufficient facility or worker planning and execution experience to provide assurance of adequate radiological controls) or represent first-time operations. Planning for such activities should include:

1. Formal radiological review in accordance with Articles 312.4 and 312.5

2. Senior management review directed toward anticipation of concerns and emphasis and specification of protective measures

3. Review and approval by the ALARA Committee

4. Enhanced line and radiological control organization management oversight during the initiation and conduct of the work.

5. The extent of the formal radiological review should be commensurate with the expected and potential hazards and required controls.

314 Temporary Shielding

1. The installation, use, and removal of temporary shielding needed to reduce exposure in high radiation areas should be controlled by postings or procedure.

2. The effects of additional weight and other potential hazards of temporary shielding on systems and components should be evaluated and established to be within the design basis prior to installation.

3. Installed temporary shielding should be periodically inspected and surveyed to verify effectiveness and integrity. Installed temporary shielding should be periodically evaluated to assess the need for its removal or replacement with permanent shielding.

4. Radiation surveys should be performed during the alteration or removal of installed temporary shielding as appropriate.

5. Removable shielding needed to prevent exposure to a high radiation area should be visibly marked or labeled with the following or equivalent wording: "Radiation Shielding - Do Not Remove without Permission from Radiological Control."

6. While site procedures may identify specific shielding applications, such as the shielding of low activity sources or samples that fall outside recommendations 1 and 5 of this Article, the remainder of this Article should be considered when additional shielding is added to permanent equipment, temporary modifications, or equipment whose purpose is the handling of fissile material.

315 Technical Work Documents

1. Technical work documents, such as procedures, work packages, or job or research plans, should be used to control hands-on work with radioactive materials. Requirements for area cleanup should also be included in technical work documents. Requirements for incidental or routine work activities that involve a low potential of worker exposure or workplace contamination, such as the collection of trash or used protective clothing, should be established in generally applicable procedures.

2. Technical work documents used to control radiological work activities should be reviewed by and acceptable to the radiological control organization.

3. Radiological control hold points should be incorporated into technical work documents for steps or conditions that require action by the radiological control organization to assess existing radiological conditions or prevent significant adverse radiological consequences during subsequent steps. Sites should define "significant adverse radiological conditions" that require the use of radiological control hold points in the site-specific radiological control manual. The following activities and potential conditions should be considered for inclusion in the requirements for radiological control hold points:

    a. Radiological control organization action needed to assess changing radiological conditions and ensure implementation of required controls
    b. Potential for radiation doses in excess of the applicable site-specific administrative control level
    c. Potential for elevated airborne radioactivity levels (e.g., levels exceeding 10 times the DAC values provided in Appendices A and C of 10 CFR 835)
    d. Potential for elevated removable surface contamination levels on accessible surfaces (e.g., levels exceeding 100 times the Table 2-2 values)
    e. Potential for unplanned or uncontrolled release of radioactive material to the environment
    f. Unexpectedly encountering a damaged packages or containers with radioactive material

4. The radiological control hold point should include the criteria that must be met or action that must be taken to satisfy the hold point prior to continuing with subsequent steps in the planned activity. Radiological control limiting conditions typically provide conditions which, if encountered, require some action, such as stopping work. Examples of radiological control limiting conditions would be encountering unanticipated levels for; dose, dose rate, removable surface contamination, airborne radioactivity concentrations, etc. (See appendix 3F, *Radiological Control Limiting Conditions.)*

316 Control of Internal Exposure

1. The primary methods used to maintain individual internal doses ALARA shall be physical design features, such as confinement, ventilation, and remote handling [see 835.1001(a)]. The design objective shall be, under normal conditions, to avoid releases of radioactive material to the workplace atmosphere. The objective, under all conditions, shall be to control inhalation of radioactive material to levels that are ALARA [see 835.1002(c)].

2. Administrative controls, including access restrictions and the use of specific work practices designed to control airborne radioactivity, shall be used as the secondary method to maintain internal doses ALARA [see 835.1001(b)].

3. When engineered and administrative controls have been applied and the potential for airborne radioactivity still exists, respiratory protection should be considered to limit internal exposures. Use of respiratory protection should be considered under the following conditions:

    a. Entry into airborne radioactivity areas
    b. During breach of contaminated systems or components
    c. During work in areas or on equipment with removable contamination levels greater than 100 times the values in Table 2-2
    d. During work on contaminated or activated surfaces with the potential to generate airborne radioactivity
    e. Work involving energetic processes such as grinding that can generate airborne radioactive material.

4. The selection of respiratory protection equipment should include consideration of worker safety, comfort, and efficiency. The use of positive pressure respiratory protection devices is recommended wherever practicable to alleviate fatigue and increase comfort. See Chapter 5, Part 3, for additional guidance on respiratory protection.

5. In specific situations, the use of respiratory protection may be inadvisable due to physical limitations or the potential for significantly increased external exposure. In such situations, and if the anticipated internal dose is likely to exceed 0.1 rem, a formal radiological review should be conducted to ensure measures are implemented to assess available options, monitor and reduce worker exposure, and provide for follow-up monitoring, as required [see 835.402(c)(1)]. The rationale for not requiring respiratory protection, including a description of measures taken to mitigate the airborne radioactivity, should be documented as part of the review process.

6. The following controls are applicable to activities authorized in accordance with the above:

    a. Stay time controls to limit intake should be established for the entry
    b. Evaluation of workplace airborne radioactivity levels should be provided using air samplers with expedited assessment and analysis of results or continuous air monitors; lapel air samplers or alarming lapel air samplers are options for consideration.

7. When notified that an individual with an open wound wishes to enter an area where contact with radioactive contamination is possible, a representative of the radiological control organization or medical services should examine the wound and require appropriate measures to prevent the entry of radioactive contamination. These measures may be range from requiring an appropriate bandage or other covering up to prohibiting access to affected areas until the wound has healed. If other (non-radiological) hazards are present in the area to be entered, the individual should be directed to contact the applicable safety personnel.

PART 2 Work Preparation

321 Radiological Work Permits

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

1. The RWP should be integrated with other work authorizations that address safety and health issues, such as those for industrial safety and hygiene, welding, or confined space entry. The RWP should include the following information, unless the information is contained in other related work-control documents:

    a. Description of work
    b. Work area radiological conditions
    c. Dosimetry requirements, including any bioassay requirements
    d. Pre-job briefing requirements, as applicable
    e. Training requirements for entry
    f. Protective clothing and respiratory protection requirements
    g. Radiological Control coverage requirements and stay time controls, as applicable
    h. Limiting radiological conditions that may void the RWP
    i. Special dose or contamination reduction considerations
    j. Special personnel frisking considerations
    k. Technical work document number, as applicable
    l. Unique identifying number
    m. Date of issue and expiration
    n. Authorizing signatures.

2. If necessary to ensure appropriate accounting, the RWP number should be used in conjunction with the radiation dose accounting system to relate individual and/or collective dose to specific activities.

322 Use of Radiological Work Permits

Many facilities find it effective to use two different types of RWPs. General RWPS are used for entry and repetitive work in areas with known and stable low-hazard radiological conditions. Job-specific RWPs are used for more complex work and for entry into higher-hazard areas.

1. RWPs should be used to control the following activities:

    a. Entry into radiological areas
    b. Handling of materials with removable contamination that exceed the values of Table 2-2
    c. Work in localized benchtop areas, laboratory fume hoods, sample sinks, and containment devices that has the potential to generate contamination in areas that are otherwise free of contamination
    d. Work that disturbs the soil in soil contamination areas
    e. Work that involves digging in underground radioactive material areas
    f. Entry into an area where the radiological conditions are unknown
    g. A radiography operation

2. Job-specific RWPs should be used to control non-routine operations or work in areas with changing radiological conditions. The job-specific RWP should remain in effect only for the duration of the job.

3. General RWPs may be used to control routine or repetitive activities, such as tours and inspections or minor work activities, in areas with well-characterized and stable radiological conditions. General RWPs should be periodically reviewed and updated, consistent with the site ISM process.

4. RWPs should be updated if radiological conditions change to the extent that protective requirements need modification.

5. RWPs should be posted at the access point to the applicable radiological work area or otherwise made available at the work location.

6. Workers should acknowledge by signature or through electronic means where automated access systems are in place, that they have read, understand, and will comply with the RWP prior to initial entry to the area and after revisions to the RWP that affect the radiological controls.

7. If needed for dose accounting purposes, worker pocket or electronic dosimeter readings should be recorded in a format that identifies and provides linkage to the applicable RWP.

8. An alternative formal mechanism, such as written procedures or experiment authorizations, may be used in lieu of an RWP as the administrative control over radiological work activities. If an alternative mechanism is used, it should meet the standards established in this Article and Articles 321 and 323.

323 Radiological Work Permit Preparation

1. The responsibility for ensuring adequate planning and control of work activities resides with line management. The lead work group responsible for the planned activity or for the area should initiate the preparation of the RWP.

2. The RWP should be based on current radiological surveys and anticipated radiological conditions.

3. The RWP, including any revisions or extensions, should be approved by the supervisor responsible for the work or area, followed by review and concurrence by the appropriate radiological control supervisor.

324 Pre-Job Briefings

1. At a minimum, pre-job briefings should be held prior to the conduct of work anticipated to exceed the trigger levels identified in Article 312.4.

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

    a. Scope of work to be performed
    b. Radiological conditions of the workplace
    c. Procedural and RWP requirements
    d. Special radiological control requirements
    e. Radiologically limiting conditions, such as contamination or radiation levels that may void the RWP
    f. Radiological control hold points
    g. Communications and coordination with other groups
    h. Provisions for housekeeping and final cleanup
    i. Provisions for responding to unanticipated or emergency conditions

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

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

5. Attendance at the pre-job briefing should be documented. This documentation should be maintained with the technical work document.

6. DOE technical standards DOE-HDBK-1211-2014, *Activity-Level Work Planning and Control Implementation*, and DOE-HDBK-1028-2009, *Human Performance Improvement Handbook*, provide additional information on pre-job briefings.

325 Use of Personal Protective Equipment and Clothing

1. Individuals shall wear protective clothing during work in contamination and high contamination areas [see 835.1102(e)] and should wear protective clothing during the following activities:

   a. Handling of contaminated materials with removable contamination in excess of Table 2-2 levels
   b. Work in airborne radioactivity areas
   c. As directed by the radiological control organization or as required by the RWP or alternative work authorization.

2. Protective clothing and shoes designated for radiological control should be:

   a. Distinctive
   b. Used only for its intended purposes.

3. Workers should proceed directly to the designated area after donning personal protective equipment and clothing.

4. General guidelines for protective clothing selection and use are provided in Appendix 3C and in Table 3-1.

5. The use of labcoats as radiological protective clothing is appropriate for limited applications, such as those discussed in Appendix 3C where the potential for personal contamination is limited to the hands, arms, and upper front portion of the body. Labcoats should not be used as protective clothing for performing physical work activities in contamination, high contamination, or airborne radioactivity areas where contamination of the lower legs is likely.

6. As appropriate for the work conditions, the RCO should consider posting instructions for donning and removing protective clothing at the dress-out areas and step-off pad(s) for the affected work areas.

7. The use of personal protective equipment or clothing (including respiratory protection) beyond that authorized by the radiological control organization or other cognizant safety authorities detracts from work performance and is contrary to ALARA principles and waste minimization practices. Such use should not be authorized.

8. For radiological control purposes, company-issued clothing that is not specifically intended to protect individuals from contamination hazards should be considered the same as personal clothing.

PART 3 Entry and Exit Provisions

331 Controlled Areas

1. DOE regulations for occupational radiation protection require that individuals complete radiation safety training commensurate with the hazards and required controls:

    a. Prior to unescorted access to controlled areas [see 835.901(a)]; and
    b. Prior to receiving occupational dose during access to controlled areas (whether escorted or not) [see 835.901(a)].

2. Training provisions for unescorted entry into controlled areas and radiological areas are specified in Table 3-1. Article 622 establishes training provisions that should be met before permitting members of the public in controlled areas.

332 Radiological Buffer Areas

1. Minimum requirements for unescorted entry into radiological buffer areas should include the following:

    a. Training in accordance with Table 3-1
    b. Primary dosimeter, as appropriate.

2. Contamination monitoring provisions for individuals who exit a radiological buffer area containing contamination areas, high contamination areas, or airborne radioactivity areas are specified in Article 338.

333 Radioactive Material, Soil Contamination, and Underground Radioactive Material Areas

Minimum requirements for unescorted entry into radioactive material areas, soil contamination areas, and underground radioactive material areas should include training in accordance with Table 3-1. If individual doses are likely to exceed the applicable monitoring thresholds, individual monitoring shall be conducted in accordance with Article 511 and Article 521 [see 835.402(a) and (c)].

334 Radiation, High Radiation, and Very High Radiation Areas

1. Minimum requirements for unescorted entry into radiation areas shall include radiation safety training [see 835.901(b)] and should include the following:

    a. Training in accordance with Table 3-1
    b. Worker's signature on the RWP, as applicable
    c. Primary dosimeter.

2. Physical controls to prevent inadvertent or unauthorized access to high and very high radiation areas are established in Appendix 3B.

3. Minimum requirements for unescorted entry into high radiation areas shall include radiation safety training [see 835.901(b)], a personnel (primary) dosimeter [see 835.402(a)(5)], a radiation survey (upon entry), and supplemental dosimeter [see 835.502(a)] and should include the following:

    a. Training in accordance with Table 3-1
    b. Worker's signature on the RWP.

4. Minimum requirements for unescorted entry into high radiation areas where dose rates exist such that an individual could exceed a whole body dose of 1 rem in one hour shall include radiation safety training [see 835.901(b)], a personnel (primary) dosimeter [see 835.402(a)(5)], a radiation survey (upon entry), and a supplemental dosimeter [see 835.502(a)]. Entry requirements should also include the following:

    a. Training in accordance with Table 3-1
    b. Worker's signature on the RWP
    c. A determination of the individual's current dose, based on primary and supplemental dosimeter readings
    d. Pre-job briefing, as applicable
    e. Review and determination by the radiological control organization regarding the required level of radiological control technician coverage.

5. Individuals shall be prevented from unauthorized or inadvertent entry to very high radiation areas [see 835.502(c)]. In addition to the controls required in Articles 334.2 and 334.3, a survey should be performed prior to the first entry to the area after the source has been secured or shielded to verify the termination of the very high radiation field.

6. Operations personnel should immediately notify the radiological control organization of operational or system changes that could result in significant changes in radiological hazards. Such notifications facilitate radiological control organization actions to erect postings and implement required entry controls.

7. The number, issue, and use of keys should be strictly controlled where locked entryways are used to control access to high and very high radiation areas.

8. The radiological control organization should maintain a current list of high and very high radiation areas.

9. Written procedures should be implemented to ensure the effectiveness and operability of barricades, devices, alarms, and locks. Determination of the effectiveness of these control devices should also consider individual training and response. Weekly inspections of the physical access controls to high and very high radiation areas should be performed to verify controls are adequate to prevent unauthorized entry.

335 Contamination, High Contamination, and Airborne Radioactivity Areas

1. Minimum requirements for unescorted entry into contamination areas shall include radiation safety training [see 835.901(b)] and protective clothing [see 835.1102(e)] and should include the following:

    a. Training in accordance with Table 3-1
    b. Worker's signature on the RWP, as applicable
    c. Personnel dosimetry, as appropriate.

2. Minimum requirements for unescorted entry into high contamination or airborne radioactivity areas shall include radiation safety training [see 835.901(b)] and protective clothing [see 835.1102(e)] and should include the following:

    a. Training in accordance with Table 3-1
    b. Worker's signature on the RWP
    c. Respiratory protection when specified by the RWP or other written authorization
    d. Pre-job briefing for high contamination or airborne radioactivity areas, as applicable
    e. Personnel dosimetry, as appropriate

3. Individuals exiting contamination, high contamination, or airborne radioactivity areas should remove protective clothing (See Appendix 3C for recommended procedure). When entering an uncontaminated area, these individuals shall be monitored, as appropriate, for the presence of contamination on their skin and clothing [see 835.1102(d)]. These individuals should perform whole body frisking to detect personnel contamination in accordance with Article 338.

4. Exit points from contamination, high contamination, or airborne radioactivity areas should include the following:

    a. Step-off pad located outside the exit point, contiguous with the area boundary
    b. Step-off pads maintained free of radioactive contamination
    c. Designated containers inside the area boundary for the collection of protective clothing and equipment
    d. Contamination monitoring equipment located as close to the step-off pad as background radiation levels permit.

5. Multiple step-off pads should be used at the exits from high contamination areas. Use of multiple step-off pads is described in Appendix 3C.

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

7. Article 421 provides requirements and guidance for removing materials and equipment from these areas.

336 Member of the Public Entry Provisions

1. Site procedures should identify area entry requirements and access restrictions for members of the public.

2. Members of the public with a demonstrated need to enter the following areas may be allowed access if such access is controlled with a combination of orientation and the use of escorts trained for the specific area:

    a. Radiological buffer areas
    b. Radiation areas
    c. Contamination areas
    d. Radioactive material areas
    e. Soil contamination areas
    f. Underground radioactive material areas

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

4. Orientation provisions for members of the public are identified in Article 622.

337 Controlling the Spread of Contamination

Controls shall be implemented as necessary to prevent the spread of removable contamination outside of radiological areas under normal operating conditions [see 835.1102(a)]. The extent of these controls is dependent upon the type and level of contamination present and the activities in and around the area. The following measures should be used to prevent the spread of contamination across the boundaries of contamination, high contamination, and airborne radioactivity areas:

1. Use solid barriers to enclose areas wherever practicable

2. Mark and secure items such as hoses and cords that cross the boundary to prevent safety hazards and the spread of contamination. Markings may include radiological hazard warning labels, ribbon, or tape.

3. Control and direct airflow from areas of lesser to greater removable contamination or airborne radioactivity

4. Use engineered controls and containment devices such as glove-bags, glove-boxes, and tents.

338 Monitoring for Personnel Contamination

1. Individuals shall be monitored as appropriate for the presence of surface contamination when exiting contamination, high contamination, and airborne radioactivity areas [see 835.1102(d)]. Individuals should perform or undergo a whole body frisk, using either portable (hand–held) or automated devices, immediately upon entry into an uncontaminated area after exiting contamination, high contamination, or airborne radioactivity areas. Individuals should also perform or undergo a whole body frisk as directed by the RWP or the radiological control organization.

2. In addition to the above, individuals exiting a radiological buffer area containing contamination, high contamination, or airborne radioactivity areas should, at a minimum, perform or undergo a hand and foot frisk. This frisk is optional if the radiological buffer area exit is immediately adjacent to the location where the exiting individual has already performed a whole body frisk.

3. Where frisking cannot be performed at the exit from contamination, high contamination, or airborne radioactivity areas due to high background radiation levels, individuals should:

    a. Remove all protective equipment and clothing at the exit
    b. Proceed directly to the nearest designated monitoring station
    c. Conduct a whole body frisk.

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

5. Guidelines for personnel frisking using hand-held instruments are provided in Appendix 3E.

6. Personal items, such as; notebooks, papers, pens, jewelry, security badges, and dosimeters, may be frisked by the individual carrying them, provided the individual has been trained to perform this function.

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

8. The personnel frisking provisions in this Article are not applicable at those facilities that contain only radionuclides, such as tritium, that cannot be detected by currently available hand-held or automated frisking instrumentation.

Table 3-1: Radiological Control Training Guidelines

ACTIVITIES	MINIMUM TRAINING	ARTICLE(S)
Member of the public entry[1]	Orientation	622
Unescorted entry into controlled areas and radioactive material areas/underground radioactive material areas where an individual is not likely to receive 0.1 rem in a year	GERT	612, 613, 621
Unescorted entry into radiological buffer areas	RWI	612, 613, 631, 632
Unescorted entry into radioactive material areas/underground radioactive material areas (>0.1 rem in a year)		
Unescorted entry into soil contamination areas for work that does not disturb the soil		
Unescorted entry into radiation areas		
Unescorted entry into contaminated areas[2]	RWII	612, 613, 631, 633
Unescorted entry into high radiation areas[3]		
Unescorted entry into soil contamination areas to perform work that disturbs the soil		
Use of containment devices with high internal contamination levels[4]		

Footnotes:

1. The radiological control manager may authorize exceptions to the escort requirements in accordance with Article 622.
2. Includes Contamination, High Contamination, and Airborne Radioactivity Areas.
3. This requirement may be satisfied by completing both RWI training and High Radiation Area Training in lieu of RWII training.
4. Includes glove boxes and other containment devices with internal surface contamination levels exceeding 100 times Table 2-2 values.

PART 4 Radiological Work Controls

341 General

1. Radiological work activities shall be conducted as specified by the controlling written authorization [see 835.501(d)].

2. Prerequisite conditions, such as tag-outs and system isolation, should be verified in accordance with the technical work documents before work is initiated.

342 Work Conduct and Practices

The following work practices are demonstrably effective in controlling worker exposure. Line management and the RCO should consider implementing these practices, as appropriate, into ongoing operations and maintenance work.

1. Monitor contamination levels caused by ongoing work and maintain them ALARA. Curtail work and perform decontamination at preestablished levels, taking into account worker exposure.

2. Inspect tools and equipment to verify operability before bringing them into contamination, high contamination, or airborne radioactivity areas.

3. Minimize the use of radiologically clean tools or equipment in contamination, high contamination, or airborne radioactivity areas by implementation of a contaminated tool crib in accordance with Article 442.5. When such measures are necessary, consider wrapping or sleeving tools or equipment in complex or inaccessible areas to minimize contamination.

4. Install engineered controls, such as containment devices, portable or auxiliary ventilation, and temporary shielding, in accordance with the technical work documents and inspect them prior to use.

