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DOE-STD-1098-99
July 1999

DOE STANDARD

RADIOLOGICAL CONTROL

U.S. Department of Energy
Washington, D.C. 20585

AREA SAFT

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*. Failure to comply with these requirements may lead to appropriate enforcement actions as authorized under the Price Anderson Act Amendments (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 series of Guides. The Guides are 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 Guides establish a macroscopic view of the various elements of a comprehensive radiation protection program and discuss concepts that the cognizant professionals should consider in developing and implementing the site- and facility-specific programs.

This Standard supplements the DOE G 441.1 series of Guides and serves as a secondary source of guidance for achieving compliance with 10 CFR 835. While there is significant overlap between the DOE G 441.1 series of Guides and this Standard, this Standard differs from the Guides in both intent and detail. In contrast to the macroscopic view adopted by the Guides, 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.

Both the science of health physics and the practice of radiological control are relatively new and continue to evolve at a rapid rate. DOE encourages the users of this Guide to submit comments regarding its content, accuracy, and utility.

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Following is a reprint of the Department of Energy Radiological Health and Safety Policy, which was originally published as DOE P 441.1 on April 26, 1996.

DEPARTMENT OF ENERGY
Radiological Health and Safety Policy

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

In meeting this policy, the Department shall:

A. **Establish and maintain a system of regulatory policy and guidance reflective of national and international radiation protection standards and recommendations.** The Assistant Secretary for Environment, Safety and Health has responsibility for promulgating and maintaining policies, standards, and guidance related to radiological protection. Departmental radiological protection requirements are, at a minimum, consistent with the presidentially approved "Radiation Protection Guidance to the Federal Agencies for Occupational Exposure" which was developed by the Environmental Protection Agency in accordance with its mandated Federal guidance responsibilities. Departmental requirements often are more stringent and reflect, as appropriate, recommendations and guidance from various national and international standards-setting and scientific organizations, including the International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, the American National Standards Institute, and others. Departmental requirements related to radiological protection will be set forth, as appropriate, in rules and Department of Energy Orders, and guidance documents will be issued on acceptable means to implement these requirements.

B. **Ensure personnel responsible for performing radiological work activities are appropriately trained.** Standards shall be established to ensure the technical competency of the Department's work force, as appropriate, through implementation of radiological training and professional development programs.

C. **Ensure the technical competence of personnel responsible for implementing and overseeing the radiological control program.** An appropriate level of technical competence gained through education, experience, and job-related technical and professional training is a critical component for achieving the goals of the Department's radiological control policy. Qualification requirements commensurate with this objective shall be established for technical and professional radiological control program positions and shall, at a minimum, be consistent with applicable industry standards and promote professional development and excellence in radiological performance as a goal.

D. **Establish and maintain, at all levels, line management involvement and accountability for departmental radiological performance.** The responsibility for compliance with Departmental radiological protection requirements, and for minimizing personnel radiation exposure, starts at the worker level and broadens as it progresses upward through the line organization. The Department's line managers are fully responsible for radiological performance within their programs and the field activities and sites assigned to them, and shall take necessary actions to ensure requirements are implemented and performance is monitored and corrected as necessary.

E. **Ensure radiological measurements, analyses, worker monitoring results and estimates of public exposures are accurate and appropriately made.** The capability to accurately measure and analyze radioactive materials and workplace conditions, and determine personnel radiation exposure, is fundamental to the safe conduct of radiological operations. Policy, guidance, and quality control programs shall be directed towards ensuring such measurements are appropriate, accurate, and based upon sound technical practices.

F. **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.** Radiological operations and activities shall be preplanned to allow for the effective implementation of dose and contamination reduction and control measures. Operations and activities shall be performed in accordance with departmental conduct of operations requirements and shall include reasonable controls directed toward reducing exposure, preventing the spread of radiological contamination, and minimizing the generation of contaminated wastes and the release of effluents.

G. **Incorporate dose reduction, contamination reduction, and waste minimization features into the design of new facilities and significant modifications to existing facilities in the earliest planning stages.** Wherever possible, facility design features shall be directed toward controlling contamination at the source, eliminating airborne radioactivity, maintaining personnel exposure and effluent releases below regulatory limits and utilizing a process that seeks exposure levels and releases as low as reasonably achievable. Radiological design criteria shall reflect appropriate consensus recommendations of national and international standards setting groups.

H. **Conduct oversight to ensure departmental requirements are being complied with and appropriate radiological work practices are being implemented**.

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

IMPORTANT NOTE

DOE Policy 450.4 establishes DOE policy with regard to integrated safety management (ISM) . The principles of ISM and relationship between DOE's ISM Policy and the provisions of this Standard are discussed in Article 118 of this Standard.

FOREWORD

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PART 1 Department of Energy (DOE) Radiological Control Standard

111 Radiological Health and Safety Policy

A key element of the Radiation Protection Guidance to the Federal Agencies for Occupational Exposure approved by President Reagan on January 20, 1987, and a fundamental principle underlying this 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 firmly committed to having a radiological control program of the highest quality. This commitment is reflected in the DOE Radiological Health and Safety Policy reproduced at the beginning of this Standard.

112 Standard Applicability and Control

DOE has established basic standards for occupational radiation protection in Federal regulation 10 CFR 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's 441.1 series of Guides provide guidance for developing and implementing an RPP sufficient to ensure compliance with 10 CFR 835. The DOE 441.1 series of Guides are primarily directed toward radiological control organization professionals who are responsible for developing programs that will ensure regulatory compliance. The Guides therefore tend to provide flexibility for the use of professional judgment and are more technical and general in nature than this Standard. This Standard is primarily 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 the DOE 441.1 series of Guides 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.

1. This Standard is a living document. DOE intends to review and update provisions on a periodic basis to incorporate lessons learned and suggestions for improvement. The Assistant Secretary for Environment, Safety and Health is responsible for this task. Recommendations to correct or improve this Standard are encouraged and should be processed in accordance with DOE's published guidance for providing comments on documents in the DOE technical standards system.

2. This Standard will be kept current and should be entered into the contractor document control system. The Office of Environment, Safety and Health will ensure that a current version of this Standard is maintained on the DOE Technical Information System (TIS).

113 Implementation

1. This Standard sets forth DOE's views on the proper course of action in the area of radiological control within the scope of DOE-sponsored activities. The 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 part 820, *Procedural Rules for DOE Nuclear Activities*, establishes requirements for obtaining exemptions from DOE regulatory requirements. 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 "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); and 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-EH. 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 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, based upon the provisions of this Standard, should be issued and approved by the DOE Operations Office Manager. 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. This Standard assumes that most facilities or sites have organizations in place that generally meet the provisions presented in the text. It is not the intent of this Standard to unnecessarily create 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. A phased approach to transition to the use of the titles of positions in this Standard should be adopted. Corresponding 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 equivalent 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

1. DOE encourages its contractors to establish informal working associations that promote dialogue among the radiological control organizations from similar or comparable facilities. User Groups should include representation from various contractors. Assignment of members to the user groups should be on a rotating basis.

2. To assist contractors in identifying and adopting proven practices and implementing procedures in a timely manner within the DOE complex, DOE encourages its contractors to develop, through the User Groups, Radiological Work Practices Handbooks that can be used by a given category or class of facilities associated with the User Group.

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 physical design features (including engineering controls) and administrative controls to balance the risks of occupational radiation exposure against the benefits arising out of the authorized activity. Lessons learned are documented, institutionalized, and considered in planning and executing subsequent activities to further the goals of the ALARA process and to provide optimal 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 system (ISM) that integrates safety (including radiological safety) into management and work practices at all levels (See DOE Policy P 450.4 and its 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 this Standard 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.

PART 2 Leadership in Radiological Control

Superior, consistent performance is achieved when qualified individuals use approved procedures and management actively monitors the workplace and assesses 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 work space. The DOE Operations 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 Operations Office Manager and the contractor senior site executive should also be familiar with the current radiological control performance record. Key principles common in a successful, well-managed radiological control program are provided in this Chapter.

121 Senior Management Commitment

1. Senior managers should establish high standards for 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 radiological control program of the highest quality. Management commitment and support should be demonstrated, in part, by allocating sufficient resources, including personnel, and providing for training to ensure workers are qualified for their assigned duties.

3. Managers should ensure that orientation, training, and indoctrination reinforce rules and guidelines for each worker to 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 adopt and promote a positive attitude toward radiological control that encourages initiatives to identify concerns at an early stage, to prevent 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 be willing to accept change that will improve radiological control performance and should foster this mindset throughout the organization.

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

9. Senior managers should be alert to opportunities for minimizing the generation of radioactive waste and discharges to the environment, controlling contamination at its source, and reducing radiation exposure to workers and the public.

10. Reporting a problem to a superior (contractor or DOE) does not absolve the manager from promptly fixing or mitigating a situation.

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 his daily duties.

2. The training program should support efforts to improve the attitude of the work force. Training instructors should be knowledgeable about the work environment and those aspects of radiological control that are important to developing a better worker attitude and perspective.

3. The attitude that constant improvement is required in radiological work should be developed at all levels of management and in the work force. Cooperation between the work force and the radiological control organization should be developed and fostered. The workers 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. 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 control rules are applicable to each individual in the workplace. A poster that displays basic worker responsibilities, such as those listed below, should be produced and displayed at appropriate access points and work areas.

TO CONTROL YOUR RADIATION EXPOSURE 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 contamination areas, high contamination areas, and airborne radioactivity areas.

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 exposure status 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.

PRIOR TO ENTERING AREA

- Assure that you are mentally alert and in physically sound condition.
- Limit the amount of material taken into contaminated areas to minimize radioactive waste and future decontamination.
- 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

Due to the continuing concerns of many individuals related to low radiation exposure and health impacts, managers should be trained to deal with personnel perceptions concerning radiation risks. Managers and first-line supervisors should be sensitive to the fact that workers have to understand the fundamentals of radiation, its risks, and their role in controlling exposure. It is not sufficient to rely solely on regulatory limits for establishing or defining acceptable work practices and work environments.

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. Such instances warrant special attention on the part of the manager. Counseling with such individuals is the preferred way to consider relevant factors. In some cases, special control levels as described in Article 216 should be applied.

125 Conduct of Radiological Operations

1. This Standard is consistent with the provisions of DOE 5480.19, Conduct of Operations Requirements for DOE Facilities. The concepts of all chapters of DOE 5480.19 apply to the conduct of radiological control activities.

2. Managers at all levels should be involved in the planning, scheduling, and conduct of radiological work. Assurance of adequate radiological safety should not be compromised to achieve production, remediation, or research objectives.

3. Supervisors should be technically knowledgeable and inquisitive and should ask questions of the work force concerning radiological work details to verify worker comprehension.

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

5. Managers, supervisors, and workers should be involved in the development of accurate, clear, written procedures for performing radiological work. If during the use of procedures a written requirement cannot be responsibly followed, the work should be stopped and guidance obtained.

6. Supervisors and managers should encourage the work force to identify radiological control deficiencies and concerns. Prompt action should be taken to address and eliminate identified issues and prevent recurrence. Training, indoctrination, and procedure review are useful in addressing these issues.

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

8. Cleanliness and good housekeeping are essential. A good radiological control program cannot exist in a sloppy, dirty workplace. Cleaning up after operations should be automatic for each person. It is not reasonable to expect radiological control to be separated from the work environment; they go together.

9. Subcontractors and subcontracted employees should be treated the same as facility staff in the area of radiological 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 Improving Worker Awareness of Radiological Conditions

In performing assigned duties within radiological areas, workers should be familiar with the area radiological conditions and be aware of the possibility that unforeseen changes may occur. Although the conduct of radiological surveys is viewed as a traditional role of radiological control technicians, experience has shown that properly trained and qualified workers are capable of performing supplemental radiological surveys in the course of work. This process results in exposure savings and improved contamination control.

Specific examples of surveys that may be effectively performed by workers and result in exposure reductions include self-monitoring of dose rates 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 the general public, that radiological work practices be continually scrutinized and questioned so that opportunities for improvement can be identified, assessed, and applied.

A formal critique process should be established to obtain pertinent facts following an unusual radiological situation or at the satisfactory conclusion of a new or unusual operation involving radiological controls. This process complements the Occurrence Reporting and Processing System (ORPS) of DOE O 232.1, 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.

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 420.1, Facility Safety. Additional design criteria are provided in Chapter 3.

PART 3 Improving Radiological Control Performance

131 Radiological Performance Goals

DOE O 210.1, Performance Indicators and Analysis of Operations Information, establishes requirements for the use of goals and performance indicators. Goals are intended as a measure of and a motivation for improvement, not an end in themselves. Goals are not to be viewed narrowly as numerical values, but as tools to assist management in focusing their priorities and attention. The following are examples of radiological control goals that may be appropriate:

1. Collective Dose (person-rem): This goal should be based upon planned activities and historical performance. For those sites that have neutron radiation, a goal for collective neutron dose should also be established.

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.

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 site executive should establish, approve, and maintain a radiological control goals and performance indicator program.

2. The radiological control goals should be measurable, achievable, auditable, challenging, and meaningful in promoting improvement.

3. Goals should be developed primarily by those responsible for performing the work. Consideration should be given to the formation of a committee that includes the active participation of the work force.

4. Radiological control goals should be reviewed at least annually and revised as appropriate. Normally, more stringent goals should be set annually to reflect the improved radiological control performance at the facility. Occasionally, a goal may be made less stringent to accommodate changes in work load or mission.

133 Radiological Control Performance Reports

1. The radiological control manager or designee should provide a monthly summary report to the contractor senior site executive for sites which exceed an annual collective dose of one person-rem. This report should include indicators of progress toward achieving 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 monthly report should provide performance indicators for the month, 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 on a frequent enough basis to permit management of radiological control performance. The frequency should be consistent with the nature of the workload and the potential for exceeding the established goals.

3. To promote worker awareness of radiological control performance, selected indicators related to their work group should be posted 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 f. Maximum neutron dose to a worker in rem
Personnel contamination a. Number of skin and personal clothing contaminations b. Number of contaminated wounds c. Number of facial contaminations
Control of internal exposure a. Number of unplanned intakes b. Number of airborne events c. Number of alarms on airborne monitors (actual and false) d. Number of airborne radioactivity areas e. Area of airborne radioactivity areas in square feet
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
Minimization of radioactive waste a. Volume and activity of radioactive waste in cubic feet and curies, respectively b. Number of cubic feet not subject to volume reduction by incineration, compaction, or other means
Control of radioactive discharges a. Activity of liquid radioactivity discharges in curies b. Activity of airborne radioactivity discharges in curies

134 Assessments

Assessment, as used in this 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 of the radiation protection program shall be conducted such that over a 36-month period, all functional elements are assessed [see 835.102]. The audits should address program performance, applicability, content, and implementation. These audits should be performed by the radiological control organization, the quality assurance organization, or other organizations having the requisite knowledge to adequately assess radiological control activities.

2. Identification of the functional elements of the program depends upon many site- or facility 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

3. Managers, supervisors, and workers should look upon assessments as helpful. It is desirable to approach assessments with nothing to hide and with the radiological control program as an open book. Results of assessments should be incorporated into the ongoing process of improving radiological control 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 be frequently 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 and 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 accurate measurements of hundreds of millirem.

- Medical intervention, such as the administration of blocking and chelating agents, to mitigate internal deposition may add risks by introducing additional chemicals into the body.

- 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.

The hierarchy of controls required to control 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 are not as well understood as the effects of gamma exposure.

! Neutron dose equivalent is more difficult to assess than gamma dose equivalent.

Article 131 provides guidance for setting goals to focus attention on controlling neutron exposure.

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.

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 and possibly be combined with other committees for 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 a more effective manner in workplace situations.

2. Radiological control personnel should monitor adherence 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 senior site executive 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, special arrangements should be made. In these situations, the assignment of a deputy with the requisite expertise and qualifications can satisfy the requirement. 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 four-year 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 be sufficiently trained 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 work space
   b. Curtailment of work schedules
   c. Deferral of work
   d. Addition of extra radiological control personnel
   e. Conduct of additional training.

3. When the workers and supervisors achieve the proper level of radiological control performance, the ongoing need for the corrective actions instituted in accordance with Article 145.2 should be reevaluated.

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 Office and applicable Field Office 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. Managers of Operations Offices and the Rocky Flats and Ohio Field Offices 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. Managers of Operations Offices and the Rocky Flats and Ohio Field Offices should designate an individual to be responsible for providing radiological control program assessments, interacting routinely with the Radiological Control Program Advisors of the affected DOE Program Offices, assisting the DOE field line organization in the use of this Standard, and interacting on a periodic basis with counterparts at other sites.

153 Department Policy

The Assistant Secretary for Environment, Safety and Health (EH) is responsible for promulgating and maintaining the overall DOE policy and standards with respect to radiological health and safety. EH is also responsible for periodically revising the Standard to make corrections or improvements to the document. Other DOE elements should rely upon subject matter experts within EH 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

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

1. Uses 10 CFR 835 as its 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 10 CFR 835 Guides (DOE G 441 Series), this Standard, or consensus standards, to achieve compliance, these documents should also be used as basis documents.