5. Verify the identity of components and systems prior to work.

6. Schedule work activities and shift changes to prevent idle time in radiological areas.

7. Where practicable, remove parts and components to areas with lower radiological hazards to perform work.

8. Upon identification of radiological concerns, such as inappropriate work controls or procedural deficiencies, workers should immediately report the concern to line supervision or the radiological control organization. If appropriate to control individual exposure to radiological hazards, the affected individual(s) should stop work per Article 345 and exit the radiological area until these issues are resolved and appropriate controls have been instituted.

9. Per Article 315 include requirements for area cleanup in technical work documents.

10. To minimize intakes of radioactive material, do not permit smoking, eating, or chewing in contamination, high contamination, or airborne radioactivity areas. When the potential for personnel heat stress exists, drinking may be permitted within a contamination area under the following conditions and controls:

    a. The potential for heat stress cannot be reduced by the use of administrative or engineered controls
    b. All drinking is from approved containers or sources
    c. The applicable requirements and controls are described in approved procedures.

343 Logs and Communications

1. During continuous or extended daily operations, radiological control personnel should maintain logs to document radiological occurrences, status of work activities, and other relevant information.

2. Oncoming radiological control personnel should review logs and receive a turnover briefing from the personnel they are relieving.

3. Communication systems required by the radiological work permit or technical work document should be checked for operability before bringing them into the work area and thereafter periodically during work.

4. Workers should keep radiological control personnel informed of the status of work activities that affect radiological conditions.

344 Review of Work in Progress

1. As part of their normal work review, both radiological control and work supervisors should periodically review ongoing jobs to ensure prescribed radiological controls are being implemented.

2. Radiological control personnel should conduct tours of the workplace to review the adequacy of radiological work practices, posting, and area controls.

3. During the performance of jobs for which a pre-job dose estimate was made, the radiological control organization, in cooperation with line management, should periodically monitor collective dose accumulation and compare it with the pre-job dose estimate. Differences should be reviewed to identify causes and assess the need for corrective actions.

345 Stop Radiological Work Authority

1. Radiological control technicians and their supervisors, line supervision, and any worker through their supervisor shall have the authority and responsibility to stop radiological work activities clearly specified [see 10 CFR 708 *DOE Contractor Employee Protection Program*, 10 CFR 851, and DOE O 440.1B]. The stop work authority should be for such reasons as:

    a. Inadequate radiological controls
    b. Radiological controls not being implemented
    c. Radiological control hold point not being satisfied

2. Stop radiological work authority should be exercised in a justifiable and responsible manner.

3. Once radiological work has been stopped, it should not be resumed until proper radiological control has been reestablished.

4. Resumption of work involving radiological hazards should require the approval of the line manager responsible for the work and the radiological control manager or designee.

346 Response to Abnormal Situations

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

2. Response to a continuous air monitor alarm should include the following actions:

    a. Stop work activities and place the area in a safe condition (i.e., secure welding equipment, terminate activities that may result in more severe conditions)
    b. Exit the area
    c. Notify radiological control personnel.

3. Response to increasing or unanticipated radiation levels, as identified by a supplemental dosimeter or area radiation monitor alarm, should include the following actions:

    a. Stop work activities and place the area in a safe condition (i.e., secure welding equipment, terminate activities that may result in more severe conditions)
    b. Alert others
    c. Affected individuals exit the area
    d. Notify radiological control personnel.

4. Response to a criticality alarm should include the following actions:

    a. Immediately evacuate the area, without stopping to remove protective clothing or perform exit monitoring
    b. Report to designated assembly area.

5. Response to a personnel contamination monitor alarm should include the following actions:

    a. Remain in the immediate area
    b. Notify radiological control personnel
    c. Take actions to minimize cross-contamination, such as putting a glove on a contaminated hand
    d. Take follow-up actions in accordance with Article 541.

6. Response to a spill of radioactive material should include the following actions:

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

7. For radioactive spills involving potentially toxic chemicals, workers should immediately exit the area without attempting to stop or secure the spill. They should then promptly notify the Industrial Hygiene or Hazardous Material Team and radiological control personnel.

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

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

1. Follow provisions for radiological work permits provided in Article 322.

2. Protective clothing should, at a minimum, include labcoats and gloves. Gloves should be secured at the wrist as necessary to prevent forearm contamination.

3. Shoecovers should be considered based on the potential for floor contamination.

4. Workers should periodically monitor their hands during work, change contaminated gloves and notify the RCO of unexpected levels of contamination.

5. Upon completion of work or prior to leaving the area, workers should monitor those areas of their body that are potentially contaminated. At a minimum, this includes hands, arms, and front portions of the body. A whole body frisk is recommended. If the working area was a contamination area, high contamination area, or airborne radioactivity area, workers shall monitor those areas of their body that are potentially contaminated [see 835.1102(d)].

6. If there is a potential for splashing or airborne radioactivity, such as when taking pressurized samples, additional controls such as rubber aprons, face shields, full PCs, or respiratory protection should be considered.

7. Gloveboxes should be inspected for integrity and operability prior to use.

8. Gloveboxes should be marked with, or survey measurements should be posted to identify, whole body and extremity dose rates on the exterior surfaces of the glovebox.

9. Laboratory fume hoods should be inspected for operability and proper air flow before use.

348 Controls for Hot Particles

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

1. Where applicable, the site-specific radiological control manual should define hot particles, such as those capable of producing an equivalent dose to the skin greater than 100 millirem in one hour, specific to facility operations and source terms.

2. Measures for controlling hot particles, as identified in items 3 through 7 of this Article, should be implemented under the following conditions:

    a. Upon identification of hot particles
    b. During new or non-routine operations with a high potential for hot particles, based on previous history
    c. Upon direction of the radiological control organization.

3. Survey provisions for areas or operations with the potential for hot particle contamination are established in Article 554.9.

4. Contamination area postings should be annotated to specifically identify the presence of hot particles.

5. Access to hot particle areas should be controlled by an RWP. The following controls should be considered for inclusion on the RWP:

    a. Periodic personnel monitoring during the work activity, at a frequency based on the potential magnitude of personnel exposure
    b. Additional personal protective equipment and clothing
    c. Direct radiological control coverage during work and assistance during protective clothing removal
    d. Use of sticky pads or multiple step-off pads.

6. Personal protective equipment and clothing used in hot particle areas should be segregated from other radiological protective equipment and clothing during laundering and surveyed prior to reuse.

7. Response to hot particle skin or clothing contamination should include the following:

    a. Immediate removal and retention of the hot particle for subsequent analysis
    b. Analysis of the particle
    c. Assessment of worker dose
    d. Evaluation of work control adequacy.

PART 5 Evaluation of Performance

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

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

351 Critiques

Critiques are meetings of the individuals knowledgeable about an event (either a success or an abnormal event) to document a chronological listing of the facts. The purpose of the critique is to establish and record the facts and develop lessons learned. Line management should follow site-specific procedures/guidance for analyzing and reporting events; in cases where site-specific guidance doesn't exist, line management should use the following guidance in a graded manner, consistent with the magnitude or complexity of the event being critiqued.

1. Critiques should be conducted for successes and abnormal events.

2. Critique meetings should be conducted as soon as practicable after the event or situation is stabilized, or after a successful evolution is completed. Critiques of abnormal events should preferably be conducted before involved personnel leave for the day.

3. At a minimum, the general critique process should include the following elements:

    a. Formal meetings, chaired by a critique leader
    b. Attendance by members of the work force who can contribute
    c. Attendance records
    d. Minutes signed by the critique leader
    e. A listing of the facts in chronological order
    f. Supporting materials, including documents, records, photographs, parts, and logs, maintained by the critique leader.
    g. Lessons learned

4. Evaluation of complex evolutions or events may require multiple critiques.

352 Post-Job Reviews

1. Performance should be reviewed after completion of non-routine radiological work. Requirements for post-job reviews should be delineated in the site-specific radiological control manual.

2. As appropriate to the work in question, post-job reviews should include reviews of:

    a. The total and individual doses compared to the pre-job estimates
    b. The efficacy of the radiological controls implemented for the work
    c. Any adverse events occurring during the work, such as skin contaminations, unexpectedly high individual exposures, or problems resulting from unnecessarily burdensome control requirements
    d. Conflicts between radiological safety requirements and other safety requirements
    e. Opportunities to improve performance or efficiency during repeated or similar work
    f. Significant differences between expected and actual radiological conditions or other issues affecting the work
    g. Worker input regarding possible improvements in radiological safety practices for repeated or similar work.

353 Lessons Learned

Lessons learned are available from post-job reviews and reports of past radiological events on site and at other facilities. The radiological control organization, in conjunction with line management, should evaluate lessons learned, provide prompt distribution, and incorporate the lessons into the site radiological control program, the radiological control training program, and related operations, as deemed appropriate by the RCO.

PART 6 Special Applications

This Part provides supplemental information to augment the basic provisions of the Standard. Articles 361 through 365 provide information to be used in developing the site-specific radiological control manual. Written guidance and requirements contained within DOE documents, consensus standards, or Federal regulations that delineate specifics for each application are referenced.

Articles 361 through 363 of this Part are applicable to those facilities where the majority of the work or operations involve the subject radionuclide as the significant source term. This Part is not intended to apply to facilities that use the subject radionuclides in limited or tracer amounts, such as analytical laboratories.

361 Plutonium Operations

Because of its long retention time in the body, relatively low levels of plutonium taken into the body can result in doses to individuals that exceed administrative control levels and dose limits. Accordingly, personnel and workplace monitoring at the levels needed to maintain effective radiological controls levels for plutonium is challenging. For this reason:

1. Primary emphasis shall be placed on engineered features to contain plutonium and to prevent airborne and surface contamination [see 835.1001(a)].

2. Methods should be established to allow for the discrimination of background activity from air-monitoring and sampling results in a timely fashion.

3. Detailed guidance is found in DOE-STD-1128-2008 *Guide of Good Practices for Occupational Radiological Protection in Plutonium Facilities*.

362 Uranium Operations

Uranium is unusual in that its chemical toxicity in the human body (i.e., the potential to cause kidney damage) is generally of greater concern than its radioactivity Also, processed uranium sometimes contains transuranic and other radionuclides from recycled materials.
Detailed guidance is found in DOE-STD-1136-2009 *Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities.*

363 Tritium Operations

The following characteristics of tritium require consideration in the implementation of the radiological control program at tritium facilities:

1. Tritium emits low energy beta particles which cannot be monitored using external dosimeters, consequently requiring the use of bioassay measurements to evaluate worker dose.

2. Worker exposure to tritium as water vapor causes a much greater dose than exposure to elemental tritium gas.

3. Normal personnel frisking techniques are ineffective for tritium. Consequently, a high reliance is placed on worker bioassay, routine contamination surveys, and air monitoring programs.

4. Due to its ability to permeate substances that it contacts, tritium is difficult to contain and is absorbed through human skin. Special attention should be directed to the selection of personal protective equipment and clothing for tritium operations.

For the above reasons, guidance contained in DOE-HDBK-1129-2008, *Tritium Handling and Safe Storage*, should be considered in preparing the site-specific radiological control manual for tritium operations. This handbook provides specific guidance related to internal dosimetry, contamination and air monitoring, special tritiated compounds (STCs), training, tritium containment practices and techniques, and personal protective equipment and clothing selection.

364 Accelerator Operations

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

1. The requirements of DOE O 420.2C, *Safety of Accelerator Facilities*, should be incorporated in the preparation of the site-specific radiological control manual. Further, DOE G 420.2-1A (2014), *Accelerator Facility Safety Implementation Guide for DOE O 420.2C, 'Safety of Accelerator Facilities,'* as amended, should be consulted to ensure best practices are being addressed and implemented.

2. In addition to the requirements of Item 1 above, provisions of this Standard coupled with general industry guidance contained in, ANSI/HPS N43.1-2011, *Radiation Safety for the Design and Operation of Particle Accelerators*, serves as a useful tool and could be considered in preparing a site-specific radiological control manual for accelerator operations. ANSI/HPS N43.1-2011 provides specific guidance related to radiological monitoring, dosimetry, shielding design, use of interlocks, and procedures and administrative controls.

3. Safety devices and interlocks that are necessary to meet the high radiation area control requirements of 10 CFR 835.501 shall be operational prior to and during operation of a beam [see 835.501(b)]. Operational status should be verified by testing. Safety devices and interlocks should be fail-safe.

365 Radiation Generating Devices

Special considerations associated with the use of radiation generating devices include the presence of extremely high dose rates and the potential for uncontrolled exposures. Operation of these devices requires stringent physical and administrative controls to prevent overexposure to operating and support personnel and those in adjacent work areas. The following procedures should be considered when developing site-specific procedures for applicable types of radiation generating devices:

1. ANSI (American National Standards Institute) N43.3-2008, *For General Radiation Safety-Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources, Energies up to 10 MeV*, establishes acceptable guidelines for operations involving the irradiation of materials.

2. ANSI N43.2-2001, *Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment*, provides guidelines for operations involving the following devices:

    a. Analytical diffraction and fluorescence
    b. Flash X-ray
    c. Sealed source irradiators used for diffraction studies.

3. Line management, in conjunction with the radiological control organization, should establish the radiological control requirements for incidental X-ray devices such as electron microscopes and electron beam welders.

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

5. Control requirements for radiographic devices include the following:

    a. Title 10 CFR 34, *Licenses for Industrial Radiography and Radiation Safety Requirements for Industrial Radiographic Operations*, establishes acceptable guidelines for operations with devices containing sealed sources.
    b. ANSI/HPS N43.3-2008, *For General Radiation Safety - Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources, Energies up to 10 MeV*, establishes acceptable guidelines for on-site operations with devices other than sealed sources for radiographic use.
    c. On-site operations conducted by off-site contractors should be approved by line management in coordination with the site radiological control organization. This process should ensure the contractor has a valid Nuclear Regulatory Commission or Agreement State license and that the operational and emergency procedures are current and available.

6. Safety devices and interlocks at fixed installations that are required to ensure compliance with 10 CFR 835.501 shall be operational prior to and during generation of a radiation field. Operational status should be periodically verified by testing. Safety devices and interlocks should be fail-safe.

PART 7 [Reserved]

Part 8 Design and Control

381 Radiological Design Criteria

The following design objectives are applicable during the design of new facilities and modification of existing facilities. Additional design criteria are provided in DOE O 420.1C.

1. For areas of continuous occupancy (2000 hours per year), the design objective shall be to maintain the average exposure level ALARA and below 0.5 millirem per hour. If occupancy is not continuous, the design objective shall be to maintain doses ALARA and below 20% of the occupational dose limits provided in Table 2-1 [see 835.1002(b)]. The information in Appendices 2B and 2C shall be used in developing design features to meet the design objectives [835.203(b)].

2. For control of airborne radioactivity, the design objective shall be to avoid releases to the work place atmosphere under normal conditions and, under any conditions, to control inhalation by workers to levels that are ALARA. Confinement and ventilation shall normally be used [see 835.1002(c)].

3. For materials used in facility construction and modification, the design objective shall be to select materials that facilitate operations, maintenance, decontamination, and decommissioning [see 835.1002(d)]. Components should be selected to minimize the buildup of radioactivity. Control of surface contamination should be achieved by containment of radioactive material.

4 In justifying facility design and physical controls, optimization methods shall be used [see 835.1002(a)].

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

6. Existing facility designs that have office space and lunchrooms or eating areas within radiological areas, require priority attention. Generally:

    a. Locating lunch rooms or eating areas, restrooms, drinking fountains, showers and similar facilities and devices is strongly discouraged within these areas
    b. Locating office spaces within these areas is strongly discouraged; to the extent that such space is essential to support radiological work, steps should be taken to preclude unnecessary occupancy.

7. Facilities currently under construction should be evaluated and the above criteria applied where it is practical to do so.

8. See DOE STD-1189-2008, *Integration of Safety into the Design Process*, for information on the procedures required for design of new nuclear facilities or major modifications of other facilities.

9. To ensure comprehensive and efficient protection of the work force, planning for radiological work should also include consideration of all other workplace hazards (e.g., industrial hygiene, chemical safety, fire safety, electrical safety, etc.), consistent with the principles of Integrated Safety Management as discussed in Article 118.

382 Administrative Control Procedures

1. Administrative control and procedural requirements shall be developed and implemented as necessary to supplement facility design features, particularly when the design of existing facilities is not in accordance with current standards [see 835.1001(b)]. Administrative control procedures include access control measures, RWPs, and technical work documents as discussed in this Standard.

2. Written procedures shall be developed as necessary to ensure compliance with the provisions of this Standard that are derived from 10 CFR 835 [see 835.104]. These procedures shall be commensurate with the radiological hazards created by the activity and the education, training, and skills of the individuals who are exposed to these hazards [see 835.104].

3. Written authorizations, including specific radiation protection measures, shall be required to control entry into and work within radiological areas [see 835.501(d)]. These authorizations may include RWPs, technical work documents, administrative procedures, and other administrative controls.

4. The combination of engineered controls and administrative control procedures shall be sufficient to ensure that, during routine operation, the Table 2-1 dose limits for general employees are met and to ensure doses are ALARA [see 835.1003(a)].

Appendix 3A

Checklist for Reducing Occupational Radiation Exposure

Preliminary Planning and Scheduling
The following elements should be considered, as applicable, during the preliminary planning and scheduling of work.

- Plan in advance
- Delete unnecessary work
- Determine expected radiation levels
- Estimate collective dose
- Sequence jobs
- Schedule work
- Select a trained and experienced work force
- Use an integrated team approach
- Identify and coordinate resource requirements
- Review operational history to identify, to the extent practical, all possible hazards associated (e.g. buried electrical cables) with the job
- Perform one or more walkdowns of the work area.

Preparation of Technical Work Documents
The following elements should be considered, as applicable, during the development of technical work documents.

- Include special radiological control requirements in technical work documents
- Perform ALARA pre-job review
- Select and optimize engineered and administrative controls to control doses
- 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 is practical outside radiological areas
- State requirements for standard tools
- Consider special tools, including robots
- State staging requirements for materials, parts and tools
- Incorporate radiological control hold points
- Analyze personal protective equipment (PPE) requirements to ensure optimization of hazard control, risks, and costs
- Minimize discomfort of workers
- Revise estimates of collective dose
- Prepare radiological work permits (RWPs)

Appendix 3A (continued)

Temporary Shielding
If temporary shielding is needed to prevent exposure to high radiation areas, the line organization and the RCO should consider the following in the development of the work package.

- Design shielding to include stress considerations
- Control installation and removal by written procedure
- Inspect after installation
- Conduct periodic radiation surveys
- Prevent damage caused by weight of heavy 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(s) occupied by worker
- Perform directional surveys to to maximize the protection provided by the shield design.
- Use mock-ups to plan temporary shielding design and installation
- Consider use of water-filled shielding

Rehearsing and Briefing
When high-consequence work is to be performed, line management and the RCO should consider including the following elements in the work planning.

- Rehearse
- Use mock-ups duplicating working conditions
- Use photographs and videotapes
- Conduct briefings of workers in accordance with Article 324

Performing Work
Line management and the RCO should consider incorporating the following elements, as applicable, into the conduct of operations.

- Comply with technical work documents and RWPs
- Post radiation levels
- Keep excess personnel out of radiation areas
- Control radiation exposure while controlling exposure to other hazards
- Supervisors and workers keep track of radiation exposure
- Workers assist in radiation and radioactivity measurements
- Delegate radiological control monitoring responsibilities
- Evaluate the size of the work crew as work progresses
- Reevaluate methods used to control radiation doses
- Compare actual collective and individual doses against pre-job estimates
- Coordinate personnel at the job site to reduce non-productive time

Appendix 3B

Physical Access Controls for High and Very High Radiation Areas

1. One or more of the following features should be used for each entrance or access point to a high radiation area and shall be used for each entrance or access point to a high radiation area where radiation levels exist such that an individual could exceed a whole body dose of 1 rem in any one hour [see 835.502(b)]:

    a. A control device that prevents entry to the area when high radiation levels exist or upon entry causes the radiation level to be reduced below that level defining a high radiation area
    b. A device that functions automatically to prevent use or operation of the radiation source or field while personnel are in the area
    c. A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry
    d. Entryways that are locked, except during periods when access to the area is required, with positive control over each entry
    e. Continuous direct or electronic surveillance that is capable of preventing unauthorized entry
    f. A control device that automatically generates audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source.

2. In addition to the above requirements, additional measures shall be implemented to ensure individuals are not able to gain access to very high radiation areas when dose rates are in excess of the posting requirements of Table 2-3 [see 835.502(c)].

3. 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 [see 835.502(d)].

Appendix 3C

Contamination Control Practices

Selection of Protective Clothing (PC)

1. Workers should inspect protective clothing prior to use for tears, holes, split seams or any other damage that would diminish protection. Any defective items should be replaced with intact protective clothing.

2. Protective clothing as prescribed by the radiological work permit should be selected based on the contamination level in the work area, the anticipated work activity, worker health considerations, area(s) of the body likely to be exposed to removable contamination, and regard for non-radiological hazards that may be present. Appendix 3D provides general guidelines for selection. As referenced in Appendix 3D, a full set and double set of protective clothing typically includes:

   Full Set of PCs
   a. Coveralls
   b. Cotton glove liners (optional)
   c. Gloves
   d. Shoe covers
   e. Rubber overshoes (optional)
   f. Hood

   Double Set of PCs
   a. Two pairs of coveralls
   b. Cotton glove liners (optional)
   c. Two pairs of gloves
   d. Two pairs of shoe covers
   e. Rubber overshoes (optional)
   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 radiological 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.

Appendix 3C (continued)

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 (Remove potentially contaminated gloves; replace with 'clean' gloves if a second glove was not originally worn.)
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

After stepping out of the contamination area or airborne radioactivity area to the step-off pad, the worker should:

10. Remove cloth glove liners
11. Replace barrier closure, as applicable
12. Commence whole body frisking
13. Monitor badge and dosimeter.

The sequence for the removal of primary and supplemental dosimetry is dependent upon where the dosimetry was worn and the potential for contamination. The sequence for removal of respiratory protection devices may be altered if it is determined that the potential for inhalation of airborne contamination or the spread of surface contamination is reduced by keeping respiratory protection devices on until all protective garments have been removed.