2. Assesses DOE Program, Operations, and applicable Field Office 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 Defense Programs, Science, Environmental Restoration and Waste Management, and Nuclear Energy, Science, and Technology, and representatives from EH, Field Management and selected Operations and Field Offices.

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

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 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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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 reduce 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 equivalent, 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. The specific value selected should be more restrictive than the administrative control level established by the Program Office. 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 executive

3. For most facilities, an annual facility administrative control level of 500 millirem or less will be challenging and achievable. An annual administrative control level above 1,500 millirem is in most cases not sufficiently challenging to meet the goals of this Standard.

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 site executive is recommended.

5. 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.

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.

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 equivalent 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, 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 an exceptional situation, 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 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 are not intended to limit actions necessary to protect health and safety under these conditions [see 835.3(d)].

   DOE believes that there are few situations in which conduct of a planned special exposure or emergency exposure will constitute a best management practice and that proper implementation of the provisions of this Standard will obviate the need for conducting these operations. Therefore, specific guidance for conduct of these operations is not provided in this Standard. Requirements for authorizing, conducting, recording, and reporting these operations are provided in 10 CFR 835 and, for emergency exposures, in DOE Emergency Management Guides.

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 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 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 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 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.
   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 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 835.206(c)].

Table 2-1 Summary of Occupational Dose Limits

TYPE OF EXPOSURE	LIMIT
General Employee: Whole Body (internal + external) (TEDE) [see 835.202(a)(1)]	5 rem/year
General Employee: Lens of the Eye (external) [see 835.202(a)(3)]	15 rem/year
General Employee: Skin and extremities (external shallow dose) [see 835.202(a)(4)]	50 rem/year
General Employee: Any organ or tissue (other than lens of eye) (internal + external) [see 835.202(a)(2)]	50 rem/year
Declared Pregnant Worker: Embryo/Fetus (internal + external) [see 835.206(a)]	0.5 rem/ gestation period
Minors: Whole Body (internal + external) (TEDE) [see 835.207]	0.1 rem/year
Minors: Lens of the eye, skin, and extremities [see 835.207]	10% of General Employee limits

Notes:

1. The weighting factors in Appendix 2B shall be used in converting organ dose equivalent to effective dose equivalent for the whole body dose [see 835.203(b)].
2. The annual limit of dose to "any organ or tissue" is based on the committed dose equivalent to that organ or tissue resulting from internally deposited radionuclides over a 50-year period after intake plus any deep dose equivalent to that organ from external exposures during the year[see 835.202(a)(2).
3. 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)].
4. See Appendix 2C for guidance on non-uniform exposure of the skin.
5. Whole body dose (TEDE) = effective dose equivalent from external exposures + committed effective dose equivalent from internal exposures [see 835.2(a)].
6. Lens of the eye dose equivalent = dose equivalent from external exposure determined at a tissue depth of 0.3 cm [see 835.2(a)].
7. Shallow dose equivalent = dose equivalent from external exposure determined at a tissue depth of 0.007 cm [see 835.2(a)].

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 for annual occupational exposure should be established for 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.

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

3. 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 engineering 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 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 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 DOE's environmental protection standards, a soil contamination area should be established 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 radiological buffer area.

223 Airborne Radioactivity Control Levels

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

2. Posting requirements for areas with airborne radioactivity 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 835.1102(c)(1)].

2. Markings indicating the status of the area shall be applied [see 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]

RADIONUCLIDE (See Note 1)	REMOVABLE (dpm/100 cm^2) (See Note 2)	TOTAL (FIXED + REMOVABLE) (dpm/100 cm^2) (See Note 3)
U-natural, U-235, U-238, and associated decay products	1,000 alpha	5,000 alpha
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[6], 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. Includes mixed fission products containing Sr-90[7].	1,000 beta-gamma	5,000 beta-gamma
Tritium and tritiated compounds	10,000	NA

Notes:

1. Except as noted in Footnote 5 below, the values in this Table apply to radioactive contamination deposited on, but not incorporated into the interior of, the contaminated item. Where contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for the alpha- and beta-gamma-emitting nuclides apply independently [see 835 App. D, note 1].
2. The amount of removable radioactive material per 100 cm^2 of surface area should be determined by swiping the area with dry filter or soft absorbent paper while applying moderate pressure and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency (Note: The use of dry material may not be appropriate for tritium.). For objects with a surface area less than 100 cm^2, the entire surface should be swiped, and the activity per unit area should be based on the actual surface area. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual contamination levels are below the values for removable contamination [see 835 App. D, note 4].
3. The levels may be averaged over 1 square meter provided the maximum activity in any area of 100 cm^2 is less than three times the values in Table 2-2 [see 835 App. D, note 3].
4. This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them It does not apply to Sr-90 that has been separated from the other fission products or mixtures where the Sr-90 has been enriched [see 835 App. D, note 5].
5. Tritium contamination may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may migrate to the surface in order to ensure the surface radioactivity value provided in this Table is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a "Total" value does not apply [see 835 App. D, note 6].
6. These values should be applied to total Sr-90/Y-90 activity resulting from processes involving the separation or purification of Sr-90.
7. These values should be applied to total Sr-90/Y-90 activity resulting from the presence of Sr-90 in mixed fission products.

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 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 10 CFR 835 Guides, 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 yellow and magenta in color.

10. Physical barriers should be placed so that they are clearly visible from all directions and at various elevations. They should not be easily walked over or under, except at identified access points. These barriers shall be set up such that they do not impede the intended use of emergency exits or evacuation routes [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. All radiological areas and radioactive material areas lie within the boundaries of controlled areas. Individuals who enter only the controlled area without entering radiological areas or radioactive material areas are not expected to receive a total effective dose equivalent 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 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 secondary boundaries within the controlled area 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.

2. A radiological buffer area should be established for exposure control adjacent to radiation, high radiation, and very high radiation areas. The boundary for the radiological buffer area should be established to limit radiation doses to general employees to less than 100 millirem per year.

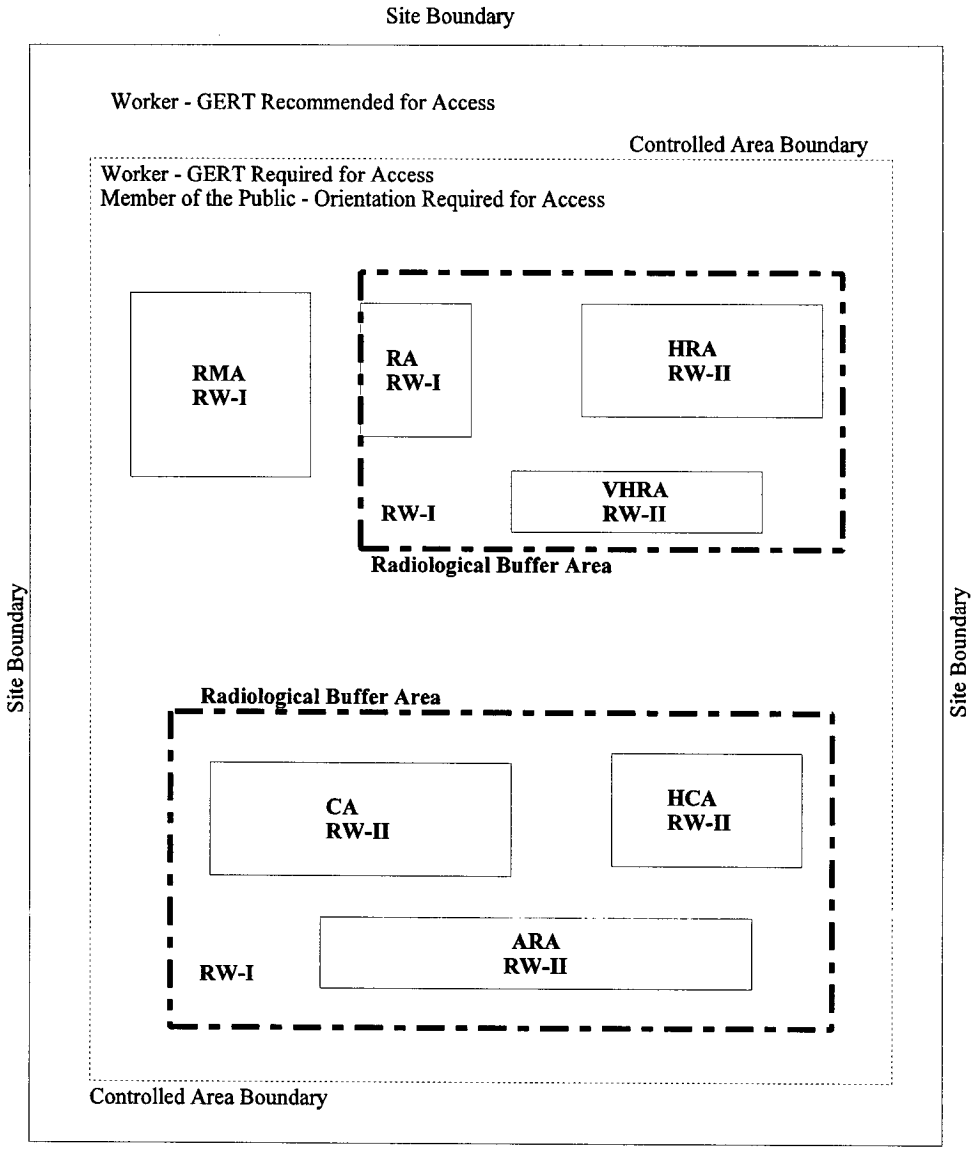
3. A radiological buffer area is not required for:

    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.

4. The need for radiological buffer areas around radioactive material areas, soil contamination areas, and underground radioactive material areas should be evaluated based upon the potential for 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
RW-II - Radiological Worker II
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, 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). At very high doses received at high dose rates (such as doses received in a very high radiation area), dose rates should be measured and recorded in units of "rads" rather than "rem" in an hour.

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"*
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"*

* 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 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"

[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 4A are used, handled, or stored shall be posted "CAUTION, RADIOACTIVE MATERIAL" [see 835.603(g)].

2. Radioactive material areas shall be located within controlled areas [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). 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.

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

3. Underground radioactive material areas may be located outside controlled areas unless access is likely to result in individual doses (total effective dose equivalent) 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 DOE's environmental protection standards, 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 equivalent 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
Weighting Factors for Organs and Tissues
[see 835.2(b), Weighting factor]

ORGANS OR TISSUES	WEIGHTING FACTOR
Gonads	0.25
Breasts	0.15
Red bone marrow	0.12
Lungs	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder	0.30
Whole Body	1.00

Notes:

1. Weighting factors as defined in ICRP Publication 26 and NCRP Report 91 are used to convert organ or tissue dose equivalent to effective dose equivalent for the whole body. The effective dose equivalent is obtained by multiplying the organ dose by the weighting factor. For example, a 5 rem dose to the thyroid would be multiplied by the weighting factor 0.03 to yield a contribution of 0.15 rem to the total effective dose equivalent.

2. "Remainder" means the five other organs or tissues with the highest dose (e.g. liver, kidney, spleen, thymus, adrenal, pancreas, stomach, small intestine, and upper large intestine). The weighting factor of 0.30 results from 0.06 for each of the five remainder organs [see 835.2(b), Weighting factor, Note 1].

3. For the case of uniform external irradiation of the whole body, a weighting factor equal to 1 may be used in the determination of the effective dose equivalent [see 835.2(b), Weighting factor, Note 2].

Appendix 2C

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(a)].

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 dose equivalent also received by the skin Recorded as the annual extremity or skin (shallow) dose equivalent (H)[1]
$\geq$ 10 cm^2 and < 100 cm^2 [see 835.205(b)(2)]	Averaged over the 1 cm^2 of skin receiving the maximum 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 dose equivalent also received by the skin Recorded as the annual extremity or skin (shallow) dose equivalent[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 dose equivalent, extremity or skin (shallow) dose equivalent recorded for the annual dose equivalent Recorded in a individual's radiation dose record as a special entry[1]

[1] Recording of shallow dose equivalents resulting from non-uniform exposure of the skin is not required if the resulting dose is less than 1 rem [see 835.702(b)].

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 certain activities, such as maintenance and modifications, may render permanently installed physical design features inadequate. In such instances, a special subset of design features, often referred to as engineering controls (e.g., temporary shielding, containment devices, and filtered ventilation systems) should be used, as appropriate, to control individual exposures. Design criteria are discussed in Part 8 of this Chapter.

3. When physical design features, including engineering 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. Maintenance and modification plans and procedures should be reviewed to identify and incorporate radiological control requirements, such as engineering 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 hazards are significant this review should be performed by a multi-disciplinary team preparing the work control procedure

2. The radiological hazard assessment and control process should be integrated with the processes used to assess and control other workplace hazards. DOE Order 440.1, Worker Protection Management for DOE Federal and Contractor Employees, and its associated guidance documents provide requirements and guidance for performing hazards assessments and implementing associated controls.

3. For routine tasks, such as surveillance, tours, and minor non-radiological 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 radiological conditions in existence or expected prior to implementation of the job-specific engineering and administrative controls. These appropriate trigger levels should include:

   a. Estimated individual or collective dose greater than preestablished 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 man-rem)
   b. Predicted airborne radioactivity concentrations in excess of preestablished 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.

5. For non-routine or complex tasks a formal hazards analysis should be conducted using a nationally recognized process as discussed in DOE G 440.1. This review is in addition to the formal radiological review discussed above. An integrated set of controls for all hazards (e.g., radiological, chemical, and physical) should be developed from this hazard analysis.

6. At a minimum, the formal 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. Engineering, design, and use of temporary shielding to reduce radiation levels
   h. Walkdown or dry-run of the activity using applicable procedures
   i. Staging and preparation of necessary materials and special tools
   j. Maximization of prefabrication and shop work
   k. Review of abnormal and emergency procedures and plans
   l. Identification of points where signatures and second party or independent verifications are required
   m. Establishment of success or completion criteria, with contingency plans to anticipate difficulties
   n. Development of a pre-job estimate of collective dose to be incurred for the job
   o. Provisions for waste minimization and disposal.

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

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 engineering review process and a detailed evaluation is not necessary. For review and planning of major tasks involving higher collective dose expenditures, a detailed and documented evaluation 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 Article 312.4

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

3. Review and approval by the ALARA Committee

4. Enhanced line and radiological control 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 should be controlled by procedure.

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

3. Installed temporary shielding should be periodically inspected and surveyed to verify effectiveness and integrity. 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.

5. Installed temporary shielding should be visibly marked or labeled with the following or equivalent wording: "Temporary Shielding - Do Not Remove Without Permission from Radiological Control."

6. Site procedures may identify specific shielding applications, such as the shielding of low activity sources or samples, that fall outside the recommendations of this Article.

315 Technical Work Documents

1. Technical work documents, such as procedures, work packages, or job or research plans, should be used to control hands-on work with radioactive materials. 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 and approved by the radiological control organization.

3. Radiological control hold points should be incorporated into technical work documents for steps 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.

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.

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

   a. Entry into 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.

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, a formal radiological review should be conducted in accordance with Article 312 to ensure measures are implemented to assess available options, monitor and reduce worker exposure, and provide for follow-up monitoring, as required. Specific justification of the need to accept the exposure, including a description of measures taken to mitigate the airborne radioactivity, should be documented as part of the review process.

6. The following controls are applicable 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 through the use of continuous air monitors or air samplers with expedited assessment and analysis of results.

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 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 include the following information:

   a. Description of work
   b. Work area radiological conditions
   c. Dosimetry 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. 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.

3. 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

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 not be approved for periods longer than 1 year.

4. Radiological surveys should be routinely reviewed to evaluate the adequacy of RWP requirements. 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 any revisions to the RWP.

7. 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 and the appropriate radiological control supervisor. At least one of the approving individuals should have been trained in formal methodologies for performing hazards analysis and implementing integrated controls.

324 Pre-Job Briefings

1. At a minimum, pre-job briefings should be held prior to the conduct of work anticipated to exceed the trigger levels identified in Article 312.3.

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

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

3. Pre-job briefings should be conducted by the cognizant work supervisor or 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. 10 CFR 835 requires maintenance of records of actions taken to maintain doses ALARA; therefore, if pre-job briefings are used for ALARA purposes, records of the briefings shall be maintained [see 835.704(b)]. A summary of topics discussed and attendance at the pre-job briefing should be documented. This documentation should be maintained with the technical work document.

325 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
   a. Work in airborne radioactivity areas
   b. As directed by the radiological control organization or as required by the RWP or other work authorization.

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

   a. Marked in accordance with Article 461
   b. Used only for radiological control purposes.

3. Protective clothing dress-out areas should be established directly adjacent to the work area. Workers should proceed directly to the radiological work area after donning personal protective equipment and clothing.

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.

6. Appropriate instructions for donning and removing protective clothing should be posted 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, such as coveralls and shoes, 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 prior to 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 primary dosimeter [see 835.402(a)(5)], a radiation survey, 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 primary dosimeter [see 835.402(a)(5)], a radiation survey, 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
   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 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 engineering controls and containment devices such as glovebags, gloveboxes, 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 a whole body frisk immediately upon entry into an uncontaminated area after exiting contamination, high contamination, or airborne radioactivity areas. Individuals should also perform 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 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 are provided in Appendix 3D.