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
8. Remove each outer shoe cover, stepping on inner step-off pad as each is removed.

Appendix 3C (continued)

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

After stepping out of the contamination area or airborne radioactivity area to the step-off pad, the worker should:

14. Remove cotton glove liners
15. Replace barrier closure, as applicable
16. Commence whole body frisking
17. Monitor badge and dosimeter.

The sequence for the removal of primary and supplemental dosimetry is dependent upon where the dosimetry was worn and the potential for contamination. The sequence for removal of respiratory protection devices may be altered if it is determined that the potential for inhalation of airborne contamination or the spread of surface contamination is reduced by keeping respiratory protection devices on until all protective garments have been removed.

Use of Multiple Step-Off Pads

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:

1. The inner step-off pad should be located immediately outside the highly contaminated work area, but still within the posted area
2. The worker should remove highly contaminated outer clothing prior to stepping on the inner step-off pad
3. 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
4. The final or outer step-off pad should be located immediately outside the contamination area.

Appendix 3D

Guidelines for Selecting Protective Clothing (PC)

WORK ACTIVITY	REMOVABLE CONTAMINATION LEVELS		
	LOW (1 to 10 times Table 2-2 values)	**MODERATE** (10 to 100 times Table 2-2 values)	**HIGH** (> 100 times Table 2-2 values)
	RECOMMENDED PROTECTIVE CLOTHING[1,2]		
Routine	Full set of PCs	Full set of PCs	Full set of PCs, double gloves, double shoe covers
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

Footnotes:

1. The RCO may increase or decrease the level of PCs needed depending on the type, level, and extent of contamination, the work to be done, and other non-radiological considerations - particularly considerations related to heat stress as discussed in Article 534.
2. For hands-off tours or inspections, in areas with removable contamination at levels 1 to 10 times the values in Table 2-2, labcoats, shoecovers, and gloves may be used instead of full PCs.

Appendix 3E

Guidelines for Personnel Contamination Monitoring with Hand-Held Survey Instruments

The RCO may modify the following provisions, as appropriate to the actual conditions.

General Guidelines

1. Verify that the instrument is in service, has a valid source check, is 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 preestablished contamination limit or the instrument alarms, remain in the area and notify radiological control personnel.

6. Sufficient time should be taken to properly conduct a whole-body frisk. A whole-body frisk of an average-sized person may take approximately 10 minutes.

Sequence 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 his/her hands before handling the probe.

Appendix 3F

Radiological Control Limiting Conditions

The following are examples of limiting radiological conditions that, if encountered, would require action, such as stop work.

Dose and dose-rate

1. Whole body dose to any individual:
   - Where the expected dose is ≤ 50 millirem, consideration may be given to using a limiting radiological condition of 25 mrem greater than expected dose.
   - Where the expected dose is > 50 and < 200 millirem, consideration may be given to using a limiting radiological condition of 1.5 times the expected dose.
   - Where the expected dose is ≥ 200 millirem, consideration may be given to using a limiting radiological condition equal to the expected dose plus 100 mrem.

     Note: These criteria are typically established for doses received over a short time period (up to several days). For long term activities, periodic ALARA reviews should be sufficient to identify significantly higher than anticipated doses and result in commensurate corrective actions.

   For example:

Expected dose (millirem)	Limiting radiological condition (millirem)
10	35
100	150
200	300
800	900

2. Whole body dose rate at the worker location:
   - Where the expected dose rate is between 5 and 40 millirem/hr consideration may be given to using a limiting radiological condition of 3 times the expected dose rate.
   - Where the expected dose rate is from 40 to 100 millirem/hr consideration may be given to using a limiting radiological condition of 2 times the expected dose rate.
   - Where the expected dose rate is ≥ 100 millirem/hr consideration may be given to using a limiting radiological condition equal to 1.5 times the expected dose rate, provided that the limiting condition does not exceed the expected dose rate by more than 1,000 mrem.

     Note: The period of time when individuals are in the area with elevated doses rates should also be considered, e.g., very short time periods in some of these areas may not justify stopping the work.
   - In addition to the above, a limiting radiological condition should be set upon encountering unexpected radiation levels which change the radiological classification of the area, e.g., a radiation area becomes a high radiation area.

   For example:

Expected dose rate (millirem/hr)	Limiting radiological condition (millirem/hr)
<1	5 (change in posting classification)
20	60
40	80
300	450
2,500	3,500

Appendix 3F (continued)

3. Extremity dose rate:
   - Where the expected dose rate is < 1,000 millirem/hr, consideration may be given to using a limiting radiological condition of at least 100 millirem/hr and equal to 2 times the expected dose rate.
   - Where the expected dose rate is ≥ 1,000 millirem/hr, consideration may be given to using a limiting radiological condition equal to 1.5 times the expected dose rate, provided that the limiting condition does not exceed the expected dose rate by more than 10,000 mrem.

   For example:

Expected dose rate (millirem/hr)	Limiting radiological condition (millirem/hr)
150	300
3,000	4,500
30,000	40,000

Removable contamination levels

- A limiting radiological condition should be set upon encountering unexpected contamination levels which; change the radiological classification of the area (e.g., a contamination area becomes a high contamination area), or indicate that the contamination monitoring or controls in place must be revised or the protective clothing must be upgraded.

For example:

Expected beta/gamma removable contamination (dpm/100 cm^2)	Limiting radiological condition (dpm/100 cm^2)
< detectable	1000 (change in posting classification)

Airborne concentrations

- Where the expected airborne levels are ≤ 10 times the 10 CFR 835 Appendix A values, consideration may be given to using a limiting radiological condition of at least the 10 CFR 835 Appendix A value and 3 times greater than expected.
- Where the expected airborne levels are ≥ 10 and < 50 times the 10 CFR 835 Appendix A values, consideration may be given to using a limiting radiological condition of 2 times greater than expected.
- Where the expected airborne levels are ≥ 50 times the 10 CFR 835 Appendix A values, consideration may be given to using a limiting radiological condition of 1.5 times greater than expected.
- In addition to the above, a limiting radiological condition should be set upon encountering unexpected airborne levels that change the radiological classification of the area, e.g., an area becomes classified as an airborne radioactivity area or which indicate that the respiratory protection must be upgraded.

For example:

Expected airborne levels (multiples of Appendix A)	Limiting radiological condition (multiples of Appendix A)
< 0.1	1
5	15
30	60
80	120

CHAPTER 4 RADIOACTIVE MATERIALS

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Table

PART 1 Radioactive Material Identification, Storage, and Control

411 General

1. Materials in contamination, high contamination, or airborne radioactivity areas shall be considered contaminated until surveyed and released [see 835.1101(a)]. Any equipment or system component removed from a process that may have had contact with radioactive material should be considered contaminated until disassembled to the extent required to perform an adequate survey, surveyed, and shown to be free of contamination at levels exceeding the Table 2-2 values. These survey and release provisions do not apply to airborne radioactivity areas where only gaseous, short-lived (half-life of 1 hour or less) radionuclides are present. Detailed provisions for release of materials from radiological areas are provided in Article 421.

2. Radioactive material located within radiological areas does not require specific labeling or packaging if sufficient information is provided to allow individuals to take appropriate protective actions [see 835.606(a)]. The information may be provided by means of postings, pre-job briefings, training, or other appropriate means.

3. The site-specific radiological control manual should include response and notification requirements associated with a loss of radioactive material, including searches, internal investigations, documentation, and reporting. The radiological control organization should be notified in the event of a loss of radioactive material.

412 Radioactive Material Labeling

1. 10 CFR 835 requires labeling of individual containers of radioactive material and radioactive items except under certain specified conditions in which existing postings and control measures provide adequate warning [see 835.605 and 835.606(a)].

2. Postings and access control requirements for radiological areas generally provide sufficient personnel protection to negate the need for individual container or item labeling; however, items having removable contamination in excess of the Table 2-2 values should be labeled when used, handled, or stored in areas other than contamination, high contamination, or airborne radioactivity areas.

3. Required labels shall include the standard radiological warning trefoil and the words “Caution” or “Danger” and “Radioactive Material” [see 835.605]. The “Danger” heading should be used when an individual exposed to, using or handling the material could receive an equivalent dose exceeding any applicable administrative control level in one hour. The radiation warning trefoil shall be black or magenta and imposed upon a yellow background [see 835.601(a)]. Magenta is the preferred color for the trefoil and the lettering.

4. Required labels shall also provide sufficient information to permit individuals handling, using, or working in the vicinity of the labeled material to take appropriate actions to control exposures [see 835.605]. The following information should be included on radioactive material labels, to the extent appropriate to the radiological hazard created by the material and the education, training, and skills of the individuals who may be exposed to the hazards:

    a. Radionuclide(s)
    b. Radiological hazard information (e.g., radiation and contamination levels)
    c. Total quantity of radioactive material (in subunits or multiple units of curies)
    d. Date of survey

5. If an item is too small to be labeled with all of the desired information, the label should be applied to the device or storage location with sufficient information available to trace the item to the appropriate label.

6. If a label is applied to packaged radioactive material, the label should be applied to the outside of the package or be visible through the package.

7. Radioactive materials and containers should be labeled in accordance with Table 4-1.

Table 4-1: Radioactive Material Labeling

ITEM/MATERIAL	REQUIRED LABELING[1]	SUPPLEMENTAL LABELING[2]
Equipment, components, and other items that are radioactive, potentially radioactive, or have been exposed to radioactive contamination or activation sources	Standard radiation warning trefoil, and "CAUTION" or "DANGER" and "RADIOACTIVE MATERIAL"	"CONTAMINATED" or "POTENTIALLY CONTAMINATED"
Sealed or other radioactive sources, or associated storage containers		
Equipment, components, and other items with actual or potential internal contamination		"INTERNAL CONTAMINATION" or " POTENTIAL INTERNAL CONTAMINATION"
Components, equipment, or other items with fixed contamination		"FIXED CONTAMINATION"

Footnotes:
1 Labeling required on item or container meets the criteria established in 10 CFR 835.605.
2 See items listed in Article 412.4.

8. Items and containers may be excepted from labeling in accordance with Table 4-2.

***Table 4-2: Exceptions from Radioactive Material Labeling Requirements*[1]**

Exception Criteria	Items Typically Included[2]
Material is used, handled, or stored in radiological areas or radioactive material areas [see 835.606(a)(1)]	All radioactive material in radiological areas and radioactive material areas. This exception should not be applied to items that have removable contamination exceeding the Table 2-2 values that is stored outside of contamination, high contamination, or airborne radioactivity areas.
Material having a total quantity of radioactive material below one tenth of the values in Appendix E of 10 CFR 835and less than 0.1 Ci. [See 835.606(a)(2)]	Items having extremely low levels of radioactive material content, such as low-activity sealed radioactive sources, laundered personal protective equipment and tools and equipment having low levels of fixed contamination
Material that has been packaged, labeled, and marked in accordance with the applicable (e.g., DOE or Department of Transportation) radioactive material transportation requirements [see 835.606(a)(3)]	Radioactive material packages awaiting shipment
Material that is inaccessible, or accessible only to individuals authorized to handle or use them, or to work in the vicinity [see 835.606(a)(4)]	Material stored in locked areas or areas having strict physical and administrative entry controls that preclude unauthorized entry. Radioactive samples being handled or transported by authorized personnel.
Material that is installed in manufacturing, process, or other equipment [see 835.606(a)(5)]	Piping, tanks, valves, instrument sensors, test sources, etc., that are installed in immobile systems
Material that consists solely of nuclear weapons or their components [see 835.606(a)(6)]	Nuclear weapons components

Footnotes:

1 Caution should also be exercised to ensure that other applicable requirements (e.g., member of the public dose limits [Table 2-1], training requirements [Table 3-1], ALARA requirements [Article 117], controlled area dose expectation [Article 232]) will be met in the absence of radioactive material labels.

2 Caution must be exercised to ensure that the listed items actually meet the criteria established in the first column.

413 Radioactive Material Packaging

1. Radioactive material that is outside contamination, high contamination, or airborne radioactivity areas and is confirmed or suspected of having removable radioactive contamination levels greater than Table 2-2 values should be securely wrapped in plastic or placed in a closed container.

2. Radioactive material with sharp edges or projections should be taped or additionally protected to ensure package integrity.

3. Radioactive material with removable or potentially removable contamination levels in excess of 100 times Table 2-2 values should have additional packaging controls such as double-wrapping or the use of plastic bags inside containers.

4. Yellow plastic wrapping material (or clear plastic bags properly marked) should be used for packaging radioactive material and should not be used for non-radiological purposes.

5. The amount of combustible material used in packaging should be minimized.

414 Radioactive Material Storage

1. Radioactive material in quantities exceeding the applicable quantities shall be used, handled, and stored in a radioactive material area or other area posted in accordance with Article 234 or 235, as appropriate [see 835.2(a), radioactive material area, and 835.603].

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

3. Each radioactive material area should be established consistent with guidelines in the site-specific radiological control manual. The radiological control manager or designee has the authority to defer the establishment of a radioactive material area.

4. A custodian should be assigned responsibility for each radioactive material area. A custodian may have responsibility for more than one storage area.

5. The custodian should conduct walk-throughs of radioactive material areas at least monthly to check integrity of containers and wrapping materials.

6. The custodian should conduct annual or more frequent reviews of each radioactive material area, with emphasis on treatment, decontamination, movement of material to long-term storage locations, and disposal of unneeded material.

7. Storage of non-radioactive material in a radioactive material area is discouraged.

8. Outdoor storage of radioactive material is discouraged. In cases where outdoor storage is necessary, the integrity of containers or wrapping materials used should be ensured to prevent degradation from weathering and subsequent release of radioactive material.

9. Radioactive material should be stored in a manner that reduces combustible loading. The use of cardboard containers for storage is discouraged.

10. Flammable or combustible materials should not be stored adjacent to radioactive material areas.

11. Fire protection measures, such as smoke detectors, water sprinklers, and fire extinguishers, should be considered when establishing a radioactive material area.

PART 2 Release and Transportation of Radioactive Material

421 Release to Controlled Areas

Once materials and equipment have entered radiological areas controlled for surface contamination or airborne radioactivity, comprehensive and time-consuming evaluations of the potential for contamination are required prior to releasing the material or equipment to controlled areas. Likewise, exposure of certain materials and equipment to a beam of neutrons or other particles produced in a nuclear reactor or particle accelerator may result in activation of that material or equipment, resulting in the creation of radioactive material requiring controlled use, storage, and disposal. The need for evaluation of the radiological characteristics of these materials and equipment and implementation of appropriate controls provides substantial impetus for implementation of measures to limit the amount of material and equipment that enters radiological areas and to prevent contamination or activation of materials and equipment that do enter these areas.

1. Accessible surfaces of material or equipment that has entered contamination, high contamination, or airborne radioactivity areas shall be surveyed prior to release from these areas to controlled areas [see 835.1101(a)]. Guidance for conducting these surveys is provided in the footnotes to Table 2-2.

2. If an assessment of the prior use of the material or equipment indicates that inaccessible surfaces are not likely to be contaminated in excess of applicable limits, a complete survey of accessible surfaces and documentation of the assessment may be an appropriate basis to release materials to the controlled area [see 835.1101(a)(2)].

3. If an assessment of the prior use of the material or equipment indicates that inaccessible surfaces are likely to be contaminated to levels in excess of the Table 2-2 values, then the material shall not be released from the radiological area, except as permitted under Article 421.5 or 421.6 [see 835.1101(a)(2)]. If it is necessary to release the material or equipment from the radiological area, the material or equipment should be disassembled to the extent necessary to perform adequate surveys.

4. Contamination levels shall be less than Table 2-2 values prior to releasing material and equipment for unconditional use in controlled areas [see 835.1101(a) & (b)].

5. Material and equipment with fixed contamination levels that exceed the total contamination values specified in Table 2-2, and removable contamination levels less than Table 2-2 values, may be released for conditional use in controlled areas outside of radiological areas [see 835.1101(c) & (c)(1)]. The material or equipment shall be routinely monitored and clearly marked or labeled to alert individuals to the contaminated status [see 835.1101(c)(2)]. Written procedures should be developed to establish requirements for monitoring of the material or equipment and surrounding areas, control of access to these areas, authorized uses of the material or equipment, and contingency plans for spread of radioactive contamination.

6. Material and equipment with total or removable contamination levels exceeding Table 2-2 values may be moved on site from one radiological area to another if appropriate monitoring is performed and appropriate controls are established and implemented [see 835.1101(b)]. These controls should include provisions for containment to the extent practicable, labeling in accordance with Article 412, monitoring and control of the transfer route and participating individuals, and control of spills.

7. The requirements of 10 CFR 835.1101 apply only to material and equipment that is radioactive due to the deposition of radioactive surface contamination. Although DOE has not established any specific controls over the release of other radioactive materials (e.g., activated materials or intrinsically-radioactive materials) to controlled areas, the release of these materials is subject to other requirements of 10 CFR 835. The following regulatory requirements and guidance are applicable to the control of this type of material and equipment.

a. Controls shall be adequate to ensure compliance with the radiation safety training requirements of 10 CFR 835.901. The presence of the material and equipment may result in occupational or non-occupational exposure of individuals to radiation or may result in individuals handling radioactive material. Chapter 6 provides guidance for implementing an appropriate training program.
b. Controls shall be adequate to ensure compliance with the 100 millirem in a year controlled area maximum total effective dose expectation [see 10 CFR 835.602]. DOE sites should adopt site- or facility-specific criteria that will ensure that intrinsically-radioactive material and other equipment in the controlled area, will not result in any individual exceeding this dose expectation.
c. Controls shall be adequate to ensure the ALARA process is properly implemented [see 10 CFR 835.101 and 1001 - 1003]. Given the low levels of radioactivity that are likely to be present in material and equipment in controlled areas, the controls should not be burdensome. Options that should be considered include retention in radiological areas, placement in specified areas with appropriate access restrictions and usage controls, posting, labeling or color-coding, storage for decay, removal of radioactive components, and disposal as radioactive waste.

8. When radioactive materials are moved outside of radiological areas, controls should be established to ensure no unmonitored individual is likely to exceed an equivalent dose that would require monitoring in accordance with Article 511 or 521.

9. Records for release of materials should describe the property, date of last survey, identity of the individual who performed the survey, type and identification number of the survey instruments used, and survey results. For small items and packages of similar items (such as boxes of tools or boxes of fasteners), it is not necessary to create a separate survey record for each item. However, the survey record should provide traceability to the individual removing the item from the radiological area.

10. Per 10 CFR 835.1(b)(7), the requirements in 10 CFR 835 do not apply to radioactive material on or within material, equipment, and real property which is approved for release when the following conditions are met:

a. The radiological conditions of the material, equipment, and real property have been documented to comply with the criteria for release set forth in a DOE authorized limit and
b. The DOE authorized limit has been approved by a Secretarial Officer in consultation with the Chief Health, Safety and Security Officer.

422 Release to Uncontrolled Areas

1. DOE O 458.1 and associated guidance documents describe the process for release/clearance of surface contaminated material, equipment or real property based on authorized limits.

a. Material, equipment or real property for which the authorized limit meet the pre-approved criteria in DOE O 458.1 may be released from DOE radiological controls without any restrictions on future use.
b. In addition, authorized limits may be approved for material, equipment or real property with surface contamination levels greater than the pre approved criteria.

2. DOE O 458.1 pre approved authorized limits for release of surface contaminated material, equipment or real property may differ from those limits established in this standard for release of surface contaminated material, equipment and real property.
3. DOE O 458.1 and associated guidance documents describe the process for obtaining approved authorized limit for releasing material, equipment or real property that has been contaminated in depth or volume, such as activated materials or smelted material.

4. Material, equipment or real property with radioactive material on its surface or within its volume is exempt from the provisions of 10 CFR 835 if it may be released in accordance with an authorized limit approved by a Secretarial Officer in consultation with the Chief Health, Safety and Security Officer [10 CFR 835.1(b)(6)].

423 Transportation of Radioactive Material

1 49 CFR 170 through 180 establish requirements for inspecting and surveying packages, containers, and transport conveyances prior to transport via the public transportation system. These regulations apply to radioactive material transportation in commerce.

2. DOE Orders 460.1C, Packaging and Transportation Safety and 460.2A, Departmental Materials Transportation and Packaging Management provide requirements that are in conformance with 49 CFR 173 requirements for transportation and packaging of radioactive material using any conveyance. 10 CFR 835.1(b)(7) excludes radioactive material transportation not performed by DOE or DOE contractors from compliance with 10 CFR 835 regulations. However, radioactive material transportation (as defined in 10 CFR 835) does not include preparation of materials for shipment, packaging and labeling, or storage of material awaiting transportation for shipment. These activities shall be conducted in accordance with 10 CFR 835 [see 835.2(a), radioactive material transportation, and 835.1(b)] and should be conducted in accordance with this Standard.

3. Table 2-2 removable contamination values are more limiting than 49 CFR requirements and should be used as controlling limits for on-site and off-site transportation when using a conveyance that is owned by DOE or a DOE contractor [835.1(d)]. However, when a shipment is received from an off-site destination, by a non-DOE conveyance, the 49 CFR 173 transportation contamination values should be applied to all subsequent on-site transfers to the ultimate on-site destination.

4. On-site transfers over non-public 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 should include requirements to ensure appropriate monitoring and control of the radioactive material and should be approved or concurred with by the radiological control organization.

5. 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 [see DOE O 460.1C].

6. Before shipment and upon receipt of a radioactive material shipment, a visual inspection of packages should be performed to ensure that packages are not damaged. The inspection should identify dents, flaking paint, debris, package orientation, and any indication of leakage.

7. Before shipment and upon receipt of a radioactive material shipment, a comparison of package count to the shipping manifest should be made to ensure accountability.

8. Transport conveyances should be visually inspected prior to loading to ensure the trailers are acceptable for the intended use.

9. To the extent practicable, transport conveyances should be radiologically surveyed before loading, especially when using commercial carriers specializing in radioactive transport. The surveys should be adequate to identify any contamination remaining on the vehicle from previous radioactive material transport evolutions, such that DOE and its contractors would not be held liable.

10. Transport of large volumes of radioactive material by non-DOE motor vehicles should be "exclusive use" to prevent commingling of DOE and other commercial shipments.

11. The site emergency plan should describe provisions for response for those potential on-site radioactive material transportation accidents that would be categorized as an Operational Emergency

12. 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 [see 835.405(a)].

13. Written procedures for safely opening packages should be developed and maintained. These procedures should include due consideration of the type of package and potential hazards present.

PART 3 Sealed Radioactive Source Controls

431 Sealed Radioactive Source Controls

Sealed radioactive sources, as defined in 10 CFR 835.2, having activities equal to or exceeding the values specified in 10 CFR 835 Appendix E are considered accountable sealed radioactive sources.

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. These procedures shall include reporting to the DOE Radiological Source Registry and Tracking system [See DOE Order 231.1B].

2. Accountable sealed sources and all other sealed radioactive sources having activities exceeding one tenth of the values in Appendix E, 10 CFR 835, or their storage containers, shall be labeled with the radiation symbol and "CAUTION" or "DANGER" and "RADIOACTIVE MATERIAL" [see 835.605]. The label shall also provide sufficient information to control exposures [see 835.605]. Because of the wide variety of labels that are affixed to sealed radioactive sources by their manufacturers, these labels are excepted from the normal color scheme of magenta or black on yellow [see 835.606(b)]. 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.

3. Each accountable sealed radioactive source shall be inventoried at intervals not to exceed six months [see 835.1202(a)]. This inventory shall [see 835.1202(a)]:

    a. Establish the physical location of each accountable sealed radioactive source.
    b. Verify that the associated posting and labeling are adequate
    c. Establish that storage locations, containers, and devices are adequate

4. 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 [see 835.1202(b)]. Source leak tests shall be capable of detecting radioactive material leakage equal to or exceeding 0.005 μCi (as indicated by the presence of 0.005 μCi or more activity on the leak test sample) [see 835.1202(b)].

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 in accordance with Article 431.3 and subject to leak testing prior to being returned to service [see 835.1202(c)].

6. If a source is located in an area that is unsafe for human entry or otherwise inaccessible, (such as due to operational or environmental constraints), then periodic inventories and leak tests need not be performed [see 835.1202(d)]. When the conditions that restrict access to the area have been terminated, the inventory and integrity test should be performed before allowing uncontrolled access to the area.

7. If an accountable sealed radioactive source is found to be leaking radioactive material, then controls shall be established to prevent the escape of radioactive material to the workplace [see 835.1202(e)]. These controls should include wrapping or containing the source, applying appropriate labels, and removing the source from service.

8. Both accountable and non-accountable sealed radioactive sources shall be used, handled, and stored in a manner commensurate with the hazards associated with the operations involving the sources [see 835.1201].

9. The site-specific radiological control manual should specify controls for sealed radioactive sources having activities below one tenth of the accountability values in Appendix E, 10 CFR 835 to ensure their retention and proper use and storage.

10. Procurement of radioactive sources should be coordinated with the radiological control organization.

11. Receipt surveys of radioactive material shipments should be performed by the radiological control organization in accordance with Articles 552 and 554.

12. Sealed radioactive sources, including radiography sources, should not be brought on-site by external organizations without the prior knowledge and approval of the radiological control organization.

13. Accountable sealed radioactive sources without any documentation concerning origin and history of use should be evaluated with regard to their use and the need to upgrade associated radiological controls. The evaluation should consider:

    a. Current source activity;
    b. Chemical and physical form;
    c. Estimated age and end-of-life expectations;
    d. Use, including anticipated challenges to the source integrity during transportation; and
    e. Potential hazards associated with failure of the source.

14. A custodian should be appointed to coordinate sealed radioactive source procurement, issue, inventory, leak testing, and other aspects of the sealed radioactive source control program. If justified by the scale of the program, sealed radioactive source user groups should appoint group-specific custodians to coordinate activities involving sealed radioactive sources within the group.

15. The sealed radioactive source control program should have in place procedures for controlling a sealed radioactive source that has exceeded its design life and is no longer in use. These procedures should address, at the least, sealed source integrity, leak testing, and disposal.

PART 4 Solid Radioactive Waste Management

441 Requirements

1. DOE O 435.1, Radioactive Waste Management, describes how solid radioactive waste is treated, packaged, stored, transported, and disposed.

2. Radiological operations generating radioactive waste should be designed and developed to promote minimization and permit segregation, monitoring, treatment, storage, and disposal [DOE O 435.1].

3. Radioactive waste minimization goals and practices should be developed and implemented [DOE O 435.1].

442 Waste Minimization

A radioactive waste minimization program should be in effect to reduce the generation of radioactive waste and spread of contamination from contamination, high contamination, or airborne radioactivity areas [see DOE O 435.1]. The following practices should be evaluated and instituted as appropriate to support waste minimization:

1. Restrict material entering radiological buffer areas and other areas surrounding contamination, high contamination and airborne radioactivity areas to that needed for performance of work.
2. Restrict quantities of hazardous materials, such as paints, solvents, chemicals, cleaners, and fuels, entering radiological buffer areas and other areas surrounding contamination, high contamination and airborne radioactivity areas and implement measures to prevent inadvertent radioactive contamination of these materials.

3. Substitute recyclable or burnable items in place of disposable ones and reuse equipment, chemicals, solvents, and cleaners when practical.

4. Select consumable materials such as protective coverings and clothing that are compatible with waste-processing systems, volume reduction, and waste form acceptance criteria.

5. Reserve an assortment of tools primarily for use in contamination, high contamination, or airborne radioactivity areas. Tools should be maintained in a designated storage or distribution area or a contaminated tool crib. Controls should be established for tool issuance and use.

6. Survey potentially contaminated material from contamination, high contamination and airborne radioactivity areas to separate uncontaminated from contaminated materials.

7. Segregate known uncontaminated from potentially contaminated waste.

8. Segregate reusable items, such as protective clothing, respirators, and tools, at the step-off pad.

9. Minimize the number and size of radioactive material areas.

10. Emphasize training in waste reduction philosophies, techniques, and improved methods.

443 Mixed Waste

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

1. Technical and administrative controls should be established to minimize the volume of mixed waste generated and the amount of radioactivity in such waste. Volume reduction methods include process optimization, materials substitution, and new technology development.

2. Materials suspected of being mixed waste should be identified and segregated as soon as practical in the generating process to avoid combining mixed waste with other waste forms.

PART 5 Control of Radioactive Liquids and Airborne Radioactivity

451 Minimization and Control of Radioactive Liquid Wastes

DOE O 435.1 provides criteria for minimizing the generation of radioactive liquid waste.

452 Control of Radioactive Drains

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

1. Radioactive drain systems should not discharge to the environment nor be used for the disposal of non-radioactive liquids.

2. Existing radioactive drains should be evaluated to ensure the following:

    a. Verification of the existing radioactive drain piping configuration
    b. Installation of flow-indicating devices in leak-off lines
    c. Use of plugs to prevent non-radioactive input
    d. Consideration of alternative work controls before systems are drained for maintenance
    e. Controls prohibiting unauthorized use of drains.

3. Modifications to the design or operation of existing radioactive drain systems should be controlled to include:

    a. Design considerations that prevent non-radioactive drain connections into radioactive drains
    b. Procedural and design controls to prevent cross-connections of radioactive drains with non-radioactive systems
    c. Management review of subsequent changes to the design of radioactive drain systems or radioactive drain controls
    d. Management controls to restrict the introduction of hazardous wastes into radioactive drain systems.

453 Control of Airborne Radioactivity

1. The radiological control organization should be notified when engineered controls that prevent worker exposure to airborne radioactivity, such as barriers, gloveboxes, and glovebags, are compromised. An evaluation should be made of continuing operations with compromised engineered controls. The use of respiratory protection to continue activities under these conditions is discouraged. Implementation of short-term engineered modifications that provide a commensurate level of worker protection is the preferred alternative.

2. Preventive maintenance and surveillance procedures should be established to ensure equipment controls are maintained in an operable condition for containment of airborne radioactivity.

PART 6 Support Activities

461 Controls and Monitoring of Personal Protective Equipment and Clothing

1. Except for disposable, single use items, protective clothing designated for radiological control use should be specifically identified by color, symbol, or appropriate labeling.

2. Protective clothing designated for radiological control use should not be used for non-radiological work.

3. Personal protective equipment and clothing should not be stored with personal street clothing.

4. Cleaned personal protective equipment, such as face shields and respirators, that comes into contact with the wearer's face and company-issued clothing (other than protective clothing used for contamination control purposes) should be surveyed prior to reuse. Contamination levels should be below Table 2-2 total contamination values prior to reuse.

5. Laundered protective clothing should be surveyed and should meet the following criteria prior to reuse:

   a. Beta-gamma radioactivity less than 10,000 dpm/100 cm^2
   b. Alpha radioactivity less than 1,000 dpm/100 cm^2 for transuranics and other alpha emitters in the same Table 2-2 category, and less than 10,000 dpm/100cm^2 for uranium.

6. Sites and facilities are encouraged to continue efforts to reduce contamination levels on reusable personal protective equipment and clothing.

462 Laundry

1. Clothing and equipment should be laundered according to facility, color, type, and level of contamination.

2. Laundry activities should be performed using processes that control worker dose and minimize the volume of waste generated.

3. Clothing and equipment should be screened before laundering to segregate those that are damaged, present special handling problems, or require disposal.

4. Waste streams that contain soaps, detergents, solvents, or other materials which could interfere with processing large-volume liquid waste streams should be segregated for separate processing.

5. Contracting for fully licensed laundry services should be considered.

6. Cleaned personal protective equipment and laundered protective clothing should be periodically inspected. Clothing should be free of tears, separated seams, deterioration, and damage, or repaired in a manner that provides the original level of protection.

463 Decontamination

1. Radiological work permits or technical work documents should include provisions to control contamination at the source to minimize the amount of decontamination needed.

2. Work preplanning should include consideration of the handling, temporary storage, and decontamination of materials, tools, and equipment.

3. Decontamination activities should be controlled to prevent the spread of contamination.

4. Water and steam are the preferred decontamination agents. Other cleaning agents should be selected based upon their effectiveness, hazardous properties, amount of waste generated, and ease of disposal.

5. Facility line management should be responsible for directing decontamination efforts.

464 Vacuum Cleaners and Portable Air-Handling Equipment

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

1. Vacuum cleaners and portable air-handling equipment used in areas established to control removable surface contamination or airborne radioactivity (except areas where only tritium is present) should be equipped with High-Efficiency Particulate Air (HEPA) filters. If the material to be vacuumed is wet enough to preclude resuspension, then HEPA filters are not necessary.

2. HEPA filters used in vacuum cleaners and portable air-handling equipment should meet the applicable efficiency and construction requirements for the devices in which they are installed. The maximum flow rate of the device should not exceed the flow rate at which the HEPA filter was efficiency tested. In addition, the device should be leak tested prior to initial use, when units have undergone any type of service that may compromise the integrity of the HEPA filter or its sealing surfaces, and annually. Leak tests are conducted by injecting di-2-ethylhexyl phthalate (DOP) or equivalent aerosols into the inlet of the device and measuring the DOP concentration at the inlet and outlet of the device. Maintenance and testing should be conducted in accordance with the manufacturer's instructions or site-specific procedures that meet the manufacturer's minimum requirements.

3. Appropriate standards for system design, construction, maintenance, and testing are provided in ASME (American Society of Mechanical Engineers) N509, *Nuclear Power Plant Air- Cleaning Units and Components*, ASME N510, *Testing of Nuclear Air Treatment Systems*, and ASME AG-1, *Code on Nuclear Air and Gas Treatment*. DOE-STD-3020-2005 *Specification for HEPA Filters Used by DOE Contractors*, and DOE-STD-3025-2007, *Quality Assurance Inspection and Testing of HEPA Filters*, and 3026 provide additional information applicable to HEPA-filtered systems.

4. Vacuum cleaners used for radiological work should be:

    a. Marked and labeled in accordance with Article 412
    b. Controlled by written work authorizations
    c. Controlled to prevent unauthorized use
    d. Designed to ensure HEPA filter integrity under conditions of use
    e. Constructed and controlled to prevent unauthorized or accidental access to the inner surfaces of the vacuum.

5. Radiation and contamination surveys should be performed periodically for vacuum cleaners in use and labels on these units should be updated. The frequency of radiation surveys should depend on the specific use of the vacuum cleaner.

6. Airborne radioactivity levels should be monitored when a vacuum cleaner is used in a high contamination area.

7. A nuclear safety review should be performed and documented prior to the use of a vacuum cleaner for fissile material.

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PART 1 External Dosimetry

511 General Provisions

1. Personnel dosimetry shall be provided to and used by individuals as follows:

    a. Radiological workers who are expected to receive from external sources an effective dose of 100 millirem or more in a year or an equivalent dose to the extremities, lens of the eye, or skin of 10 percent or more of the corresponding limits specified in Table 2-1 [see 835.402(a)(1)]
    b. Declared pregnant workers who are expected to receive from external sources an equivalent dose of 50 millirem (ten per cent of dose limit [see 835.206]) or more to the embryo/fetus during the gestation period [see 835.402(a)(2)]
    c. Occupationally exposed minors likely to receive from external sources an effective dose in excess of 50 millirem [see 835.402(a)(3)]
    d. Members of the public who enter the controlled area and are likely to receive from external sources an effective dose of 50 millirem or more in a year [see 835.402((a)(4)]
    e. Individuals entering a high or very high radiation area [see 835.402(a)(5)].

2. Neutron dosimetry shall be provided when an individual is likely to exceed any of the criteria provided in Article 511.1 from neutrons [see 835.401(b)(2) and 835.402(a and b)].

3. Dosimeters should be issued only to individuals knowledgeable of their proper use and worn only by those to whom the dosimeters were issued.

4. To minimize the number of individuals in the dosimetry program, DOE discourages the issuance of dosimeters to individuals other than those entering areas where there is a likelihood of external exposure in excess of the monitoring thresholds established in Article 511.1. Implementation of an unnecessarily broad dosimetry program is not an acceptable substitute for development of a comprehensive workplace monitoring program.

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

6. Individuals should wear their primary dosimeters on the chest area, on or between the waist and the neck, or in the manner prescribed by radiological control procedures or work authorizations.

7. DOE discourages the practice of taking personnel dosimeters off-site.

8. Individuals should not wear dosimeters issued by their resident facilities while being monitored by a dosimeter at another facility unless authorized by the radiological control manager or designee. Individuals should not expose their dosimeters to excessive heat, or medical sources of radiation, and, unless required, to security X-ray devices.

9. An individual whose dosimeter is lost, damaged, or contaminated should place work in a safe condition, immediately exit the area, and report the occurrence to the radiological control organization. The individual should be restricted from entry into radiological areas until a review has been conducted to verify that dose limits have not been exceeded.

512 Technical Provisions for External Dosimetry

1. External dosimetry programs shall be adequate to demonstrate compliance with the Table 2-1 limits [see 10 CFR 835.402(b)]. External dosimetry programs implemented to meet the requirements of Article 511.1 shall be:

   a. Accredited by the DOE Laboratory Accreditation Program for Personnel Dosimetry (DOELAP) [see 835.402(b)(1)]; or
   b. Excepted from accreditation by the DOELAP Program [see 835.402(b)(1)]; or
   c. Otherwise approved by a Secretarial Officer responsible for environment, safety and health matters [see 835.402(b)(2)].

   DOE-STD-1095-2011 *Department of Energy Laboratory Accreditation Program for External Dosimetry* specifies the requirements for accreditation of personnel external dosimetry monitoring programs by DOELAP. A technical basis document should be developed and maintained for the external dosimetry program. Personnel external dosimeters include, but are not limited to, thermoluminent dosimeters (TLDs), track etch dosimeters, and optically stimulated luminescence (OSL) dosimeters.

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

3. Facilities are encouraged to participate in inter-comparison studies for external dosimetry programs.

4. Multiple dosimeters should be issued to individuals to assess effective dose in non-uniform radiation fields. Non-uniform radiation fields exist when the dose to a portion of the whole body will exceed the dose to the primary dosimeter by more than 50 percent and the anticipated whole body dose is greater than 100 millirem. When the radiation field is well characterized and the worker's orientation is known, relocation of the primary dosimeter is permitted in lieu of issuance of multiple dosimeters. Under such conditions, the individual's dosimeter should be relocated to the portion of the whole body likely to receive the highest dose. Dosimeter relocation should be conducted in conformance with facility procedures or specific work authorizations, such as RWPs. The technical basis document should describe the methodology used in determining the dose of record when multiple dosimeters are used and when dosimeters are relocated.

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

6. A monitoring program implemented at the discretion of the contractor (i.e., personnel monitoring that is not required by Article 511.1) should either utilize the contractor’s existing DOELAP-accredited program or establish a program that is excepted from DOELAP accreditation.

7. External dose measurements should be based on the operational quantities specified in Appendix 5A.

513 Pocket and Electronic Dosimeters

Pocket and electronic dosimeters are supplemental dosimeters that provide real-time indication of exposure to radiation and assist in maintaining personnel doses less than administrative control levels.

1. Individuals entering a high radiation or very high radiation area shall be monitored by a supplemental dosimeter or other means of determining the individual’s effective dose during the entry (see Article 334 for entry requirements) [see 835.502(a)(2)]. Supplemental dosimeters should also be issued when planned activities could cause an individual to exceed 50 millirem or 10 percent of a facility administrative control level from external

gamma radiation in 1 work day, whichever is greater, or when required by a radiological work permit. Pocket dosimeters should be selected with the lowest range applicable (typically 0-200 mR) for anticipated personnel exposures.

2. Supplemental dosimeters should be worn simultaneously with the primary dosimeter and located in accordance with Article 511.6.

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

4. Work authorized by written authorization should be stopped when supplemental dosimeter readings indicate dose rates or integrated dose greater than limiting radiological conditions specified in Appendix 3F, or substantially greater than planned. The radiological control organization should be consulted prior to restart of work.

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

6. DOE encourages the use of electronic dosimeters for entry into high radiation areas or when planned doses greater than 100 millirem in 1 work day are expected. An electronic dosimeter provides an early warning of elevated exposure through the use of alarm set points at specified dose rates or integrated doses.

7. When the dose results from the pocket or electronic dosimeters differ by more than 50 percent from the primary dosimeter result and the primary dosimeter result is greater than 100 millirem, an investigation should be initiated to explain the difference.

514 Area Monitoring Dosimeters

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

1. Area monitoring dosimeters may be used to record and document radiation levels in routinely occupied areas adjacent to areas where radiation or operations with radiation exist. This monitoring provision does not apply when the radiation arises solely from low-energy beta sources (e.g., carbon-14 or tritium).

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

3. Area monitoring dosimeters may be used in controlled areas to supplement existing monitoring programs and to provide data in the event of an emergency.

515 Nuclear Accident Dosimeters

1. Facilities that possess fissile materials in sufficient quantities to create a critical mass such that the potential exists for excessive exposure of individuals in an accident shall provide nuclear accident dosimetry to affected individuals [see 835.1304(a)].

2. The nuclear accident dosimetry system shall include the following:

    a. A method to conduct initial screening of potentially exposed individuals to identify those who have received significant doses [see 835.1304(b)(1)]
    b. Equipment and methods sufficient to analyze appropriate biological samples [see 835.1304(b)(2)] and dosimeters
    c. A system of fixed nuclear accident dosimeter units [see 835.1304(b)(3)] capable of measuring the estimated neutron dose and approximate neutron spectrum
    d. Personnel nuclear accident dosimeters [see 835.1304(b)(4)].

3. The fixed dosimeters discussed above should:

    a. Be capable of determining the neutron dose from 10 rads to approximately 10,000 rads with an accuracy of ± 25%
    b. Be capable of measuring fission gamma radiation from 10 rads to approximately 10,000 rads in the presence of neutron radiation with an accuracy of approximately ± 20%.

4. Personnel nuclear accident dosimeters should be capable of measuring an absorbed dose in or on a phantom from 10 rads to approximately 1,000 rads with an accuracy of ± 20% for gamma radiation and ± 30% from neutron radiation.

5. An analysis of the fixed dosimetry system needs should be documented and should consider such factors as the nature of operations, structural design of the facility, area accessibility, number of dosimeters and their location, and the effect of intervening shielding. The analysis should be reevaluated as necessary to ensure facility modifications do not impair the capabilities of the fixed dosimetry system.

PART 2 Internal Dosimetry

521 General Provisions

1. The following individuals shall participate in an internal dosimetry program:

    a. Radiological workers who are likely to receive a committed effective dose of 100 millirem or more from all radionuclide intakes in a year [see 835.402(c)(1)]
    b. Declared pregnant workers likely to receive intakes resulting in an equivalent dose to the embryo/fetus of 50 millirem or more during the gestation period [see 835.402(c)(2)]
    c. Occupationally exposed minors likely to receive a committed effective dose in excess of 50 millirem from all radionuclide intakes in a year [see 835.402(c)(3)].
    d. Members of the public who enter a controlled area and are likely to receive an intake resulting in a committed effective dose exceeding 50 millirem in a year [see 835.402(c)(4)].

2. The estimation of internal dose shall be based on bioassay data rather than air concentration values unless one of the following conditions exists [see 835.209(b)]:

    a. bioassay data are unavailable
    b. bioassay data are inadequate
    c. internal dose estimates based on representative air concentration values are demonstrated to be as or more accurate.

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

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

5. The bioassay program should establish appropriate frequencies for the collection of bioassay samples, such as urine or fecal samples, and for participation in bioassay monitoring, such as whole body or lung counting. Individuals should participate at the frequency required by the bioassay program.