6. Personal items, such as notebooks, papers, and flashlights, 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. At such facilities, additional emphasis should be placed on bioassay programs and routine area contamination survey and air sampling programs.

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 contamination levels[4]		

Notes:
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 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

1. Contamination levels caused by ongoing work should be monitored and maintained ALARA. Work should be curtailed and decontamination performed at preestablished levels, taking into account worker exposure.

2. Tools and equipment should be inspected to verify operability before being brought into contamination, high contamination, or airborne radioactivity areas.

3. The use of radiologically clean tools or equipment in contamination, high contamination, or airborne radioactivity areas should be minimized by the implementation of a contaminated tool crib in accordance with Article 442.5. When such use is necessary, tools or equipment with complex or inaccessible areas should be wrapped or sleeved to minimize contamination.

4. Engineering controls, such as containment devices, portable or auxiliary ventilation, and temporary shielding, should be installed in accordance with the technical work documents and inspected prior to use.

5. The identity of components and systems should be verified prior to work.

6. Work activities and shift changes should be scheduled to prevent idle time in radiological areas.

7. Where practicable, parts and components should be removed 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 individuals should exit the radiological area until these issues are resolved and appropriate controls have been instituted.

9. Requirements for area cleanup should be included in technical work documents. Work activities should not be considered complete until support material and equipment have been removed and the area has been returned to at least pre-work status.

10. To minimize intakes of radioactive material, smoking, eating, or chewing should not be permitted 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 engineering controls
    b. All drinking is from approved containers or sources
    c. At a minimum, workers' hands and faces are monitored for contamination prior to drinking
    d. Participating workers are monitored as part of the bioassay program
    e. The applicable requirements and controls are described in approved procedures.

343 Logs and Communications

1. Radiological control personnel should maintain logs to document radiological occurrences, status of work activities, and other relevant information.

2. During continuous or extended daily operations, oncoming radiological control personnel should review logs and receive a turnover briefing from the personnel they are relieving.

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

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

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 frequent tours of the workplace to review the adequacy of radiological work practices, posting, and area controls.

3. During the performance of jobs for which a pre-job dose estimate was made, the 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 for any of the following reasons [see DOE 440.1A.g]:

    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.

For radioactive spills involving highly 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. Provisions for radiological work permits are provided in Article 322.

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

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

4. Workers should periodically monitor their hands during work.

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

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 instituted.

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.

348 Controls for Hot Particles

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

1. The site-specific radiological control manual should define hot particles, such as those capable of producing a shallow dose equivalent 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 a job-specific RWP. The following controls should be considered for inclusion on the RWP:

   a. Periodic personnel monitoring during the work activity, at a frequency based on the potential magnitude of 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 lessons learned.

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

351 Conduct of Critiques

Critiques are meetings of the 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 not to assign blame, but to establish and record the facts.

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

2. Critique leaders should be trained in the required elements of the critique process and the appropriate methods of conducting and controlling the critique.

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

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

    a. Formal meetings, chaired by a critique leader
    b. Attendance by all members of the work force who can contribute
    c. Personal statement forms completed by selected personnel before the meeting
    d. Attendance records
    e. Minutes, recorded and signed by the critique leader and all contributors
    f. Pertinent personal statements from individuals involved in the event, signed and attached to the meeting minutes
    g. A listing of the facts in chronological order
    h. Supporting materials, including documents, records, photographs, parts, and logs, maintained by the critique leader.

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

352 Post-Job Reviews

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.

PART 6 Special Applications

This Part provides supplemental information to augment the basic requirements 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

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

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

2. In addition to the provisions of this Standard, guidance contained in the document, DOE-STD-1128-98, Guide to Good Practices For Occupational Radiation Protection in Plutonium Facilities, should be considered in preparing the site-specific radiological control manual for plutonium operations. This standard provides specific guidance related to dosimetry, radiological monitoring, instrumentation, contamination control, and applicable radiological control procedures.

362 Uranium Operations

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

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

363 Tritium Operations

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

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

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

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

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

For the above reasons, guidance contained in DOE-HDBK-1079-94, Primer on Tritium Safe Handling Practices, 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, tritium containment practices and techniques, and personal protective equipment and clothing selection.

364 Accelerator Operations

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

1. In addition to the provisions of this Standard, guidance contained in the document, Health Physics Manual of Good Practices for Accelerator Facilities, SLAC-327, should be considered in preparing the site-specific radiological control manual for accelerator operations. This manual provides specific guidance related to radiological monitoring, dosimetry, shielding design, use of interlocks, and procedures and administrative controls.

2. Consideration should be given to the information provided in DOE O 420.2, Safety of Accelerator Facilities, in preparing the site-specific radiological control manual .

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 divides 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. Site-specific procedures should contain the following provisions for applicable types of radiation generating devices:

1. ANSI N43.3, American National Standard 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. The provisions of ANSI N43.2 entitled, Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment, shall be adhered to for operations involving the following devices [see DOE 5480.4.2.d]:

   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. On-site operations with devices containing sealed sources for radiographic use should be conducted in accordance with the requirements contained in Title 10 CFR part 34, Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations.
   b. ANSI N43.3, American National Standard 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 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 Order 420.1.

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)]. DOE recommends that design criteria be established to limit individual worker doses below 0.25 millirem per hour (500 millirem TEDE per year).

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)].

4. 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.

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

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

7. A neutron quality factor of 20 for conditions of unknown spectra (or doubling of the neutron quality factor associated with known neutron energies) should be used for design purposes only. Design analyses based on these neutron quality factors are intended to estimate the additional construction cost resulting from neutron quality factor increases. The results of these analyses should be used to ascertain the economic feasibility of incorporating such modifications in the final design. This quality factor is not to be used for determination of individual dose equivalents.

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

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

9. Facilities currently under construction should be evaluated and the above criteria applied where practicable.

382 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 design features 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

- Plan in advance
- Delete unnecessary work
- Determine expected radiation levels
- Estimate collective dose
- Sequence jobs
- Schedule work
- Select a trained and experienced work force
- Identify and coordinate resource requirements

Preparation of Technical Work Documents

- Include special radiological control requirements in technical work documents
- Perform ALARA pre-job review
- Select and optimize engineering 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 practicable outside radiation areas
- State requirements for standard tools
- Consider special tools, including robots
- State staging requirements for materials, parts and tools
- Incorporate radiological control hold points
- Analyze 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)

Temporary Shielding

- Design shielding to include stress considerations
- Control installation and removal by written procedure
- Inspect after installation
- Conduct periodic radiation surveys
- Prevent damage caused by 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 improve design of shielding by locating source of radiation
- Use mock-ups to plan temporary shielding design and installation
- Consider use of water-filled shielding

Rehearsing and Briefing

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

Performing Work

- 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
- Compare actual dose against pre-job estimates
- 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 dose against pre-job estimate
- 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, or split seams that would diminish protection. Any defective items should be replaced with intact protective clothing.

2. Protective clothing as prescribed by the radiological work permit should be selected based on the contamination level in the work area, the anticipated work activity, worker health considerations, area(s) of the body likely to be exposed to removable contamination, and regard for non-radiological hazards that may be present. Table 3-1 provides general guidelines for selection. As referenced in the table, a full set and double set of protective clothing typically includes:

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

   Double Set of PCs
   a. Two pairs of coveralls
   b. Cotton glove liners
   c. Two pairs of gloves
   d. Two pairs of shoe covers
   e. Rubber overshoes
   f. Hood

3. Cotton glove liners may be worn inside standard gloves for comfort, but should not be worn alone or considered as a layer of protection.

4. Shoecovers and gloves should be sufficiently durable for the intended use. Leather or canvas work gloves should be worn in lieu of or in addition to standard gloves for work activities requiring additional strength or abrasion resistance.

5. Use of industrial safety equipment, 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.

8. Outer personal clothing should not be worn under protective clothing for entry to high contamination areas or during work conditions requiring a double set of protective clothing.

Removal of Protective Clothing

Potentially contaminated protective clothing should be removed without spreading contamination and in particular without contaminating the skin. Workers should be instructed not to touch the skin or place anything in the mouth during protective clothing removal.

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

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

1. Remove exposed tape
2. Remove rubber overshoes
3. Remove gloves
4. Remove hood from front to rear
5. Remove respiratory protection, as applicable
6. Remove coveralls, inside out, touching inside only
7. Take down barrier closure, as applicable
8. Remove tape or fastener from inner shoe cover
9. Remove each shoe cover, placing shoe onto clean step-off pad
10. Remove cloth glove liners
11. Replace barrier closure, as applicable
12. Commence whole body frisking
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.