6. Individuals should be notified promptly of positive bioassay results and the results of dose assessments and subsequent refinements. Dose assessment results shall be provided in terms of rem or millirem [see 835.2(b), dose term definitions, and 835.4].

522 Technical Provisions for Internal Dosimetry

1. All bioassay programs implemented to demonstrate compliance with Article 521.1 shall be:

    a. Accredited by the DOE Laboratory Accreditation Program for Radiobioassay (DOE-STD-1112-98) [see 835.402(d)]; or
    b. Excepted from accreditation by the DOELAP Program [see 835.402(d)(1)]; or
    c. Otherwise approved by a Secretarial Officer responsible for environment, safety and health matters [see 835.402(d)(2)].

2. A technical basis document should be developed for the internal dosimetry program.

3. Baseline bioassay monitoring of individuals who are likely to receive intakes resulting in a committed effective dose greater than 100 millirem in a year should be conducted before they begin work that may expose them to internal radiation exposure.

4. Routine bioassay monitoring methods and frequencies should be established for individuals who are likely to receive intakes resulting in a committed effective dose greater than 100 millirem in a year. The technical basis for the methods and frequency of bioassay monitoring should be documented.

5. Confirmatory bioassay monitoring should be performed as described in DOE-STD-1121-2008, *Internal Dosimetry*, section 5.7, *Confirmatory Bioassay Program*.

6. Management should request termination bioassay monitoring when an individual who participated in the bioassay program terminates employment or concludes work involving the potential for internal exposure.

7. Bioassay analyses should also be performed when any of the following occurs:

   a. Facial or nasal contamination is detected that indicates a potential for internal contamination exceeding any monitoring threshold established in Article 521.1
   b. Airborne monitoring indicates the potential for intakes exceeding 100 millirem committed effective dose
   c. Upon direction of the radiological control organization when an intake is suspected.

8 Levels of intakes that warrant the consideration of medical intervention should be established for site-specific radionuclides. The effectiveness of medical intervention, such as blocking or chelating agents, should be documented using bioassay results.

9. A preliminary assessment of intakes detected should be conducted prior to permitting an employee to return to radiological work.

10. Internal dosimetry program personnel should use radionuclide standards from or traceable to the National Institute of Standards and Technology (NIST).

11. Internal dosimetry program personnel are encouraged to participate in inter-comparison studies and to use the "DOE Phantom Library." Information on the DOE Phantom Library may obtained from the DOE's DOELAP Program Administrator or the Phantom Library Administrator at the Radiological and Environmental Sciences Laboratory.

12. Internal dose measurements should be based on the operational quantities specified in Appendix 5A.

13. A site radiobioassay program implemented at the discretion of the contractor (i.e., for personnel monitoring that is not required by Article 521.1) should either utilize the contractor's existing DOELAP-accredited program or establish a program that is excepted from DOELAP accreditation..

523 Technical Provisions for Dose Assessment

Interpretations of bioassay results and subsequent dose assessments should be documented. Detailed technical guidance for performing and documenting dose assessments is contained in DOE Standard 1121-2008, *Internal Dosimetry*.

PART 3 Respiratory Protection Program

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

531 General Provisions

1. Use of respiratory protection shall be reduced to the minimum practicable by implementing engineered controls and work practices to contain radioactivity at the source [see 29 CFR 1910.134, *Respiratory Protection*].

2. 10 CFR 851, *Worker Safety and Health Program*, requires DOE contractors to comply with 29 CFR 1910.134, *Respiratory Protection*, and ANSI Z88.2, *Practices for Respiratory Protection*. 29 CFR 1910.134 establishes requirements for a respiratory protection program that are applicable to most DOE facilities. ANSI Z88.2 provides requirements and guidance for implementation of the respiratory protection program and associated training of personnel. In addition, both 10 CFR 851 and DOE Order 440.1B Chg. 1, *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*, require the "use of respiratory protection equipment tested under the DOE Respirator Acceptance Program for Supplied-Air Suits (DOE Technical Standard 1167-2003) when National Institute for Occupational Safety and Health-approved respiratory protection does not exist for DOE tasks that require such equipment."

3. Respirators shall be issued only to individuals who are trained, fitted, and medically qualified to wear the specific type of respirator. Training and qualification testing shall be performed annually [see 29 CFR 1910.134 and ANSI Z88.2].

4. Positive controls should be maintained for the issue, use, and return of respirators to ensure that only qualified individuals wear respirators.

5. 29 CFR 1910.134 mandates that breathing air meet the specifications of ANSI/CGA G-7.1 *Grade D Breathing Air*. Compressed air supplied to respirators shall be tested quarterly. Compressors shall be of the breathing air type and shall not allow oil or other chemicals and fumes to enter the breathing air supply. Special attention shall be focused on the location of compressor air supply intakes and on cross-connections to other compressed gas systems to prevent contamination [see 29 CFR 1910.134].

6. Facility safety analyses should not take credit for the use of respiratory protection for routine work involving potential exposure to airborne radioactive materials.

532 Medical Assessments

Each prospective respirator wearer shall have a medical assessment prior to being fit-tested. The medical assessment shall determine if an employee's medical condition precludes the use of respirators and should follow the guidance in ANSI Z88.6, *Physical Qualifications for Respiratory Use*, on frequency and content of the examination [see 29 CFR 1910.134 and ANSI Z88.2]. The ability of an employee to accommodate the additional stress placed on the body when working in a respirator is part of this assessment.

533 Use of Respiratory Protection

The use of respiratory protection devices may impair worker communication, mobility and vision and cause the worker discomfort and stress. For these reasons, the issuance and use of respiratory protective devices must be controlled.

1. Individuals using respiratory protection shall:

    a. Perform fit checks of close-fitting respirators to ensure a proper seal before entering areas requiring respirator use
    b. Be clean shaven in the area of the facial seal, if applicable
    c. Use corrective lenses, if needed, that are approved for respirators
    d. Be trained to leave the work area when experiencing respirator failure
    e. Be trained to remove their respirators to avoid life-threatening situations when exiting an area after a respirator failure such as the loss of supplied air [see 29 CFR 1910.134 and ANSI Z88.2].

534 Heat Stress

Heat stress may result from working in areas of high heat, humidity, and radiant heat; working in protective clothing; and using respirators, particularly where other protective equipment is required. Heat stress has occurred at ambient temperatures less than 70°F when multiple sets of anti-contamination clothing or plastic suits were in use or strenuous work was required.

1. The planning stages for work in hot environments should address heat stress controls, as applicable.

2. Job supervisors should inform their personnel of heat stress precautions prior to work on job assignments in hot environments. Precautions that should be considered during work that includes a high probability of heat stress include:

    a. Engineered controls to moderate airborne or surface contamination in the work area environment;
    b. Appropriate work time limits;
    c. Use of protective clothing made of materials that wick perspiration away from the body;
    d. Use of body cooling devices;
    e. Provision of beverages at or near the work site, using appropriate contamination controls;
    f. Relaxation of protective clothing requirements.

3. If an individual begins to feel symptoms of heat illness, the individual should immediately notify the nearest co-worker, exit the area, remove personal protective equipment, notify the supervisor, and rest in a cool area. In such cases, medical assistance should be provided.

535 Half-Face Respirators

Half-face respirators have limited applications because of the design of the facial seal area. As a result, their permitted protection factor is low. Full-face respirators are generally preferred over half-face respirators because of the significant increase in protection offered with minimal loss of worker comfort.

1. The use of half-face respirators is permitted in situations where intakes of radioactive material will be low, such as those resulting in a few millirem, and where industrial and safety considerations warrant, such as during the operation of heavy equipment.

2. Due to the limited protection afforded by half-face respirators, DOE discourages the use of half-face respirators for emergency evacuation purposes.

PART 4 Handling Radiologically Contaminated Personnel

541 Skin Contamination

1. Survey techniques should be established to determine the extent of skin contamination.

2. When personnel detect skin contamination, they should notify the radiological control organization.

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

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

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

6. Individuals with skin contamination that triggers the need for dose assessment should be informed of the initial dose estimate to their skin as soon as practicable, preferably prior to the end of their work day.

7. Individuals with skin contamination for which dose assessment was not performed should be informed of the nature of the contamination and an upper estimate on the potential dose (such as less than 10 millirem) as soon as practicable, preferably prior to the end of their work day.

8. An assessment of skin exposure requires time to conduct a detailed evaluation. Requirements for assessments are provided in Appendix 2D. Promptly after completion, the results should be explained to the persons affected.

542 Contaminated Wounds

1. Emergency medical care should be administered immediately for injuries involving radioactive materials. National Council on Radiation Protection and Measurements Report Number 161, *Management of Persons Contaminated with Radionuclides: Handbook*, contains applicable information. Medical treatment of injuries takes precedence over radiological control considerations.

2. The treatment of contaminated injuries should include the following:

    a. Treatment of contaminated wounds by medically qualified personnel
    b. Monitoring of wounds and associated bandages for contamination, including alpha emitters if applicable
    c. Identification of the radionuclides involved
    d. Medical determination of the need to lower internal dose through therapeutic intervention such as surgery or administration of chelating or other decorporation agents
    e. Initiation of appropriate bioassay monitoring
    f. Determination of need for work restrictions.

3. An injured individual should be counseled promptly on the medical and radiological implications resulting from contaminated wounds that are likely to result in internal doses greater than 2 percent of the Table 2-1 limits. The counseling should be performed by senior radiological control and medical professionals.

543 Handling Individuals Exposed to Airborne Radioactivity

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

1. Identify individuals potentially exposed to airborne radioactivity.

2. Analyze air samples to determine airborne concentrations where appropriate.

3. Determine duration of potential exposure to airborne radioactivity.

4. Perform bioassay appropriate for the type and quantity of radionuclides involved.

5. Determine the need to lower internal dose through medical intervention such as administration of chelating or other decorporation agents for intakes greater than 2000 millirem ED. This action should performed by the site medical organization in consultation with the site radiological protection organizations. National Council on Radiation Protection and Measurements Report Number 161, *Management of Persons Contaminated with Radionuclides: Handbook*, contains applicable information.

6. Evaluate dose prior to permitting the worker to return to radiological work.

PART 5 Radiological Monitoring

551 General Provisions

Workplace monitoring provides a basis for posting and labeling, development of RWPs and other work authorizations, implementation of ALARA measures, issuance of individual monitoring devices, and verification of the efficacy of design measures and engineered controls. Development of a workplace monitoring program sufficient to meet the provisions of this chapter should include consideration of these factors to ensure the adequacy of the program.

1. Radiological monitoring of radiation exposure levels, contamination, and airborne radioactivity shall be conducted to:

    a. Characterize workplace conditions and detect changes in those conditions [see 835.401(a)(2) & (3)]
    b. Verify the effectiveness of engineered and administrative controls [see 835.401(a)(5)]
    c. Demonstrate regulatory compliance [see 835.401(a)(1)]
    d. Detect the gradual buildup of radioactive material in the workplace [see 835.401(a)(4)]
    e. Identify and control potential sources of personnel exposure [see 835.401(a)(6)]
    f. Determine exposure rates during each entry to a high or very high radiation area [see 835.502(a)(1)].

2. Monitoring shall be performed only by individuals who have the appropriate education, training, and skills [see 835.103]. The instruments used shall be [see 835.401(b)]:

    a. Periodically maintained and calibrated
    b. Appropriate for the types, levels, and energies of radiation to be detected
    c. Appropriate for existing environmental conditions
    d. Routinely tested for operability.

3. Monitoring for radiation, contamination, and airborne radioactive materials should be performed as specified in technical work documents and radiological work permits.

4. The radiological control organization should perform and document a review of the adequacy of sampling and monitoring programs as part of any facility or operational changes affecting radiological control. In the absence of such changes, a review should be conducted annually.

5. Instruments used to perform radiation monitoring should be performance-checked daily or, if not checked within the past 24 hours, prior to operation. Ambient background radiation should not be used for performance checks. When performance checks are not within ±20 percent of the expected value, the instrument should be taken out of service. When performance checks are not feasible, such as with instruments used to measure neutrons or tritium, compensatory actions should be established to ensure proper instrument performance.

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

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

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

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

10. Results of current surveys or survey maps should be conspicuously posted or available at access points to the surveyed area to inform personnel of the radiological conditions.

11. Survey results should be made available to line management and used in support of pre- and post-job evaluations, preparation or selection of appropriate radiological work permits, ALARA preplanning, contamination control, and management of radiological control operations.

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

552 Radiation Exposure Monitoring

1. In addition to the requirements of Article 551, routine radiation monitoring programs should be established to ensure that surveys are performed at a frequency that is consistent with the existing and potential hazards and activities planned in the area. The following survey frequencies are suggested and should be modified as necessary to ensure area hazards are adequately characterized, based upon facility-specific experience:

    a. Daily, in office space located in radiological buffer areas and other areas surrounding radiological areas where the potential exists for external radiation exposure
    b. Weekly, in routinely occupied radiological buffer areas and radiation areas
    c. Weekly, for operating HEPA-filtered ventilation units
    d. Weekly, for temporary radiation area boundaries to ensure that radiation areas do not extend beyond posted boundaries
    e. Monthly, or upon entry, if entries are less frequent than monthly, for radioactive material areas
    f. Monthly, for potentially contaminated ducts, piping, and hoses in use outside of radiological facilities.

2. Radiation monitoring should include dose rate measurements of the general area, dose rates at a distance of 30 centimeters from a source or surface of interest to evaluate potential whole body exposures, and dose rates on contact with potential sources of radiation where there is a potential for hands-on work or other direct contact.

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

4. When radioactive material exceeding a Type A quantity (as defined in 10 CFR 71) is received, radiation monitoring of the received packages shall performed if:

    a. The package is labeled in accordance with the applicable transportation requirements (e.g., Radioactive White I or Yellow II or III label) [see 835.405(b)(1)]; or
    b. The package has been transported as low specific activity (LSA) material on an exclusive vehicle [see 835.405(b)(2)].

    The external surfaces of all packages received from transportation should be monitored to determine the external radiation level, unless the packaged materials are not capable of creating an external radiation hazard (i.e., the packages contains only materials that emit radiation of low penetrating ability). 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.

5. Monitoring shall also be performed when a received package containing greater than a Type A quantity of radioactive material shows evidence of degradation, such as packages that are crushed, wet, or damaged [see 835.405(b)(3)].

6. Monitoring of received packages of radioactive material shall be performed as soon as practicable following receipt, but not later than eight hours following the beginning of the working day following the receipt of the package [see 835.405(d)].

7. Monitoring is not required for packages transported on a DOE site which have remained under the continuous observation and control of a DOE employee or DOE contractor employee who is knowledgeable of and implements required exposure control measures [see 835.405(e)].

8. See Articles 554 for additional provisions for radioactive material receipt.

553 Area Radiation Monitors

1. In addition to the requirements and recommendations of Article 551, area radiation monitors (not to include area monitoring dosimeters discussed in Article 514) should be installed in frequently occupied locations with the potential for unexpected increases in dose rates and in remote locations where there is a need for local indication of dose rates prior to personnel entry.

2. Area radiation monitors should not be substituted for radiation exposure surveys in characterizing a workplace.

3. The need for and placement of area radiation monitors should be documented and assessed when changes to facilities, systems, or equipment occur.

4. In addition to the requirements of Article 562, area radiation monitors should be tested periodically (e.g., quarterly) to verify audible alarm system operability and audibility under ambient working conditions and operability of visual alarms when so equipped.

5. If installed instrumentation is removed from service for maintenance or calibration, temporarily, a radiation monitoring program providing similar detection capability should be provided, consistent with the potential for unexpected increases in radiation dose rates.

6. Where an area radiation monitor is incorporated into a safety interlock system, the circuitry should be such that a failure of the monitor either prevents entry into the area or prevents operation of the radiation producing device. If the circuitry is required to ensure compliance with the high radiation area access control requirements of 10 CFR 835.502, then the circuitry shall be fail-safe [see 835.502(b)].

554 Contamination Monitoring

1. In addition to the requirements of Article 551, contamination monitoring programs should be established to ensure that surveys are performed at a frequency that is consistent with the existing and potential hazards and activities planned in the area. The following survey frequencies are suggested and should be modified as necessary to ensure area hazards are adequately characterized, based upon facility-specific experience:

    a. Prior to transfer of equipment and material from one radiological buffer area established for contamination control to another - unless the material was monitored immediately prior to this transfer, such as upon removal from a contamination area
    b. 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
    c. Daily, at contamination area control points, change areas, or step-off pads when in use, or per shift in high use situations
    d. Daily, in office space located in radiological buffer areas
    e. Daily, in lunch rooms or eating areas near radiological buffer areas
    f. Daily in accessible areas where operations likely to produce hot particles are under way
    g. Weekly, in routinely occupied radiological buffer areas
    h. Weekly, or upon entry if entries are less frequent, in contamination areas and other areas where materials having removable contamination exceeding the Table 2-2 values are handled or stored
    i. Weekly, or upon entry if entries are less frequent, where contamination area boundaries or postings are located
    j. During initial entry into a known or suspected contamination area
    k. Monthly, in and around areas of fixed contamination
    l Periodically during work in a contamination area or, at completion of job, or as specified in a radiological work permit
    m. After a leak or spill of radioactive materials.

2. Articles 421 and 422 provide requirements and guidance for material release surveys.

3. When radioactive material is received (other than gaseous or special form materials), contamination monitoring of the received packages shall be performed if:

    a. The package is labeled in accordance with the applicable transportation requirements (e.g., Radioactive White I or Yellow II or III label) [see 835.405(b)(1)]; or
    b. The package has been transported as low specific activity material on an exclusive vehicle [see 835.405(b)(2)].

    The external surfaces of all packages received from transportation should be monitored to determine the external contamination level, unless the packaged materials are not capable of creating a contamination hazard (i.e., the packages contain only gaseous or special form materials). 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.

4. Monitoring shall also be performed when a received package of radioactive material shows evidence of degradation, such as packages that are crushed, wet, or damaged [see 835.405(b)(3)], unless the packages contain only special form or gaseous radioactive material.

5. When monitoring of received packages is required (as specified in Article 554.3)**,** monitoring shall be performed as soon as practicable following receipt, but not later than eight hours following the beginning of the working day following the receipt of the package [see 835.405(d) and 835.405(e)].

6. Contamination surveys should incorporate techniques to detect both removable and fixed contamination.

7. Swipe surveys for removable contamination should be recorded in units of disintegrations per minute per 100 cm^2 (dpm/100 cm^2). For swipe surveys of small items covering less than 100 cm^2, the results should be recorded in units of dpm per area swiped. If contamination levels exceed the range of the available count rate meters, the swipes should be analyzed by holding an appropriate exposure rate meter within one half inch and the results should be recorded in units of millirad or rad per hour.

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

9. Areas identified as either contaminated with, or having the potential for being contaminated with, highly radioactive particles ("hot particles") should be surveyed using special swipe techniques to collect hot particles, such as tape and large area wipes.

555 Airborne Radioactivity Monitoring

1. In addition to the requirements of Article 551, air monitoring programs should be established to ensure that airborne radioactivity monitoring is performed at a frequency that is consistent with the existing and potential hazards and activities planned in the area. Selection of air monitoring equipment should be based on the specific job being monitored. Air monitoring equipment includes portable and fixed air sampling equipment and continuous air monitors.

2. Air sampling equipment shall be used where an individual is likely to receive an annual exposure of 40 or more Derived Air Concentration (DAC) hours [see 835.403(a)(1)]. This intake generally represents a committed effective dose to an individual of approximately 100 millirem. Samples shall also be taken as necessary to characterize the hazard in areas where respiratory protection devices have been prescribed for protection against airborne radionuclides [see 835.403(a)(2)]. Air samples should be adequate to evaluate the concentrations of airborne radioactive materials at the individual's work locations.

3. Real-time air monitors, such as continuous air monitors (CAMs) are used to provide early warning to individuals of events that could lead to substantial unplanned exposures to airborne radioactivity. Such exposures could result from a breakdown of engineered controls or improper establishment of boundaries during work that creates airborne radioactivity. Real-time air monitoring shall be conducted as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material [see 835.403(b)].

4. Air sampling equipment should be positioned to measure air concentrations to which individuals are exposed. If this cannot be achieved, a program of personal breathing-zone air sampling should be initiated. The Nuclear Regulatory Commission's NUREG-1400, *Air Sampling in the Workplace*, Chapter 3, *Demonstration that Air Sampling is Representative of Inhaled Air*, provides information on breathing-zone air sampling.

5. Air monitoring equipment shall be routinely calibrated and maintained on an established frequency [see 835.401(b)]. Air monitoring equipment should be calibrated at least once each year. CAMs should be capable of measuring 1 DAC when averaged over 8 hours (8 DAC-hours) under laboratory conditions.

6. Real-time air monitoring equipment required by Article 555.3 should have alarm capability and sufficient sensitivity to alert individuals that immediate action is necessary to minimize or terminate inhalation exposures.

7. A technical basis document should be developed for the airborne radioactivity monitoring program. The technical basis document should provide the basis for air monitor selection, placement, and operation.

8. The proper operation of real time air monitoring equipment should be verified daily (e.g., by performing an operational check, or verifying the CAM is operating normally as indicated by 'power on', 'normal count-rate reading', and no 'trouble' or 'failure' alarms). Operational checks typically include positive air-flow indication, non-zero response to background activity, and internal check sources or 60 Hz electronic checks when available. Real-time air monitoring equipment detector operation should be verified weekly by checking for instrument response with a check source or with ambient levels of radon and thoron daughters.

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

10. Air sample results should be evaluated as quickly as practicable for evaluation of the need for respiratory protection, area evacuation (if necessary), worker intake, and worker relief from respirator use.

11. Site-specific temporal and spatial averaging techniques may be used in determining the requirements for air monitoring. Justification for these techniques should be documented and retained and the results of these analyses used in documentation of the RPP.

12. Approved respirator protection factors may be considered in specifying application of CAMs if all individuals in the affected area will be wearing respiratory protection devices. This provision supplements the Department's reliance upon engineered and administrative controls for airborne radioactivity control and does not diminish the need to perform workplace monitoring as required by 10 CFR 835.401(a). In addition, the accompanying provision regarding the need to alert individuals to unexpected transients remains in effect and must be considered. Criteria requiring the use of CAMs should be fully described in the RPP.

13. Any of the various available air sampling methods (high or low flow rate grab samples, CAMs, lapel samples, etc.) may be used to demonstrate compliance with 10 CFR 835.403(a)(1). Specific guidance should be developed and provided to individuals performing the sampling (such as in site procedures) to ensure proper application of the specified method.

14. Air monitoring results may be used for determination of internal doses but only under the conditions specified in 10 CFR 835.209(c). Efforts should be made to acquire and analyze air samples using the most representative and accurate techniques that are available, considering site-specific factors such as available resources and potential for missed dose.

15. When performing air monitoring to demonstrate compliance with either 10 CFR 835.403(a)(1) or (2), the method used must be appropriate for the existing environmental conditions, consistent with 10 CFR 835.401(c)(3). Any conflicts between this requirement and the specific monitoring requirements of 10 CFR 835.403(a) should be considered in development of the RPP.

PART 6 Instrumentation and Calibration

561 Standardization

DOE encourages standardization on the use of commercially-available radiological instrumentation.

562 Inspection, Calibration, and Performance Tests

1. Radiological instruments shall be used only to measure the radiation for which their calibrations are valid [see 835.401(b)(2)]. ANSI N323A, *American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments* provides appropriate comprehensive guidance for establishing and operating a radiological instrumentation calibration program. Calibrations should use NIST traceable sources.

2. Calibration procedures should be developed for each radiological instrument type and should include frequency of calibration, pre-calibration requirements, primary calibration requirements, periodic performance test requirements, calibration record requirements, and maintenance requirements.

3. All radiological monitoring instruments, including pocket and electronic dosimeters and area radiation monitors, shall be maintained and calibrated on an established frequency [see 835.401(b)(1)]. Calibration frequencies should be determined in accordance with National Conference of Standards Laboratories Recommended Practice RP-1, *Establishment and Adjustment of Calibration Intervals*.

4. The effects of environmental conditions, including interfering radiation, on an instrument shall be known prior to use [see 835.401(b)(3)].

5. Operational tests should be used to assess instrumentation designs that include alarms or that involve a process control. An operational test should be developed to test all components involved in an alarm or trip function and performed at least annually.

6. In unusual and limited situations it may be necessary to use an instrument in an application other than that envisioned by the manufacturer. Special calibrations should be performed for use of instrumentation outside manufacturer's specifications. The instrument should be adjusted, calibrated, and labeled to identify the special conditions and used only under the special conditions for which it was calibrated.

7. Measures should be implemented to ensure that individuals using an instrument can verify its calibration status.

8. Instruments whose "as found" readings indicate that the instrument may have been used while out of calibration should be reported to the radiological control organization. The radiological control organization should review surveys performed with the instrument while it was out of calibration and consider the need for additional surveys.

563 Maintenance

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

2. Preventive and corrective maintenance should be performed using components and procedural recommendations at least as stringent as those specified by the manufacturer of the instrument.

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

564 Calibration Facilities

1. Radiological monitoring instrument inspections, calibrations, performance tests, calibration equipment selection, and quality assurance should be performed using documented protocols/procedures. ANSI N323A provides detailed technical guidance for the establishment of calibration programs.

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

Appendix 5A

Protection and Operational Quantities

Protection Quantities

The ICRP Publication 60 dosimetric quantities adopted in 10 CFR 835 and reflected in Table 2-1 of this standard have been designated by ICRP as "protection quantities" that are intended for defining and calculating the numerical limits and action levels used in radiation protection standards such as 10 CFR 835. Protection quantities provide a way to relate the magnitude of a radiation exposure to the risk of a health effect that is applicable to an individual and that is largely independent of the type and source (internal or external) of the radiation. In addition the protection quantities can be easily calculated for use in planning radiological work.

These goals are achieved using a combination of theoretical and practical considerations. For example, absorbed dose is assumed to be averaged over a tissue or organ. Radiation weighting factors are used to account for the biological effectiveness of various types and energies of radiation and tissue weighting factors are used to account for the sensitivity of various tissues to radiation induced cancer. See Appendices 2B and 2C of Chapter 2 of this standard for listings of values. The tissue and radiation weighting factors are based on both biological and epidemiological studies and have been updated as new research became available. Nevertheless, the values of these weighting factors are approximations that account for both uncertainty in the underlying data and the need to ensure that the protection quantities do not underestimate the true dose and hence the risk. Protection quantities used in 10 CFR 835 include: equivalent dose, effective dose, committed equivalent dose, committed effective dose, total effective dose, and cumulative total effective dose.

Operational Quantities

Because protection quantities were developed to provide an index of the risk resulting from energy imparted to tissue by radiation, they are theoretical and not measurable. Fortunately, it is possible to use the measurable properties of radiation fields and radioactive materials associated with exposure to external radiation sources or intake of radioactive materials to estimate and demonstrate compliance with the protection quantities. These measurable quantities are called operational quantities.

Although many types of operational quantities are possible, a well characterized set of operational quantities for assessing doses received from external exposure have been selected by the International Commission on Radiation Units and Measurements (ICRU) in Report 51, *Quantities and Units in Radiation Protection Dosimetry*. These operational quantities have been adopted in recommendations of the ICRP and in the standards implementing the ICRP recommendations written by the International Atomic Energy Agency (IAEA) and the European Union (EU). In addition, the ICRP, in Publication 74, *Conversion Coefficients for Use in Radiological Protection against External Radiation*, compared and contrasted doses determined using the ICRP system of protection quantities with doses determined using the ICRU based operational quantities. For almost all situations considered, doses determined with the operational quantities were greater or equal to the doses determined using protection quantities. These operational quantities and their relation to the protection quantities listed in DOE G 441.1-1C are contained in the tables below.

Appendix 5A (continued)

Relation between protection quantities and operational quantities for individual monitoring of doses from external exposure

Protection quantity	Operational quantity (depth [d] in tissue [mm])
Equivalent dose to the whole body from external sources*	$H_p(10)$
Equivalent dose to the lens of the eye from external sources	$H_p(3)$
Equivalent dose to the extremity or skin from external sources	$H_p(0.07)$

Where:

$H_p(d)$ is the personal equivalent dose at depth d in tissue
See ICRU Report 51 for the definition of $H_p(d)$
* Same as effective dose from external sources.

Relation between protection quantities and operational quantities for individual monitoring of doses from intakes of radioactive material

Protection quantity	Operational quantity
Committed effective dose	$\sum_j h_{j,eff,50,inh} I_{j,inh} + \sum_j h_{j,eff,50,ing} I_{j,ing}$
Committed equivalent dose	$\sum_j h_{j,T,50,inh} I_{j,inh} + \sum_j h_{j,T,50,ing} I_{j,ing}$
Total effective dose (Equivalent dose to the whole body from external sources + Committed effective dose)	$H_p(10) + \sum_j h_{j,eff,50,inh} I_{j,inh} + \sum_j h_{j,eff,50,ing} I_{j,ing}$

Where:

$h_{j,eff,50,inh}$ is the committed effective dose per unit of radioactivity intake by inhalation (*inh*)
$h_{j,eff,50,ing}$ is the committed effective dose per unit of radioactivity intake by ingestion (*ing*)
$h_{j,T,50,inh}$ is the committed equivalent dose to a tissue (T) per unit of radioactivity intake by inhalation
$h_{j,T,50,ing}$ is the committed equivalent dose to a tissue (T) per unit of radioactivity intake by ingestion
$I_{j,inh}$ is an intake by inhalation
$I_{j,ing}$ is an intake by ingestion
j is a radionuclide

Appendix 5A (continued)

In addition to the operational quantities used for individual monitoring, the following table contains operational quantities that may be measured to characterize certain aspects of radiation fields in the workplace.

Operational quantities for use in characterizing workplace radiation fields

Workplace measurement	Suggested operational quantity
Control of effective dose	$H^*(10)$
Control of dose to the skin, the extremities and the lens of the eye	$H'(0.07, \Omega)$
Control of dose to the lens of the eye	$H'(3, \Omega)$

Where: $H^*(10)$ is the ambient equivalent dose at a depth of 10 mm in tissue
$H'(0.007, \Omega)$ is the directional equivalent dose at a depth of 0.07mm in the ICRU sphere
$H'(3, \Omega)$ is the directional equivalent dose at a depth of 3 mm in the ICRU sphere
Ω defines the direction of the radiation field
See ICRU Report 51 for the definitions of ambient equivalent dose and directional equivalent dose

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CHAPTER 6 TRAINING AND QUALIFICATION

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PART 6 Training For Special Applications

PART 1 Radiological Control Training and Qualification

611 Purpose

The provisions of this chapter ensure that individuals are trained to work safely in and around radiological hazards and to maintain their individual radiation exposure and the radiation exposures of others ALARA. Training provisions in this chapter apply to individuals entering controlled areas at DOE sites and other individuals who are responsible for developing and implementing radiological control measures.

612 Standardization

10 CFR 835.901 establishes requirements for radiation safety training programs for two classes of individuals: 1) individuals who are permitted unescorted access to controlled areas or are occupationally exposed to radiation in a controlled area; and 2) individuals who are permitted unescorted access to radiological areas or perform unsupervised assignments as a radiological worker. Within this Standard, these training programs are referred to as General Employee Radiological Training and Radiological Worker Training (I and II), respectively. In addition, 10 CFR 835.103 establishes requirements for the education, training, and skills of individuals who are responsible for developing and implementing measures necessary for ensuring compliance with 10 CFR 835. DOE sponsored the development of core courses and training materials to achieve consistency in the level and quality of Department-wide training. In establishing local training programs, DOE's core-courses should be utilized to the extent practicable and should be supplemented with site-specific information. Core-course training material is developed and maintained by DOE Headquarters (AU) and consists of lesson plans, viewgraphs, student handbooks, qualification standards, question banks, and Program Management Guides.

1. Radiation safety training programs are necessary to ensure compliance with 10 CFR 835.901. Training programs for members of the public, general employees, and radiological workers should be developed consistent with Parts 2, 3, and 6 of this Chapter to ensure compliance with these requirements. Additional training programs consistent with those discussed in Parts 4,5 and 6 of this Chapter may be necessary to ensure compliance with the education, training, and skills requirements of 10 CFR 835.103. Affected individuals may include, but not be limited to, managers, supervisors, radiological control technicians, technical specialists, researchers, clerks, and engineers.

2. DOE's core course training material, supplemented by site-specific training materials, should be used to the extent practicable to satisfy the training requirements of both 10 CFR 835.901 and 10 CFR 835.103. DOE has sponsored the development of standardized courses for:

    a. General Employee Radiological Training
    b. Radiological Worker Training
    c. Radiological Control Technician Training
    d. Radiological Safety Training for Plutonium Facilities
    e. Radiological Training for Tritium Facilities
    f. Radiological Safety Training for Accelerator Facilities
    g. Radiological Safety Training for Uranium Facilities
    h. ALARA Training for Technical Support Personnel

3. Successful completion of the entire core academic component of a DOE core course at one DOE site within the past two years may be recognized by other DOE sites. Allowances may also be made for individuals who have successfully completed other types of radiological control training. Documentation of previous training should include the individual's name, date of training, topics covered, and name of the certifying official. However, under these circumstances, any additional radiological control training necessary for the individuals to perform

radiological work or to enter specific areas, including site-specific aspects of the radiation safety training, shall be completed [see 835.901(c)]. Site-specific training for General Employee Radiological Training and Radiological Worker I and II training may be included with other site orientation training.

4. At sites where there are multiple facilities, the training may be facility-specific if personnel access is limited to those facilities for which training has been completed.

613 General Provisions

1. 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:

    a. Risks of exposure to radiation and radioactive materials, including prenatal radiation exposure [see 835.901(c)(1)]
    b. Basic radiological fundamentals and radiation protection concepts [see 835.901(c)(2)]
    c. Controls, limits, policies, procedures, alarms, and other measures implemented at the facility to control doses, including both routine and emergency actions [see 835.901(c)(3)]
    d. Individual rights and responsibilities as related to implementation of the facility radiation protection program [see 835.901(c)(4)]
    e. Individual responsibilities for implementing ALARA measures [see 835.901(c)(5)]
    f. Individual exposure reports that may be requested [see 835.901(c)(6)].

2. Prior to permitting an individual to enter a radiological area unescorted or perform unescorted/unsupervised radiological work, successful completion of training commensurate with the hazard in the area and required controls shall be demonstrated [see 835.901(b)]. Chapter 3 provides guidance regarding the level of training appropriate for each defined area. Examinations and performance demonstrations shall be used to demonstrate satisfactory completion of initial Radiological Worker Training [see 835.901(b)]. Examinations shall be used to demonstrate satisfactory completion of biennial Radiological Worker Training and Radiological Worker Training provided for significant changes to the radiological control program [see 835.901(e)]. Examinations should be written; however, the radiological control manager may approve alternatives to accommodate special needs. Alternative examinations should be equivalent in content to written examinations. The RCO should consider the following when developing the examination process:

    a. Minimizing the number of true/false questions and not allow open-book examinations
    b. Use of questions randomly selected from the question bank
    c. Acknowledgment by signature that the student participated in a post-examination review
    d. That competence in required skills be measured using performance-based examinationse. Remedial actions for failure to meet the minimum score
    f. Maximizing the question bank questions that test what the student is expected to remember months after the training rather than to test short term memory of theoretical material.

3. Training should address both normal and abnormal situations in radiological control.

4. General Employee Radiological Training and Radiological Worker training shall be completed at intervals not to exceed 24 months [see 835.901(e)]. This biennial training should not be limited to subjects with which the students are already familiar, but should focus on applicable lessons learned and topics that will increase the students' knowledge of radiological hazards and controls. Training shall also be provided to affected individuals when there is a significant change to the radiological control program [see 835.901(e)]. Changes to the radiological control program should be incorporated into the training program on a periodic basis.

5. Measures should be implemented to ensure that each individual's current training status can be assessed as necessary to ensure appropriate job assignments and to permit effective entry control. Appropriate measures include electronic databases or wallet-sized training certificates that identify current training status.

6. Site-specific training and refresher training should include changes in requirements and applicable updates of lessons learned from operations and maintenance experience and occurrence reporting, for the site and across the DOE complex.

7. Verification of the effectiveness of radiation safety training should be accomplished by surveying a limited subset of former students in the workplace. This verification is in addition to performance evaluations routinely performed by training departments. This evaluation should include observation of practical applications and discussions of the course material and may include written examinations. The survey should be performed by radiological control managers and supervisors, quality assurance personnel, or senior instructors after the former student has had the opportunity to perform work for several months. The results should be documented and may be used to identify the need for remedial training.

8. Training programs developed for radiation safety should meet the requirements for performance-based training.

9. Reading and comprehension skills in the English language are generally necessary for radiation safety training. The radiological control manager is authorized to approve alternative measures for those lacking reading and comprehension skills in the English language until adequate English language skills can be achieved. Training in an alternate language should be equivalent to training in English. The alternative measures should be sufficient to ensure that the affected individuals can respond appropriately to any audible or visible warnings that they may encounter in the facility. Orientation and the use of trained escorts provide an alternate to training with the concurrence of the radiological control manager.

10. Additional requirements for personnel training are established in DOE O 426.2, *Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities*.

11. The site radiological control manager or designee should concur in radiation safety training material.

12. Requirements and guidance for training records and course documentation are provided in Article 725.

614 Instructor Training and Qualifications

1. All instructors should be qualified in accordance with the contractor's site Instructor Qualification Program or possess equivalent qualifications.

2. Instructors should have the technical knowledge, experience, and instructional skills required to fulfill their assigned duties.

3. Instructors-in-training should be monitored by a qualified instructor.

4. Subject matter experts without instructor qualification may provide training in their areas of expertise. However, these subject matter experts should be trained as instructors when this occurs routinely.

PART 2 General Employee Radiological Training

Table 3-1 specifies those individuals who should receive General Employee Radiological Training.

621 Site Personnel

1. Individuals shall complete radiation safety training prior to receiving occupational radiation exposure during access to controlled areas and prior to unescorted access to controlled areas [see 835.901(a)]. This training shall address the radiation safety training topics in Article 613.1 to the extent appropriate for the degree of exposure to radiological hazards that may be encountered and the required controls [see 835.901(a)].

   General Employee Radiological Training should include DOE's core course training materials (DOE-HDBK-1131-2007), as applicable, and should be expanded to include site-specific information, such as site-specific radiation types, alarm responses, and policies. This site-specific information may be included in GERT, or in facility orientations.

   For purposes of determining the need for training, occupational radiation exposure is considered to commence at the start of a job assignment that involves work with radiation producing devices or radioactive materials, or of a job assignment located within a controlled area where radiation levels, resulting from DOE activities, are expected to be distinguishable from background.

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

3. Additional training beyond General Employee Radiological Training should be required for unescorted entry into:

   a. Radiological buffer areas,
   b. Radioactive material areas (where the expected dose is likely to exceed > 0.1 rem in a year),
   c. Underground radioactive material areas (where the expected dose is likely to exceed > 0.1 rem in a year), or
   d. Soil contamination areas to perform work that does not disturb the soil (see table 3-1)

4. Information may be communicated by classroom lecture, videotape, or other appropriate methods. An examination is not required.

5. In the alternate year when full training is not completed, the latest General Employee Radiological Training Handbook (Student Guide) should be available for self-study.

6. If an escort is used in lieu of training, then the escort shall have completed the level of training required for the areas to be entered and the work to be performed and shall ensure that the escorted individual complies with the radiation protection program [see 835.901(d)]. In addition, the untrained individual, if occupationally exposed in a controlled area at a DOE site or facility, shall complete at least those portions of the training related to the risks of exposure to radiation and radioactive materials, including prenatal radiation exposure and individual exposure reports that may be requested [10 CFR 835.901(a)]. In this situation, such training may be provided by a use of a brochure or a poster.

622 Radiological Safety Training and Orientation for Members of the Public

1. Members of the public shall receive radiation safety training prior to being permitted unescorted access to controlled areas [see 835.901(b)]. This training shall address the radiation safety training topics in Article 613.1 to the extent appropriate for the degree of exposure to radiological hazards that may be encountered and the required controls [see 835.901(a)].

2. DOE encourages its operating entities to continuously escort members of the public in the controlled area. However, when members of the public are trained in accordance with Article 622.1, the following additional criteria should be met prior to permitting unescorted access to controlled areas:

    a. Prior approval by the radiological control manager
    b. Appropriate limitations are established on the areas to be entered and the activities to be undertaken to prevent occupational exposure
    c. The individual receives enhanced training providing information commensurate with the areas to be entered and activities to be undertaken while unescorted.

3. Members of the public, including tour groups and visiting non-DOE dignitaries, who enter the controlled area and are continuously escorted, should receive a radiological safety orientation. This orientation should include the following topics and be commensurate with the hazards present in the areas to be entered and the required controls:

    a. Risk of low-level occupational radiation exposure, including cancer and genetic effects
    b. Risk of prenatal radiation exposure
    c. Member of the public and management responsibilities for radiation safety
    d. Adherence to radiological posting and labeling
    e. Applicable emergency procedures
    f. Training for issuance of dosimeters, where applicable.

4. Information may be communicated by classroom lecture, videotape, or other appropriate methods. An examination is not required.

5. Sign-in logs may be used as radiation safety training and orientation records as required by Article 725.

PART 3 Radiological Worker Training

Table 3-1 specifies those individuals who should receive Radiological Worker Training.

631 General Provisions

1. Each individual shall demonstrate knowledge of the radiation safety training topics established in Article 613.1, commensurate with the hazards in the area and required controls, by successful completion of an examination and appropriate performance demonstrations prior to being permitted unescorted access to radiological areas and prior to performing unescorted assignments as a radiological worker [see 835.901(b)]. Radiological Worker Training should include the DOE's core course training materials (DOE-HDBK-1130-2008), as applicable, and should be expanded to include site-specific information.

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

3. Radiological Worker I Training may be structured to be a prerequisite for Radiological Worker II training.

4. Radiological Worker II Training includes all of the requirements of Radiological Worker I Training and expands on the topic of hands-on work with radioactive materials. Radiological Worker II Training prepares the worker to deal with higher levels of radiation and radioactive contamination.

5. Individuals with current Radiological Worker I Training may be upgraded to allow unescorted access to other areas by completing only the additional training provided in Radiological Worker II Training.

6. In the alternate year when training is not performed, refresher training should be completed.

7. If an escort is used in lieu of training, then the escort shall have completed the level of training required for the areas to be entered and the work to be performed and shall ensure that the escorted individual complies with the radiation protection program [see 835.901(d)].

632 Radiological Worker I

1. Site-specific Radiological Worker I Training, including High/Very High Radiation Area Training (Article 632.3), should encompass at a minimum the following practical factors:

    a. Entering and exiting simulated radiological buffer areas and radiation areas (and high radiation areas when such training is included)
    b. Performance of frisking for personnel contamination, as applicable
    c. Verification of instrument response and source check
    d. Proper response to alarm situations.

2. Course length will vary dependent upon the amount of site-specific material.

3. Unescorted worker access to high and very high radiation areas may be permitted upon successful completion of Radiological Worker I Training and High/Very High Radiation Area Training. Additional training (RWII) is required to enter contamination, high contamination, or airborne radioactivity areas unescorted, and should be required for entry into soil contamination areas during activities that will disturb the soil.

633 Radiological Worker II

1. Site-specific Radiological Worker II Training should encompass at a minimum the following practical factors:

    a. Donning of protective clothing, if applicable
    b. Entering a simulated radiological buffer area, contamination area and high radiation area to perform a task, if applicable
    c. Proper response to simulated abnormal situations
    d. Proper response to simulated alarms or faulty radiological control equipment
    e. Removing protective clothing and equipment and subsequently exiting the simulated area, if applicable
    f. Performance of frisking for personnel contamination, if applicable
    g. Verification of instrument response and source check.