Before stepping to the outer step-off pad, the worker should:

9. Remove inner rubber gloves
10. Remove inner coveralls, inside out, touching inside only

11. Take down barrier closure, as applicable
12. Remove tape or fastener from inner shoe cover
13. Remove each inner shoe cover, placing shoe on clean outer step-off pad
14. Remove cotton glove liners
15. Replace barrier closure, as applicable
16. Commence whole body frisking
17. Monitor badge and dosimeter.

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

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

    a. The inner step-off pad should be located immediately outside the highly contaminated work area, but still within the posted area
    b. The worker should remove highly contaminated outer clothing prior to stepping on the inner step-off pad
    c. Additional secondary step-off pads, still within the posted area, may be utilized as necessary to restrict the spread of contamination out of the immediate area
    d. The final or outer step-off pad should be located immediately outside the contamination area.

Table 3-2 Guidelines for Selecting Protective Clothing (PC)

	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)
WORK ACTIVITY	**RECOMMENDED PROTECTIVE CLOTHING**		
Routine	Full set of PCs	Full set of PCs	Full set of PCs, double gloves, double shoecovers
Heavy work	Full set of PCs, work gloves	Double set of PCs, work gloves	Double set of PCs, work gloves
Work with pressurized or large volume liquids, closed system breach	Full set of non-permeable PCs	Double set of PCs (outer set non-permeable), rubber boots	Double set of PCs and non-permeable outer clothing, rubber boots

Note:

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

Appendix 3D

Guidelines for Personnel Contamination Monitoring with Hand-Held Instruments

General Requirements

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

Performance of Monitoring:

1. Frisk the hands before picking up the probe.

2. Perform the frisk in the following order:

   a. Head (pause at mouth and nose for approximately 5 seconds)
   b. Neck and shoulders
   c. Arms (pause at each elbow for approximately 5 seconds)
   d. Chest and abdomen
   e. Back, hips and seat of pants
   f. Legs (pause at each knee for approximately 5 seconds)
   g. Shoe tops
   h. Shoe bottoms (pause at sole and heel for approximately 5 seconds)
   i. Personnel and supplemental dosimeters.

3. Return the probe to its holder and leave the area. The probe should be placed on the side or face up to allow the next individual to monitor his/her hands before handling the probe.

CHAPTER 4 RADIOACTIVE MATERIALS

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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 radiological control organization should develop 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(a) 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 a dose equivalent 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. Nature of material (e.g., sealed radioactive source, contaminated component, activated target)
   c. Radiological hazard information (e.g., radiation and contamination levels)
   d. Total quantity of radioactive material (in subunits or multiple units of curies)
   e. Required precautions
   f. Name of surveyor
   g. 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
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" [see 10 CFR 835.605]	"CONTAMINATED" or "POTENTIALLY CONTAMINATED"
Sealed and unsealed 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"

[1] Labeling required in item or container meets the labeling criteria established in 10 CFR 835.605.

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

Table 4-2 Exceptions from Radioactive Material Labeling Requirements

Exception Criteria	Items Typically Included*
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 Appendix 4A values [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 sytems
Material that consists solely of nuclear weapons or their components [see 835.606(a)(6)]	Nuclear weapons components

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

Note - 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.

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 plastic wrapping materials emblazoned with yellow markings) 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 Appendix 4A 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 approved by the radiological control manager or designee.

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. Removable contamination levels shall be less than Table 2-2 values prior to releasing material and equipment for unrestricted use in controlled areas [see 835.1101(a)(1) & (a)(2)].

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 restricted 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 contamination. Although DOE has not established any specific controls over the release of other radioactive materials (e.g., activated materials or materials that are naturally-radioactive) 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 release 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 [see 10 CFR 835.901]. Release of material and equipment to controlled areas may result in occupational or non-occupational exposure of individuals to radiation. 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 equivalent expectation [see 10 CFR 835.602]. DOE sites should adopt site- or facility-specific criteria that will ensure that intrinsically-radioactive material and equipment that is released to the controlled area, in combination with other sources of radiation 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 being considered for release to 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 a dose equivalent 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.

422 Release to Uncontrolled Areas

1. DOE 5400.5 describes radiological criteria for releasing material to uncontrolled areas.

2. DOE 5400.5 provides guidance obtaining approvals on a case-by-case basis for releasing material that has been contaminated in depth or volume, such as activated material or smelted contaminated material.

3. The criteria for unrestricted release of materials established in DOE 5400.5 may be more stringent than those established in this Standard for release to controlled areas.

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

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 Order 460.1, DOE Order 460.2 and DOE 5610 series Orders provide requirements that are in conformance with 49 CFR requirements for transportation of radioactive material using any conveyance. 10 CFR 835.1(b)(4) excludes radioactive material transportation activities that are performed in accordance with the applicable transportation requirements (i.e., DOT or DOE requirements) from the requirements of 10 CFR 835. However, radioactive material transportation (as defined in 10 CFR 835) does not include preparation of materials for shipment, packaging and labeling, or performance of radiological monitoring required for occupational radiation protection. Therefore, 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. However, when a shipment is received from an off-site destination, by a non-DOE conveyance, the 49 CFR 173 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 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 460.1].

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. 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 appropriate responses for potential on-site radioactive material transportation accidents.

12. Drivers of DOE and non-DOE motor vehicles should have a copy of their emergency response plan, or the emergency response information required by 49 CFR 172.600, during transport on-site or during off-site transportation.

13. 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)].

14. 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 having activities equal to or exceeding the values specified in Appendix 4A [see 835.2(a)] are considered accountable sealed radioactive sources.

1. Written procedures should 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.

2. Accountable sealed sources and all other sealed radioactive sources having activities exceeding one tenth of the Appendix 4A values, 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. Sealed radioactive sources having activities below one tenth of the Appendix 4A values should be labeled consistent with Article 412 and should be periodically inventoried 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 553 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. 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.

PART 4 Solid Radioactive Waste Management

441 Requirements

1. DOE 5820.2A describes how solid radioactive waste is treated, packaged, stored, transported, and disposed.

2. Radiological operations generating radioactive waste shall be designed and developed to promote minimization and permit segregation, monitoring, treatment, storage, and disposal [DOE 5820.2A].

3. Radioactive waste minimization goals and practices shall be developed and implemented [DOE 5820.2A].

442 Waste Minimization

A radioactive waste minimization program shall be in effect to reduce the generation of radioactive waste and spread of contamination from contamination, high contamination, or airborne radioactivity areas [see DOE 5820.2A]. 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 radiological 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 radiological 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 radiological areas to separate uncontaminated from contaminated materials.

7. Segregate known uncontaminated from potentially contaminated waste.

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

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

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

443 Mixed Waste

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

1. 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 5820.2A 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 engineering controls that prevent worker exposure to airborne radioactivity, such as barriers, gloveboxes, and glovebags, are compromised. An evaluation should be made of continuing operations with compromised engineering controls. The use of respiratory protection to continue activities under these conditions is discouraged. Implementation of short-term engineering modifications that provide a commensurate level of worker protection is the preferred alternative.

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 Control 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 use. 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 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 N509 and N510, and ASME AG-1, Code on Nuclear Air and Gas Treatment. Several of the DOE 3020 series Technical Standards (e.g., DOE-STD-3020, 3022, 3025, & 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.

Appendix 4A

Values for Establishing Sealed Radioactive Source Accountability and Radioactive Material Posting and Labeling Requirements

Nuclide	Activity(μCi)	Nuclide	Activity(μCi)	Nuclide	Activity(μCi)
Ac-227	1.5E+00	Cl-36	4.6E+05	Ge-68	5.7E+02
Ag-105	2.1E+06	Cm-241	6.8E+04	H-3	1.6E+08
Ag-108m	1.8E+01	Cm-242	5.8E+02	Hf-172	3.1E+04
Ag-110m	2.2E+01	Cm-243	3.3E+01	Hf-175	1.8E+06
Al-26	1.6E+01	Cm-244	4.0E+01	Hf-178m	4.1E+03
Am-241	2.3E+01	Cm-245	2.2E+01	Hf-181	3.5E+02
Am-242m	2.4E+01	Cm-246	2.2E+01	Hf-182	3.0E+03
Am-243	2.3E+01	Cm-247	2.4E+01	Hg-194	3.5E+04
As-73	5.4E+02	Cm-248	6.0E+00	Hg-203	4.9E+02
Au-195	4.8E+02	Cm-250	1.1E+00	Ho-166m	2.2E+01
Ba-133	5.2E+01	Co-56	4.0E+01	I-125	3.5E+02
Be-10	2.8E+04	Co-57	2.3E+02	I-129	1.8E+02
Be-7	3.2E+03	Co-58	1.4E+02	In-114m	7.8E+02
Bi-207	1.7E+01	Co-60	1.8E+01	Ir-192	1.4E+02
Bi-208	1.5E+01	Cs-134	2.7E+01	Ir-192m	2.6E+04
Bi-210m	1.3E+03	Cs-135	2.2E+06	Ir-194m	2.7E+01
Bk-247	1.7E+01	Cs-137	6.0E+01	K-40	2.8E+02
Bk-249	7.2E+03	Dy-159	4.1E+06	La-137	1.1E+05
C-14	4.8E+06	Es-254	6.3E+01	Lu-173	4.4E+05
Ca-41	7.4E+06	Es-255	4.6E+04	Lu-174	2.5E+05
Ca-45	1.5E+06	Eu-148	7.0E+05	Lu-174m	3.9E+05
Cd-109	1.6E+02	Eu-149	5.3E+06	Lu-177m	5.8E+01
Cd-113m	6.5E+03	Eu-152	3.1E+01	Md-258	6.0E+02
Cd-115m	1.0E+04	Eu-154	3.1E+01	Mn-53	2.0E+07
Ce-139	2.4E+02	Eu-155	3.7E+02	Mn-54	6.5E+01
Ce-141	2.4E+03	Fe-55	3.7E+06	Mo-93	7.7E+01
Ce-144	1.5E+03	Fe-59	2.0E+02	Na-22	1.9E+01
Cf-248	2.0E+02	Fe-60	1.3E+04	Nb-91	7.0E+01
Cf-249	1.7E+01	Fm-257	4.3E+02	Nb-91m	3.6E+02
Cf-250	3.8E+01	Gd-146	2.6E+05	Nb-92	1.8E+01
Cf-251	1.7E+01	Gd-148	3.0E+01	Nb-93m	4.4E+02
Cf-252	6.4E+01	Gd-151	1.1E+06	Nb-94	2.3E+01
Cf-254	3.4E+01	Gd-153	2.1E+02	Nb-95	3.4E+02
Ni-59	7.5E+06	Re-184	2.6E+02	Tc-97m	3.6E+02
Np-235	1.2E+02	Re-184m	1.5E+02	Tc-98	2.5E+01
Np-236	2.2E+01	Re-186m	2.8E+05	Tc-99	6.8E+06

Nuclide	Activity(μCi)	Nuclide	Activity(μCi)	Nuclide	Activity(μCi)
Np-237	1.9E+01	Rh-101	2.5E+05	Te-121m	1.9E+02
Os-185	1.4E+02	Rh-102	8.3E+04	Te-123m	2.8E+02
Os-194	1.5E+04	Rh-102m	2.1E+05	Te-125m	4.4E+02
Pa-231	7.8E+00	Ru-103	4.4E+02	Te-127m	8.0E+02
Pb-202	1.0E+05	Ru-106	2.1E+04	Te-129m	2.3E+03
Pb-205	9.1E+01	S-35	4.0E+06	Th-228	2.9E+01
Pb-210	9.2E+01	Sb-124	9.1E+01	Th-229	4.7E+00
Pd-107	7.8E+05	Sb-125	6.8E+01	Th-230	3.1E+01
Pm-143	1.3E+02	Sc-46	6.2E+01	Th-232	6.1E+00
Pm-144	2.9E+01	Se-75	6.4E+01	Ti-44	1.6E+02
Pm-145	2.6E+02	Se-79	1.0E+06	Tl-204	2.2E+04
Pm-146	4.5E+01	Si-32	9.9E+03	Tm-170	8.4E+03
Pm-147	2.5E+05	Sm-145	9.1E+05	Tm-171	2.8E+04
Pm-148m	1.1E+02	Sm-146	1.2E+02	U-232	1.5E+01
Po-209	6.3E+03	Sm-151	2.5E+05	U-233	7.4E+01
Po-210	1.1E+03	Sn-113	3.1E+02	U-234	7.5E+01
Pt-193	4.4E+07	Sn-119m	3.3E+02	U-235	6.7E+01
Pu-236	6.9E+01	Sn-121m	8.7E+05	U-236	8.0E+01
Pu-237	3.3E+02	Sn-123	1.3E+04	U-238	8.4E+01
Pu-238	2.5E+01	Sn-126	1.8E+02	V-49	2.9E+07
Pu-239	2.3E+01	Sr-85	1.2E+02	W-181	1.1E+03
Pu-240	2.3E+01	Sr-89	2.4E+05	W-185	3.9E+06
Pu-241	1.2E+03	Sr-90	7.7E+03	W-188	6.4E+04
Pu-242	2.4E+01	Ta-179	1.5E+06	Y-88	3.4E+01
Pu-244	2.5E+01	Ta-182	7.3E+01	Y-91	5.0E+04
Ra-226	1.2E+03	Tb-157	2.5E+03	Yb-169	5.5E+02
Ra-228	2.1E+03	Tb-158	3.9E+04	Zn-65	1.1E+02
Rb-83	9.2E+01	Tb-160	1.2E+02	Zr-88	1.2E+02
Rb-84	2.0E+02	Tc-95m	1.3E+02	Zr-93	3.1E+04
Re-183	5.4E+02	Tc-97	8.1E+01	Zr-95	2.0E+02

Notes:

1. The value for any alpha emitting nuclide not listed above and for mixtures of unknown alpha emitters is 10 μCi [see 835, Appendix E].
2. The value for any non-alpha emitting nuclide and for mixtures of these nuclides of unknown composition is 100 μCi [see 835, Appendix E].
3. When the radioactive material consists of a mixture of known quantities of listed nuclides, determine the value by summing the fractions of the quantity of each radionuclide divided by the accountability value for that nuclide. If the sum of the fractions exceeds unity (1), the value has been exceeded [see 835, Appendix E].

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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 equivalent of 100 millirem or more in a year or a dose equivalent 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 a dose equivalent of 50 millirem 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 exposure 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 an annual external deep dose equivalent 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. Although issuing dosimeters to individuals who are not occupationally exposed to radiation can appear to be a conservative practice, it creates the impression that the wearers are occupationally exposed to radiation. 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. Film dosimeters should not be worn or taken off-site unless specifically authorized by the radiological control manager or designee.

8. DOE discourages the practice of taking thermoluminescent dosimeters (TLDs) off-site.

9. 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 security X-ray devices, excessive heat, or medical sources of radiation.

10. 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 and management has approved reentry.

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 the Assistant Secretary for Environment, Safety and Health [see 835.402(b)(2)].

   DOE-STD-1095-95 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, TLDs, track etch dosimeters, film badges, and neutron sensitive film.

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

3. Facilities should participate in inter-comparison studies for external dosimetry programs.

4. Multiple dosimeters should be issued to individuals to assess deep dose equivalent 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. Monitoring programs implemented at the discretion of the contractor (i.e., for personnel monitoring that is not required by Article 511.1) need not be accredited under the DOELAP Program. Programs implemented outside the scope of the DOELAP Program should include:

   a. Documented assessment of each individual's potential occupational dose to support the decision to operate outside the DOELAP Program. Such assessments should be based upon facility design reviews, the results of a comprehensive workplace monitoring program, and, if available, the results of previous individual monitoring results.
   b. Comprehensive routine surveys of areas that may be entered by these individuals to ensure that individual doses are not likely to exceed the Article 511.1 monitoring thresholds.

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 (e.g., stay-time tracking) capable of providing an estimate of the individual's deep dose equivalent 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 total dose or rate of exposure substantially greater than planned. The radiological control organization should be consulted prior to continuation 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 saves in the costs of operating the dosimetry program and reduces costs associated with maintaining personnel with enhanced training and qualifications.

1. Area monitoring dosimeters should 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 should be used to support dosimetry investigations where individuals express concerns about their work environments and exposure to ionizing radiation.

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

515 Nuclear Accident Dosimeters

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 ± 25%.

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 ± 25%.

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 equivalent 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 a dose equivalent 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 equivalent 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 equivalent 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 equivalent 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 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 Bioassay Programs [see 835.402(d)(1)]; or
   b. Excepted from accreditation by the DOELAP Program [see 835.402(d)(1)]; or
   c. Otherwise approved by the Assistant Secretary for Environment, Safety and Health [see 835.402(d)(2)].

   Compliance with the requirements for bioassay program accreditation shall be achieved no later than January 1, 2002 [see 835.101(f)].

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 equivalent 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 equivalent greater than 100 millirem in a year. The technical basis for the methods and frequency of bioassay monitoring should be documented.