2. Course length will vary dependent upon the amount of site-specific material.

634 Specialized Radiological Worker Training

1. Specialized Radiological Worker Training should be completed for non-routine operations or work in areas with changing radiological conditions. This training is in addition to Radiological Worker I or II Training and should be provided to personnel planning, preparing, and performing jobs that have the potential for significant radiological consequences. Such jobs may involve special containment devices, the use of mockups, and ALARA considerations. In some cases, dependent upon site-specific criteria, pre-job briefings provide an acceptable alternative to Specialized Radiological Worker Training. The site-specific radiological control manual should establish the appropriate criteria that require Specialized Radiological Worker Training.

2. Based on the information cited above and requirements of 10 CFR 835, institution of the Radiological Worker I and II and specialized radiological worker training programs is sufficient to satisfy the job-specific training requirement of 10 CFR 835.902. The Department recognizes that other training provided in the workplace, including mock-up training for specific jobs, trade or craft specific training, laboratory safety training, and pre-job briefings, may include specific instructions regarding radiological controls. While the Department continues to encourage comprehensive training of the work force, documentation of these types of training is not required to satisfy the requirements of 10 CFR 835.902. The extent to which documentation of additional training is required to satisfy other provisions of 10 CFR 835 should be prescribed in the documented radiation protection program developed by the operating entity and approved by the Department.

PART 4 Radiological Control Technician and RCT Supervisor Qualification

641 General Provisions

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

642 Radiological Control Technician

1. Because of the nature of their duties (e.g., monitoring the workplace, implementing administrative controls and entry controls), RCTs would generally be expected to have responsibility for implementing measures necessary for ensuring compliance with 10 CFR 835. Therefore, RCTs will generally be subject to the education, training, and skills requirements of 10 CFR 835.103. RCT training should include the standardized core course training materials, (DOE-HDBK-1122-2009) as applicable, which should be expanded to include site-specific information.

2. RCT candidates who have prerequisite knowledge, such as college credit, operational experience, or related qualifications, may satisfy individual sections of the standardized core course training requirements by passing comprehensive challenge examinations.

3. Entry-level prerequisites should be established to ensure that RCTs meet the standards for physical condition and education. At a minimum, these standards should include the following:

    a. High school education or equivalency
    b. Fundamentals of mathematics, physics, chemistry, and science
    c. Systems and fundamentals of process, operations, and maintenance
    d. Reading and comprehension level sufficient to follow procedures, write permits, prepare survey maps, write reports, and prepare shipping and transfer permits
    e. Ability to work in a support role, including communicating verbal instructions to others
    f. Physical requirements to handle personal protective equipment and other equipment and assist others in work locations, commensurate with assignment.

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

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

643 Qualification Standards for Radiological Control Technicians

Qualification Standards define the requirements for demonstrating completion of training. Signatures on the forms in Qualification Standards provide documentation of satisfactory proficiency.

1. The Qualification Standards from the standardized core course should be supplemented to include site-specific elements.

2. Qualification Standards for the RCT position should include on-the-job training to provide hands-on experience directly applicable to the job.

3. An RCT trainee should be under direct supervision of a qualified RCT. Direct supervision would allow a qualified RCT to intervene if necessary.

644 Oral Examination Boards

The oral examination board provides an opportunity to identify areas of strength and weakness related to performance of radiological control technician duties and supervisor functions. The oral examination board also provides the opportunity to identify additional training needs to enhance RCT and supervisor training programs.

1. The radiological control manager should consider using an oral examination board to determine the initial qualification and requalification of candidates for RCT and supervisor positions.

2. The radiological control manager should designate the board members and appoint a chairperson.

3. The board constituted to evaluate RCT qualification should be composed of at least three persons to include an RCT supervisor, radiological control staff, and line management operations department supervisors and staff personnel, as applicable. RCT instructors may participate as non-voting members.

4. The board should assess the candidate's response to normal and emergency situations. Questions should be of the type that is not normally covered in a written examination.

5. The board constituted to evaluate RCT supervisor qualification should not include peers or subordinates as voting members.

645 Continuing Training

1. Following initial qualification, the RCT should begin a 2-year cycle of continuing training required for requalification.

2. Every requalification should include completion of practical training and a comprehensive written examination. A final oral examination board is encouraged.

3. Continuing training in radiological protection knowledge and skills should provide continued improvement in the knowledge and skills of the RCT.

4. Continuing training should include site-specific and DOE-wide changes in requirements and updates of lessons learned from operating experience and industry events.

5. Continuing training should include written examinations as applicable, demonstrations of proficiency controlled by qualification standards, and oral examinations as needed to ensure understanding of the topic.

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

646 Radiological Control Technician Supervisors

1. Because of the nature of their duties, RCT supervisors would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103. Training and education standards for RCT supervisors should be consistent with DOE-STD-1107-97, *Knowledge, Skills, and Abilities for Key Radiation Protection Positions at DOE Facilities*.

2. RCT supervisors should have supervisory and leadership capabilities to direct the work of technicians; effectively interact with crafts, line supervisors, professional staff, and other managers; and be able to respond and direct others in emergency and abnormal situations.

3. RCT supervisors' knowledge of facility radiological control hazards, programs, and procedures should be reassessed every 2 years. DOE encourages the use of comprehensive oral examination boards in accordance with Article 643.

4. Oral examination boards should focus on the ability to analyze situations and supervise subordinates. The RCT supervisor's depth of knowledge should exceed that expected of an RCT.

647 Subcontracted Radiological Control Technicians

1. Because their responsibilities closely parallel those of in-house RCTs, subcontracted RCTs would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should have the same knowledge and qualifications required of facility technicians performing the same duties. To obviate the need for full training as an RCT, the training and qualification program should include the following:

    a. Review of resumes to identify technicians with experience in jobs similar to those for which they will be employed
    b. Written examination and oral evaluation to verify appropriate knowledge level
    c. Identification of the duties technicians will be authorized to perform
    d. Training in facility procedures and equipment associated with the authorized duties
    e. Training on site-specific information, as applicable
    f. Observation of on-the-job performances by the radiological control technician Supervisor.

2. Subcontracted technicians who work at the facility for extended time periods (more than 6 months) should receive continuing training commensurate with their assigned duties, as applicable to the contract agreement. Completion of an oral examination in accordance with Article 643 is encouraged.

PART 5 Other Radiological Training

651 Management Training

1. Training and education standards for line managers of radiological control programs (or elements of those programs) should be consistent with DOE-STD-1107-97.

2. Line managers (DOE and contractors) who manage, supervise, or provide oversight of radiological control programs would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should be trained in the principles of this Standard. DOE has developed a course appropriate for these individuals. This course is, Radiological Control Training for Supervisors (DOE-HDBK-1130-2008, *Radiological Worker Training Appendix A - Radiological Control Training for Supervisors*).

3. Such training should be based on DOE's core course training materials supplemented by site-specific procedures and be completed by new personnel prior to formally assuming line supervision and management responsibilities. This training should include the following:

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

4. Incumbents should participate in continuing training. The continuing training should emphasize self-assessment and external evaluations including performance indicators, root causes, and lessons learned based on operational experience.

652 Technical Support Personnel

Appropriate technical support personnel (engineers, schedulers, procedure writers) may be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should be trained in the ALARA fundamentals and dose reduction techniques. They should also participate in selected portions of job-specific and specialized training, particularly in situations using mock-ups. Technical support personnel should receive training consistent with DOE-HDBK-1110-2008, *ALARA Training for Technical Support Personnel*.

653 Planners

Planners who develop detailed work plans involving or associated with radioactivity or radioactive materials should have Radiological Worker Training to the level required by the workers using the work plans. It is recommended that planners have Radiological Worker II training. Planners would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103. Planners should receive training consistent with DOE-HDBK-1110-2008, *ALARA Training for Technical Support Personnel*.

654 Radiological Control Personnel

1. Radiological Control senior staff (see Article 143) and management would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should have:

    a. A combination of education and experience commensurate with their job responsibilities
    b. Continuing training based on an assessment of job responsibilities to maintain and enhance proficiency
    c. Continuing training to remain cognizant of changes to the facility, operating experience, procedures, regulations, and quality assurance requirements.

2. Radiological support personnel may include but are not limited to: dosimetry technicians; instrument technicians; medical personnel; records clerks; whole body counter technicians; and laboratory personnel.

3. Radiological support personnel would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should have:

    a. Applicable training on standardized core course topics from Radiological Worker I and II and Radiological Control Technician Training and additional job-specific topics
    b. Training appropriate to the tasks to be performed
    c. Continuing training to provide continued improvement in knowledge and skills.

4. Training and education standards for radiological control senior staff and support personnel should be consistent with DOE STD-1107-2007.

5. DOE encourages certification and involvement with professional industry organizations.

655 Radiographers and Radiation Generating Device Operators

1. Radiographers would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should have training in accordance with 10 CFR 34.31.

2. Radiation generating device operators would generally be considered to be subject to the education, training, and skill requirements of 10 CFR 835.103 and should have training appropriate for the radiation source involved and commensurate with the level described in 10 CFR 34.43

3. DOE has developed a course appropriate for operators of x-ray devices. This course is Radiological Safety Training for Radiation-Producing (X-Ray) Devices (DOE-HDBK-1130-2008, *Radiological Worker Training Appendix C - Radiological Safety Training for Radiation-Producing (X-Ray) Devices*).

656 Emergency Response Personnel

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

1. Emergency response personnel, from both on-site and off-site, may be required to work in radiological areas.

2. Emergency response personnel should receive special radiological worker training commensurate with the situations they are likely to encounter. Any individual assigned to perform emergency actions that may result in a dose exceeding the occupational dose limits shall receive Radiological Worker or equivalent training [see 835.1302(c)].

3. Such training should be based on DOE's Radiological Worker core course and site-specific training materials.

4. If such workers are not trained, trained escorts should be assigned.

5. Training should make it clear that lifesaving has priority over radiological controls.

6. Records of this training should be maintained.

PART 6 Training For Special Applications

661 Plutonium Facilities

The content of DOE-HDBK-1145-2008, *Radiological Safety Training for Plutonium Facilities*, should be considered in addition to DOE's core training materials at plutonium facilities.

662 Uranium Facilities

The content of DOE-HDBK-1113-2008, *Radiological Safety Training for Uranium Facilities*, should be considered in addition to DOE's core training materials at uranium facilities.

663 Tritium Facilities

The content of the training appendix to DOE-HDBK-1129-2008, *Tritium Handling and Safe Storage*, should be considered in addition to DOE's core training material at tritium facilities.

664 Accelerator Facilities

The content of DOE-HDBK-1108-2002, *Radiological Safety Training for Accelerator Facilities*, should be considered in addition to DOE's core training material at accelerator facilities.

665 Radiological Contamination Control for Laboratory Research

DOE has developed a course appropriate for individuals who participate in laboratory research using radioactive materials. This course is, Radiological Contamination Control for Laboratory Research, (DOE-HDBK-1130-2008, *Radiological Worker Training Appendix B - Radiological Contamination Control for Laboratory Research*).

CHAPTER 7 RADIOLOGICAL CONTROL RECORDS

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PART 1 General Provisions

711 Purpose

This chapter prescribes practices for preparing and retaining radiological control records. The work force and management are required to use records to document radiological safety afforded to individuals on-site. Records of radiological control programs may be required to support worker health studies and future disputes or claims. Therefore, these records should be high quality, readily retrievable, and managed for the prescribed retention period. Consideration should be given to cross-referencing related records to aid retrievability. Records shall be handled such that personal privacy is protected.

712 Records Management Program

1. A radiological records management program should be established. This program should ensure that auditable records and reports are controlled through the stages of creation, distribution, use, arrangement, storage, retrieval, media conversion (if applicable), and disposition. The records management program shall be sufficient to ensure that records are maintained as necessary to document compliance with 10 CFR 835 [see 835.701(a)] and should include records of the following:

    a. Radiological Control Policy Statements
    b. Radiological Control Procedures
    c. Individual Monitoring Records
    d. Internal and External Dosimetry Policies and Procedures (including Bases Documents)
    e. Personnel Training (course records and individual records)
    f. ALARA Program Implementation
    g. Radiological Instrumentation Test, Maintenance, and Calibration
    h. Radiological Surveys
    i. Area Monitoring Dosimetry Results
    j. Radiological Work Permits
    k. Radiological Performance Indicators and Assessments
    l. Radiological Safety Analysis and Evaluation Reports
    m. Quality assurance measures
    n. Radiological Incident and Occurrence Reports (and Critique Reports, if applicable)
    o. Sealed radioactive source accountability and control
    p. Release of material to controlled areas
    q. Reports of loss of radioactive material.

2. Where radiological services (for example, dosimetry and laboratory analyses) are purchased, there should be a clear agreement regarding records responsibility during performance of the service. Records of results should reside in the custody of the originating contract organization.

3. Detailed information concerning an individual's exposure shall be made available to that individual, upon request. An individual's exposure information may be provided to others consistent with the Privacy Act of 1974 (PA), which contains requirements to protect the privacy of individual records [see 835.702(f) and 801(d)].

4. The records management program shall:
    a. Protect records containing entire or partial social security numbers as Personally Identifiable Information (PII).
    b. Only disclose information in accordance with the Privacy Act and the Health Insurance Portability and Accountability Act of 1996 (HIPAA) as appropriate.

713 Recordkeeping Standards

1. Radiological control records should be accurate and legible. The records should include the following:

    a. Identification of the facility, specific location, function, and process
    b. Signature or other identifying code of the preparer and date
    c. Legible entries in ink
    d. Corrections identified by a single line-out, initialed and dated
    e. Supervisory signature to ensure review and proper completion of forms.

2. A file of names, signatures, and initials for future identification of the individual who signed or initialed a record should be maintained, as needed, with the record or by the radiological control organization.

3. Radiological control records should not include:

    a. Opaque substances for corrections
    b. Shorthand or other non-standardized terms.

4. Similar procedural standards should be established for records of data that are recorded and stored electronically.

5. Unless otherwise specified, radiological control records shall use the special units of curie, roentgen, rad, and rem, including multiples of these units, or other conventional units such as dpm, dpm/100 cm^2 [see 835.4]. Use of the international system of units (becquerel, gray, and sievert) should be limited to calculational, scientific, or reference purposes. The SI units, ecquerel (Bq), gray (Gy), and sievert (Sv), may be provided parenthetically for reference with scientific standards.

PART 2 Employee Records

721 Employment History

1.For each radiological worker whose occupational exposure is monitored in accordance with Article 511.1 or 521.1, efforts shall be made to obtain records of prior years' occupational doses. If formal records of previous occupational doses cannot be obtained, a written estimate signed by the individual may be accepted [see 835.702(e)]. Where practical, the association between the radiation dose and job function should be preserved for trending purposes and future worker health studies. The following information should be maintained:

a. Previous work history detailing radiological work assignments, to the extent practical, and yearly occupational doses at other DOE and non-DOE facilities.
b. Nuclear Regulatory Commission Form 4 or equivalent that documents previous occupational radiation doses.
c. Ongoing work history documenting job classification and radiation doses; the facility and occupational codes required by DOE O 231.1B, Environment Safety and Health Reporting, for reporting occupational dose to DOE should be used for this process.
d. DOE standardized forms to document previous and ongoing radiation doses.

722 Personnel Radiological Records

1. Individual monitoring records shall be maintained to demonstrate compliance with the regulatory limits [see 835.701(a)].

   a. Records of doses received by all individuals for whom individual monitoring was performed as required by Article 511.1 or 521.1, including records of zero dose, shall be maintained [see 835.702(a)].
   b. These records shall be sufficient to evaluate compliance with all applicable dose limits and monitoring and reporting requirements [see 835.702(c)(1) & (2)].

2. Radiation dose records shall contain information sufficient to identify each person, including social security, employee number, or other unique identifier [see 835.702(c)(2)].

3. Procedures, data, and supporting information needed to reconfirm an individual's dose at a later date shall be maintained [see 835.702(g)].

4. External dose records shall include applicable extremity, skin, lens of the eye, and whole body dose monitoring results [see 835.702(c)(3)]. These doses are usually measured with personnel dosimeters, but records may include:

   a. Evaluations resulting from anomalous dose results such as unexpected high or low doses
   b. Dose evaluations from lost or damaged dosimeters, or for unmonitored workers
   c. Evaluations of non-uniform radiation doses.

5. Internal dose records shall include committed effective dose [see 835.702(c)(4)(i)], committed equivalent doses to the affected organs and tissues [see 835.702(c)(4)(ii)], and identity of radionuclides [see 835.702(c)(4)(iii)]. The supporting information typically includes the following:

    a. Applicable whole body and lung counting results (including chest wall thickness measurements where applicable)
    b. Applicable urine, fecal and specimen analysis results, including estimated intake
    c. Dose assessment, as required.

6. Records of the summation of external equivalent dose to the whole body and committed equivalent dose to any organ assigned a dose shall be maintained for the individual receiving such dose [see 835.702(c)(5)(ii)].

7. The total effective dose received by each individual monitored in accordance with Article 511.1 or 521.1 shall be maintained for each year the individual is monitored [see 835.702(c)(5)(i)].

8. The equivalent dose to the embryo/fetus of a declared pregnant worker shall be maintained [see 835.702(c)(6)] and should be kept with the occupational dose records for that worker.

9. Individual dose records shall include the cumulative total effective dose [see 835.702(c)(5)(iii)].

10. Reasonable efforts shall be made to obtain records of prior years' doses for each radiological worker monitored in accordance with Article 521 or 522 [see 835.702(e)]. If an individual's previous employer is not responsive to initial efforts to obtain these records, at least two additional attempts should be made. Records of lifetime occupational dose should be maintained with the individual's occupational dose records. Some radiological workers, such as Defense Nuclear Facilities Safety Board and DOE Headquarters staff members, may have site access but not be expected to exceed 100 mrem in a year at the site. Maintenance of lifetime dose records for these individuals is not expected.

11. Records of authorization to exceed administrative control levels should be retained.

12. Emergency doses and planned special exposures [see 835.204 & 1302] shall be accounted for separately, but should be maintained with the individual's occupational dose records.

13. Records of non-uniform dose to the skin need not be retained in an individual's dose records if the dose is less than 2 percent of the limit for the skin in Table 2-1 [see 835.702(b)] (see Article 723 for requirements for records of radiological incidents and occurrences).

14. Records of internal dose (committed effective dose or committed equivalent dose) are not required if the dose is less than 0.01 rem (0.1 mSv). The bioassay or air monitoring result used to estimate the dose shall be maintained. The unrecorded internal dose estimated for any individual in a year shall not exceed the applicable monitoring threshold.

723 Other Personnel Radiological Records

1. The complete records of radiological incidents and occurrences involving personnel dose should be retained in, or cross-referenced to, the individual's dose records. Records related to doses exceeding the Table 2-1 limits including authorized emergency doses and planned special exposures and other, non-authorized doses exceeding the limits, shall be maintained [see 835.1301(b)].

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

3. Records of the formal written declaration of pregnancy, including the estimated conception date, and revocations of declarations of pregnancy shall be maintained [see 835.704(d)]. Records indicating that the pregnancy has concluded (therefore, the conditions of Article 215 do not apply) should also be maintained.

724 Medical Records

1. Pre-employment medical records, if available, and reports of periodic medical examinations should be maintained.

2. Physical examination reports and fit testing results for respirator use should be maintained for respirator users.

3. Medical evaluations and treatment performed in support of the radiological control program should be documented.

4. Medical treatments such as chelation therapy to reduce the committed effective dose and committed equivalent dose from unplanned internal exposures.

5. Disclosure of medical records shall be consistent with HIPAA.

725 Radiological Training and Qualification Records

1. Records of training and qualification in radiological control are maintained to demonstrate that an individual received appropriate information to perform the work assignment in a safe manner. Qualification standard records are retained for on-the-job and practical factor training as well as for formal classroom training.

2. Formal records or summary reports of training and qualification should be readily available to first-line supervision and management of involved personnel to aid in making work assignments.

3. Personnel training records shall be controlled and retained [see 835.704(a)]. At a minimum, these records should include the following:

    a. Course title
    b. Attendance records with instructor's name
    c. Employee's name and identification number
    d. Date of training
    e. Identification of the examination or evaluation form, including sufficient data to identify which test each individual completed
    f. Verification document or record confirming satisfaction of the training requirement
    g. Documentation related to exceptions for training requirements and extensions of qualification
    h. Quizzes, tests, responses and acknowledgments of training, with the date and signature of the individual trained
    i. Special instructions to females, their supervisors, and coworkers concerning prenatal radiation dose, acknowledged by the worker's signature.

4. Records shall be retained for the following types of radiation safety training [see 835.704(a)]:

    a. General employee radiological training
    b. Radiological worker training
    c. Periodic training, as appropriate
    d. Members of the public training for unescorted access.

5. Records should be retained for the following types of radiation safety training:

    a. Instructor training
    b. Training of other radiological control personnel
    c. Respiratory protection training
    d. Qualifications for special tests or operations
    e. Orientation of members of the public
    f. Training of emergency response personnel.

6. Records shall be maintained as necessary to demonstrate that individuals who are responsible for the development and implementation of measures necessary to ensure compliance with 10 CFR 835 have the appropriate education, training, and skills to execute these responsibilities [see 835.103 and 835.701(a)]. These records should include records of the training provided in accordance with Parts 4 and 5 of Chapter 6 of this Standard.

7. The following instructional materials should be maintained:

    a. Course name, with revision and approval date.
    b. Instructor's manuals, course content, or lesson plans containing topical outlines.
    c. Video and audio instructional materials, including the dates and lessons for which they were used.
    d. Official handouts or other materials retained with the master copy of the course.
    e. Job-specific training documents, such as instrument use, radiological procedures, radiological work permit special training requirements, pre-job briefings, and mock-up training.

PART 3 [Reserved]

PART 4 Radiological Control Procedures

741 Policies, Procedures, and Radiological Work Permits

Records of the radiological control program should consist of policy statements, procedures, work authorizations, and supporting data. The records should be maintained in a manner that will allow correlation with the corresponding support information. For example, procedures for performing radiation surveys should be identifiable with the survey results. Completed radiological work permits should be maintained.

742 ALARA Program Records

Records of actions taken to maintain occupational exposures ALARA shall be maintained [see 835.701(a)]. These records shall include facility design and control measures [see 835.704(b)] and should include:

a. ALARA plans and goals
b. The minutes of ALARA committees and other committees where radiological safety issues are formally discussed
c. Records of pre-job briefings and post-job evaluations
d. Records of temporary shield and portable ventilation installation and removal.

743 Quality Assurance Records

Records of quality assurance reviews and audits developed for radiological control functions shall be retained to ensure that sufficient records are specified, prepared, reviewed, approved, and maintained to accurately reflect completed work [see 835.704(c)]. DOE O 414.1D, *Quality Assurance* and 10 CFR 830.120 provide additional information regarding quality assurance records. Quality assurance records should include:

a. Assessment checklists
b. Assessment methods
c. Assessment results
d. Assignment of corrective actions
e. Completion and verification of corrective actions.

PART 5 Radiological Monitoring

751 Area Monitoring Records

1. Radiological control programs require the performance of radiation, airborne radioactivity, and contamination monitoring to determine existing conditions in a given location. Databases, forms or maps with sufficient detail to permit identification of original survey and sampling locations should be maintained. Radiological monitoring results should be recorded on appropriate standard forms or in appropriate electronic formats and should include the following common elements:

    a. Date, time, and purpose of the survey
    b. General and specific location of the survey
    c. Name and signature of the surveyor and analyst
    d. Pertinent information needed to interpret the survey results
    e. Reference to a specific radiological work permit if the survey is performed to support the permit.

2. Records shall be maintained to document:

    a. Results of monitoring and surveys for radiation and radioactive materials [see 835.703(a)]
    b. Results of monitoring and calculations used to determine individual occupational doses [see 835.703(b)]
    c. Results of surveys for release of materials from radiological areas [see 835.703(c)]
    d. Results of sealed radioactive source leak tests and inventories [see 835.704(f)]
    e. Results of surveys of radioactive material packages received from transportation [see 835.405 and 701(a)]
    f. Changes in monitoring equipment, techniques, and procedures [see 835.704(e)].

752 Radiation Monitoring

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

    a. Instrument model and serial number
    b. Results of the measurements of area dose rates
    c. Locations of hot spots and other radiological hazards
    d. Facility conditions existing during the survey that may have affected radiological conditions, as applicable.

753 Airborne Radioactivity Monitoring

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

    a. Model and serial number of the sampler or unique identifier of each sampler and laboratory counting instrument and appropriate supporting parameters including counting efficiency, counting time, and correction factors
    b. Locations of fixed air samplers
    c. Locations of portable air samplers used for a survey
    d. Measured air concentrations
    e. Supporting parameters, including collection efficiency, flow rate, duration of sampling, correction factors, and filter medium
    f. Identification (e.g., names and/or employee numbers) of individuals in the area for whom DAC-hour exposure should be calculated.

754 Contamination Monitoring

In addition to the elements provided in Article 751, records of contamination monitoring should include, at a minimum, the following information:

a. Model and serial number of counting equipment, when direct-reading surveys are conducted
b. Contamination levels (using appropriate units) and whether the contamination was fixed or removable
c. Appropriate supporting parameters such as counting efficiency, counting time, correction factors, type of radiation
d. Location of areas found to contain hot particles or high concentrations of localized contamination
e. Follow-up survey results for decontamination processes, preferably cross-referenced to the original survey.

755 Sealed Radioactive Source Leak Tests and Inventories

1. In addition to the elements provided in Article 751, records of sealed radioactive source leak tests should include, at a minimum, the following information:

   a. Model and serial number of counting equipment
   b. Contamination levels (using appropriate units) and type of radiation with appropriate supporting parameters such as counting efficiency, counting time correction factors
   c. Corrective actions for leaking sources.

2. Records of accountable sealed radioactive source inventories shall include, at a minimum, the following information [see 835.704(f) and 835.1202(a)]:

   a. The physical location of each accountable sealed radioactive source
   b. Verification of the presence and adequacy of associated postings and labels
   c. Verification of the adequacy of storage locations, containers, and devices.

PART 6 Instrumentation and Calibration Records

761 Calibration and Operational Checks

1. Calibration records for fixed, portable, and laboratory radiation measuring instruments and equipment and individual monitoring devices shall be maintained [see 835.703(d)]. These calibration records should include frequencies, method, dates, personnel, training, and traceability of calibration sources to NIST or other acceptable standards.

2. Calibration and maintenance records shall be maintained for instruments and equipment used for monitoring [see 835.703d]. Calibration and maintenance records should be maintained for the following equipment:

    a. Portable survey instruments
    b. Bioassay measurement equipment
    c. Laboratory, counting room, and fixed radiation measuring equipment
    d. Process and effluent monitors and sampling equipment
    e. Radiation area monitors
    f. Portal monitors and other personnel contamination monitors
    g. Pocket and electronic dosimeters
    h. Air sampling equipment
    i. Tool and waste monitoring equipment
    j. Protective clothing and equipment monitors.

3. Documentation of instrument operational checks for documented surveys shall be maintained [see 835.701(a) & 835.401(b)(4)]. Such records should be maintained for a period not less than the calibration period of the instrument.

4. Maintenance results for each instrument and device shall be created and retained [see 835.703(d)]. Maintenance histories for each instrument and device should be created and include the nature of any defects and corrective actions taken.

762 Special Calibration Records

Records of additional tests and checks of instrumentation used in conjunction with a suspected overexposure, questionable indication, or unusual occurrence should be retained. In addition, records of special instrument calibrations and modifications made in accordance with Article 562.6 shall be retained [see 835.703(d)].

PART 7 Records Management

771 Media

A combination of media may be used for a comprehensive records system. All records should be stored in a manner that ensures their integrity, retrievability, and security and, unless otherwise specified, shall be retained until final disposition is authorized by DOE [see 835.701(b)].

772 Microfilm

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

1. Verification that a copy printed from microfilm is legible.

2. Confirmation that all information within a record has been copied to microfilm.

3. Periodic quality audits of the final microfilm version of a record.

773 Computerization of Records

1. Records may be transferred to electronic storage media provided certain precautions are taken to ensure that the information is maintained in a retrievable configuration.

2. Controls for the use and handling of electronic storage media should include the following:

    a. A master index of documents on the electronic storage medium
    b. A program to ensure back-up and retrievability of information
    c. Quality control during data entry and analysis
    d. An index identifying software applications used in conjunction with the data
    e. Software validation and verification
    f. Periodic quality audits of software
    g. Prevention of unauthorized manipulation of data
    h. Assurance that previously stored information is retrievable and useable after system modifications.
    i. Provisions for converting the data to new storage media and software before the current storage media and software become obsolete.

774 Retention

1. 10 CFR 835 establishes requirements for retaining records. Upon cessation of activities that could result in the occupational exposure of individuals, all required records related to individual exposure monitoring shall be transferred to DOE [see 835.702(h)].

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

775 Physical Protection of Records

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

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

3. Records should, as a minimum, be protected from:

    a. Exposure to fire, equivalent to an Underwriters Laboratories, Inc., 1.5-hour, or greater, fire resistance rating.
    b. Exposure to water damage caused by a 100-year flood.
    c. Exposure to windstorm velocities of 100-year recurrence.

PART 8 Radiological Reporting

781 Reports to Individuals

1. Individuals who are monitored in accordance with Article 511.1 or 521.1 shall be provided an annual report of their dose [see 835.801(c)]. Upon request, an individual shall be provided detailed information concerning his or her exposure [see 835.801(d)].

2. Upon request, terminating employees shall be provided a report, as soon as data are available but not later than 90 days following the last day of employment. A written estimate, based upon available information, shall be provided upon termination, if requested [see 835.801(b)].

3. Reports of individual doses shall include the site or facility name, the individual's name and social security number, employee number, or other unique identification number, and all dose information required by Articles 722.4 – 722.9 [see 835.801(a)]. Reporting of lifetime occupational dose is suggested.

4. Reports of individual exposure to radiation or radioactive material required under DOE O 232.2, *Occupational Reporting and Processing of Operations Information* or as a result of a planned special exposure, emergency exposure, or accident should be submitted to DOE in accordance with applicable occurrence reporting requirements. Copies of the individual dose information contained in these reports shall be provided to the affected individual at a time not later than transmittal of the report to the Department [see 835.801(e)].

5. Monitoring results, including zero dose, should be reported to each member of the public monitored in accordance with Article 511 or 521 within 30 days and no later than 90 days after the end of the visit. This report may serve as the annual report to these individuals. However, if an individual visits a site or facility more than once in a year, then an annual report should be sent which sums the doses from all of the visits.

6. Radiation exposure data pertaining to a special individual, as defined by DOE O 231.1B, *Environment, Safety and Health Reporting*, who visits a DOE or DOE contractor site or facility to conduct Department-related business, must be reported to the REMS repository simultaneous with dispatch of reports to individuals, within 30 days after the assessment of the radiation exposure.

782 Annual Radiation Dose Summary

DOE O 231.1B, *Environment, Safety and Health Reporting*, provides reporting requirements for the Annual Radiation Dose Summary. This report includes internal and external radiation dose results for monitored DOE and DOE contractor employees, and for monitored members of the public.

REFERENCES
Citation [Article(s)]

10 CFR 34, *Licenses for Industrial Radiography and Radiation Safety Requirements for Industrial Radiographic Operation,* U.S. Nuclear Regulatory Commission [365.5, 655.1, 655.2]

10 CFR 71, *Packaging and Transportation of Radioactive Material*, U.S. Nuclear Regulatory Commission [423.12, 552.4]

10 CFR 708, *Doe Contractor Employee Protection Program*, U.S. Department of Energy [345]

10 CFR 820, *Procedural Rules for DOE Nuclear Activities*, U.S. Department of Energy [113.2]

10 CFR 830, *Nuclear Safety Management*, U.S. Department of Energy [118.4, 743.1]

10 CFR 835, *Occupational Radiation Protection*, U.S. Department of Energy [multiple citations]

10 CFR 851, *Worker Safety and Health Program*, U.S. Department of Energy [118.4, 312.2]

29 CFR 1910.134, *Respiratory Protection*, Occupational Safety and Health Administration [531, 533.1]

49 CFR 173, *Shippers - General Requirements for Shipments and Packagings*, U.S. Department of Transportation [423.1]

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

ANSI N2.1, (2011) *Radiation Symbol*, [Glossary]

ANSI N43.1 (2011), *Radiation Safety for the Design and Operation of Particle Accelerators* [364]

ANSI N43.2, (2001) *Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment*, [365.2]

ANSI N43.3, (2008) *For General Radiation Safety - Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources, Energies up to 10 MeV*, [365.1]

ANSI N323A, (1997) *Radiation Protection Instrumentation Test and Calibrations, Portable Survey Instruments*, [562.1, 564.1]

ANSI Z88.2, (1992) *Practices for Respiratory Protection*, [531.1. 531.2, 532, 533.1]

ANSI Z88.6, (1984) *Physical Qualifications for Respirator Use*, [532]

ASME AG-1, (2009) *Code on Nuclear Air and Gas Treatment*, [464.3]

ASME N509, (1996) *Nuclear Power Plant Air-Cleaning Units and Components*, [464.3]

ASME N510, (1995) *Testing of Nuclear Air Treatment Systems*, [464.3]

DOE G 151.1-4, (7/11/07) *Response Elements*, [213.2]

DOE G 420.2-1A (8/1/14), *Accelerator Facility Safety Implementation Guide for DOE O 420.2B, 'Safety of Accelerator Facilities* [364]

DOE G 440.1-1B, (10/20/11) *Worker Safety and Health Program for DOE (Including the National Nuclear Security Administration) Federal and Contractor Employees*, [312.2]

DOE G 441.1-1C Admin Chg 1, (7/8/11) *Radiation Protection Programs Guide for Use with Title 10, Code of Federal Regulations, Part 835, Occupational Radiation*, [112, 154.1, App 5A]

DOE O 231.1B, Admin Chg 1 (11/28/12) *Environment, Safety, and Health Reporting*, [431.1, 721.1, 781.6, 782]

DOE O 232.2 (8/29/11) *Occurrence Reporting and Processing of Operations Information*, [127, 781.4]

DOE O 414.1D, (4/25/11) *Quality Assurance*, [743]

DOE O 420.1C, (12/4/12) *Facility Safety*, [118.4, 128, 381]

DOE O 420.2C, (7/21/11) *Safety of Accelerator Facilities*, [364.2]

DOE O 422.1, (6/29/11) *Conduct of Operations*, [125]

DOE O 426.2, (4/21/10) *Personnel Selection, Qualification and Training Requirements at DOE Nuclear Facilities*, [613.10]

DOE O 435.1 Admin Chg1, (8/28/01) *Radioactive Waste Management*, [118.4, 441, 442, 451]

DOE O 440.1B Admin Chg1, (8/21/12) *Worker Protection Program for DOE (including National Nuclear Security Administration) Federal Employees*, [118.4, 312.2]

DOE O 450.2, (4/25/09) *Integrated Safety Management*, [118]

DOE O 458.1 Admin Chg 3, (615/13) *Radiation Protection of the Public and the Environment*, [118.4, 222.4, 238.1, 422]

DOE O 460.1C, (5/14/10) *Packaging and Transportation Safety*, [118.4, 423.5]

DOE P 450.4A, (4/25/09) *Safety Management System Policy*, [118]

DOE-HDBK-1108-2002 (CN1), (1/07) *Radiological Safety Training for Accelerator Facilities*, [664]

DOE HDBK-1110-2008, (2/08) *ALARA Training for Technical Support Personnel*, [652, 653]

DOE-HDBK-1113-2008, (4/08) *Radiological Safety Training for Uranium Facilities*, [662]

DOE-HDBK-1122-2009 (CN-2) (2011) *Radiological Control Technician Training*, [642.1]

DOE-HDBK-1129-2008, (12/08) *Tritium Storage and Safe Handling*, [363,663]

DOE-HDBK-1130-2008 (CN-1), (6/09) *Radiological Worker Training*, [631,651.2, 655.3, 665]

DOE-HDBK-1131-2007 (CN-1), (6/09) *General Employee Radiological Training*, [621.1]

DOE-HDBK-1145-2008, (4/08) *Radiation Safety Training for Plutonium Facilities*, [661]

DOE-STD-1095-2011, (1/11) *Department of Energy Laboratory Accreditation Program for External Dosimetry*, [512.1]

DOE-STD-1107-97 (CN1), (11/07) *Knowledge, Skills, and Abilities for Key Radiation Protection Positions at DOE Facilities*, [142.3, 143.3, 646.1, 651.1, 654.4]

DOE-STD-1112-98, (12/98) *Department of Energy Laboratory Accreditation Program for Radiobioassay*, [522.1]

DOE-STD-1121-2008, (10/08) *Internal Dosimetry*, [523]

DOE-STD-1128-2008, (12/08) *Guide of Good Practices for Occupational Radiological Protection in Plutonium Facilities*, [361.2]

DOE-STD-1136-2009, (7/09) *Guide of Good Practices for Occupational Radiation Protection in Uranium Facilities*, [362]

DOE-STD-1189-2008, (3/08) *Integration of Safety into the Design Process*, [381]

DOE-STD-3020-2005, (12/05) *Specification for HEPA Filters Used by DOE Contractors*, [464]

DOE-STD-3025-2007, (2/07) *Quality Assurance Inspection and Testing of HEPA Filters*, [464]

Health Insurance and Portability and Accountability Act of 1996, Public Law 104-191 [712.4, 724.5]

ICRP Publication 60, (1991) *Recommendations of the International Commission on Radiological Protection* [App 5A]

ICRP Publication 74, (1996) *Conversion Coefficients for Use in Radiological Protection against External Radiation* [App 5A]

ICRU Report 51, (1993) *Quantities and Units in Radiation Protection Dosimetry* [App 5A]

NCRP Report 161, (2008) *Management of Persons Contaminated with Radionuclides* [542.1, 543.6]

NRC NUREG-1400, (1993) *Air Sampling in the Workplace* [555.4]

Privacy Act of 1974, as amended, Public Law 93-579 [712.4]

Resource Conservation and Recovery Act of 1976, as amended, Public Law 94-580. [443]

ADDITIONAL REFERENCES

In addition to the documents cited in this Standard, references to documents that may be pertinent to the Department's occupational radiological control program may be found in the reference section of DOE G 441.1-1C.

GLOSSARY

Terms from 10 CFR 835 [see 835.2] are not included in the glossary and are used in this Standard consistent with their regulatory definition.

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

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

administrative control level: A numerical occupational dose constraint established at a level below the occupational dose limits provided in Chapter 2 to administratively control and help reduce individual and collective dose.

ALARA Committee: Multi-disciplined forum that reviews and advises management on improving progress toward controlling radiation exposure and radiological releases.

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

becquerel (Bq): The International System (SI) derived unit for radioactivity. One becquerel is equal to one nuclear decay or transformation per second.

collective dose: The sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation

company-issued clothing: Clothing provided by the company for non-radiological purposes, such as work coveralls and shoes.

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

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

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

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

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

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

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

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

direct contamination reading: The apparent surface contamination level, expressed in disintegrations per minute per 100 cm^2, resulting when an appropriate contamination probe or detector is placed in close proximity (e.g., ~1/4 inch) to the soil surface. Appropriate efficiency and geometry correction factors should be applied to such a reading.

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

DOELAP: Department of Energy Laboratory Accreditation Program for personnel dosimetry and bioassay programs.

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

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

engineered controls: A special form of physical design feature in which components and systems, such as piping, containments, ventilation, filtration, or shielding, are used to reduce airborne radioactivity, radiation levels, and the spread of contamination.

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

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

fixed contamination: Radioactive material that has been deposited onto a surface and cannot be readily removed by non-destructive means, such as casual contact, wiping, brushing, or laundering. Fixed contamination does not include radioactive material that is present in a matrix, such as soil or cement, or radioactive material that has been induced in a material through activation processes.

frisk or frisking: Process of surveying personnel for contamination. Frisking can be performed with hand-held survey instruments or automated monitoring devices.

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

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

high-efficiency particulate air (HEPA) filter: Throwaway extended pleated medium dry-type filter with 1) a rigid casing enclosing the full depth of the pleats, 2) a minimum particle removal efficiency of 99.97 percent for thermally generated monodisperse di-octyl phthalate smoke particles with a diameter of 0.3 micrometer, and 3) a maximum pressure drop of 1.0 inch w.g. when clean and operated at its rated airflow capacity.

hot particle: Fuel, activated corrosion product, or other particles of small size that have a high specific activity as a result of nuclear fission or neutron activation. When in direct contact with the skin, hot particles are capable of producing a equivalent dose to the skin of 100 millirem or more in one hour to a localized area.

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

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

irradiator: Sealed radioactive material used to irradiate other materials and that has the potential to create a radiation level exceeding 500 rad (5 grays) in 1 hour at 1 meter. Although not addressed in this Standard, acceptable radiological controls for irradiator use are specified in Title 10, Code of Federal Regulations, Part 36.

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

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

personal protective equipment: Equipment such as respirators, face shields, safety glasses and protective clothing used to protect workers from excessive exposure to radioactive or hazardous materials.

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

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

planned special exposure: Preplanned, infrequent exposure to radiation, separate from and in addition to the annual dose limits.

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

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

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

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

rad: Unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs per gram or 0.01 joules per kilogram (0.01 gray).

radioactive material: Any material that spontaneously emits ionizing radiation (e.g., X- or gamma rays, alpha or beta particles, neutrons). The term "radioactive material" also includes materials onto which radioactive material is deposited or into which it is incorporated. For purposes of practicality, both 10 CFR 835 and this Standard establish certain threshold levels below which specified actions, such as posting, labeling, or individual monitoring, are not required. These threshold levels are usually expressed in terms of total activity or concentration, contamination levels, individual doses, or exposure rates.

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

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

radiography: Examination of the structure of materials by non-destructive methods, using a radioactive source or a radiation generating device.

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

radiological control hold point: Cautionary step in a technical work document requiring the radiological control organization to perform some action or verification. The radiological control hold point requirements should be satisfactorily completed before the work is continued.

radiological control technician: A radiological worker whose primary job assignment involves assessment of workplace radiological conditions, specification of protective measures, and provision of assistance and guidance to other individuals in implementation of radiological controls.

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

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

Radiological Source Registry and Tracking (RSRT) system: DOE's centralized repository for reporting information on sealed sources according to DOE O 231.1B.

radiological work: Any work that requires handling of radioactive material or access to radiological areas.

radiological work permit (RWP): Permit that identifies radiological conditions, establishes worker protection and monitoring requirements, and contains specific approvals for radiological work activities. The radiological work permit serves as an administrative process for planning and controlling radiological work and informing the worker of the radiological conditions.

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

release to uncontrolled areas: Release of material from administrative control after confirming that the residual radioactive material meets the requirements in DOE O 458.1

rem: Unit of equivalent dose and effective dose.

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

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

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

site: An area managed by DOE where access can be limited for any reason. The site boundary encompasses controlled areas.

soil contamination area: An area in which soil contamination is present at levels that are not releasable in accordance with DOE's environmental protection standards.

standard radiological warning trefoil: Symbol designed and proportioned as illustrated in ANSI N2.1.

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

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

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

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

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

transferable contamination: The total contamination levels, expressed in terms of disintegrations per minute per 100 cm^2, on items such as shoes, shoe covers, vehicle tires, tools, or other equipment that have come into contact with contaminated soils.

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

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

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