5. Management should require termination bioassay monitoring when an individual who participated in the bioassay program terminates employment or concludes work involving the potential for internal exposure. The number of persons failing to achieve this monitoring should be reviewed periodically and should be used to determine whether further efforts to get cooperation are warranted.

6. 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
   b. Airborne monitoring indicates the potential for intakes exceeding 100 millirem committed effective dose equivalent
   c. Upon direction of the radiological control organization when an intake is suspected.

7. 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.

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

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

10. Internal dosimetry program personnel should participate in the conduct of inter-comparison studies and should use the "DOE Phantom Library."

11. Bioassay programs implemented at the discretion of the contractor (i.e., for personnel monitoring that is not required by Article 521.1) need not be accredited under the DOELAP Program. Programs implemented outside the scope of the DOELAP Program should include:

    a. Documented assessment of each individual's potential occupational exposure to support the decision to operate outside the DOELAP Program.
    b. Comprehensive monitoring of the areas that may be entered by these individuals to ensure that individual doses are not likely to exceed the Article 521.1 monitoring thresholds.

523 Technical Provisions for Dose Assessment

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

1. Characteristics of the radionuclide, such as chemical and physical form
2. Bioassay results and the individual's previous exposure history
3. Exposure information, such as route of intake and time and duration of exposure
4. Biological models used for dosimetry of radionuclides
5. Models to estimate intake or deposition and to assess dose
6. Intra-departmental coordination between the radiological control organization and the medical organization for doses that may require medical intervention.

PART 3 Respiratory Protection Program

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

531 General Provisions

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

2. 29 CFR 1910.134 establishes requirements for respiratory protection program that are applicable to most DOE facilities. ANSI Z88.2 provides acceptable detailed guidance for implementation of the respiratory protection program and associated training of personnel.

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 Assessment

Each prospective respirator wearer shall have a medical assessment prior to being fit-tested. The medical assessment shall determine if an employee's medical condition precludes the use of respirators and should follow the guidance in ANSI Z88.6 on frequency and content of the examination [see 20 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 can impair worker mobility and vision and cause worker discomfort and stress. For these reasons, the issue 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 fit, 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 respirator failure [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.

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. Engineering controls to moderate 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 2C. Promptly after completion, the results should be explained to the persons affected.

542 Contaminated Wounds

1. Emergency medical care should be administered immediately for injuries involving radioactive materials in accordance with National Council on Radiation Protection and Measurements Report Number 65. Medical treatment of injuries takes precedence over radiological 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 for therapeutic intervention such as blocking or chelating agents
   e. Initiation of appropriate bioassay monitoring
   f. Determination of need for work restrictions.

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

543 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 equivalent greater than 100 millirem, the following actions should be taken:

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

PART 5 Radiological Monitoring

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 engineering 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 physical design features and engineering and process 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. 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 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 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 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. 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 at least quarterly to verify audible alarm system operability and audibility under ambient working conditions and operability of visual alarms when so equipped.

5. If installed instrumentation is removed from service for maintenance or calibration, a radiation monitoring program providing similar detection capability should be maintained, consistent with the potential for unexpected increases in radiation dose rates.

6. Where an area radiation monitor is incorporated into a safety interlock system, the circuitry 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 825.502(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 are under way that are likely to produce hot particles
    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, periodically during work, at completion of job, or as specified in a radiological work permit
    k. Monthly , in and around areas of fixed contamination
    l. 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 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. 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)].

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 equivalent 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 (or continuous) air monitors 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 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.

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. Continuous air monitors 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 continuous air monitoring equipment should be verified daily by performing an operational check. Operational checks should include positive air-flow indication, non-zero response to background activity, and internal check sources or 60 Hz electronic checks when available. Real-time air monitoring equipment 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.

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 N323 provides appropriate comprehensive guidance for establishing and operating a radiological instrumentation calibration program. Calibrations should use National Institute of Standards and Technology (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 in accordance with the recommendations of ANSI N323. Responsible individuals should:

   a. Locate activities in a manner to control radiation exposure to operating personnel and to personnel in adjacent areas
   b. Minimize sources of interference, such as backscatter and non-ionizing radiation, during the calibration of instrumentation and correct for interferences as necessary
   c. Operate in accordance with the referenced standards
   d. Generate records of in accordance with the referenced standards.

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

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CHAPTER 6 TRAINING AND QUALIFICATION

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PART 1 Radiological Control Training and Qualification

611 Purpose

This 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 occupationally exposed to radiation; and 2) individuals who are permitted unescorted access to radiological areas or perform unescorted 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 and recommends the use of these materials to achieve consistency in the level and quality of training given Department-wide. In establishing local training programs, DOE's core courses should be utilized to the extent practicable and supplemented with site-specific information. Core course training material developed and maintained by DOE Headquarters (EH) 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 with those discussed in Parts 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, 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 I and II Training
    c. Radiological Control Technician Training
    d. Radiological Assessor Training
    e. Radiological Support Personnel Training
    f. Radiological Control Manual Training for Supervisors
    g. Higher Level Training for Supervisors
    h. Plutonium Facility Training
    i. Radiological Training for Tritium Facilities
    j. Radiological Safety Training for Accelerator Facilities
    k. Radiological Safety Training for Uranium Facilities
    l. ALARA Training for Technical Support Personnel
    m. Radiological Safety Training for Radiation Producing Devices

3. Successful completion of the entire core academic component of a DOE core course at one DOE site within the past two years should be recognized by other DOE sites. 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 radiological work, training commensurate with the hazard in the area and required controls shall be completed [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 examination process should require:

   a. That true/false questions and open-book examinations not be included
   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 examinations
   e. Remedial actions for failure to meet the minimum score
   f. That the question bank contain questions that test what the student is expected to remember months after the training rather than to test short term memory of theoretical material.

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 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 Order 5480.20A, Personnel Selection, Qualification, Training and Staffing Requirements at DOE Reactor and Non-Reactor 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 summarizes the requirements for those individuals who should receive General Employee Radiological Training.

621 Site Personnel

1. Individuals shall complete radiation safety training prior to unescorted access to controlled areas and prior to receiving occupational radiation exposure during 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, as applicable, and should be expanded to include site-specific information, such as site-specific radiation types, alarm responses, and policies.

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 radiological buffer areas or areas posted for radiological control other than controlled areas.

4. Information may be communicated by classroom lecture, videotape, or other appropriate methods.

5. In the alternate year when full training is not completed, the latest General Employee Radiological Training Handbook (Student Guide) should be distributed 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(e)].

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 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 summarizes the requirements for 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, 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 is not 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. Individuals who complete this training should not be allowed to enter contamination, high contamination, or airborne radioactivity areas unescorted, nor should they be allowed to enter 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 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.

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, 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 radiological control technician position should include on-the-job training to provide hands-on experience directly applicable to the job.

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 radiological control technician and supervisor training programs.

1. An oral examination board should 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 are 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 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 prepare for the comprehensive biennial requalification.

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 recent operating experience
    f. Observation of on-the-job performances by the radiological control technician Supervisor.

2. Subcontracted technicians who work at the facility for extended time periods (more than 6 months) should receive continuing training commensurate with their assigned duties. 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, Knowledge, Skills, and Abilities for Key Radiation Protection Positions at DOE Facilities.

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 sponsored development of three core courses appropriate for these individuals. These courses are, RadCon Manual Training for Managers, Higher Level Training for Supervisors, and Radiological Assessors Training.

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-1110-97, 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-1110-97, 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-1107-97, Knowledge, Skills, and Abilities for Key Radiation Protection Positions at DOE Facilities.

5. Certification and involvement with professional industry organizations should be encouraged.

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 34.31.

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/EH-0425, Plutonium Facility Training, should be considered in addition to DOE's core training materials at plutonium facilities.

662 Uranium Facilities

The content of DOE-HDBK-1113-98, 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 DOE-HDBK-1105-96, Radiological Training for Tritium Facilities, should be considered in addition to DOE's core training material at tritium facilities.

664 Accelerator Facilities

The content of DOE-HDBK-1108-97, DOE Handbook for Radiological Safety Training for Accelerator Facilities, should be considered in addition to DOE's core training material at accelerator facilities.

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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 should 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 Radiological Doses
    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, consistent with the Privacy Act of 1974, which contains requirements to protect the privacy of individual records [see 835.702(f) and 801(d)].

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 black ink
   d. Corrections identified by a single line-out, initialed and dated
   e. Supervisory signature to ensure review and proper completion of forms.

2. The radiological control organization should maintain a file of names, signatures, and initials for future identification of the individual who signed or initialed a record.

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 computerized records.

5. Unless otherwise specified, radiological control records shall use the special units of curie, roentgen, rad, and rem, including multiples of these units [see 835.4]. Use of the international system of units (becquerel, gray, and sievert) should be limited to calculational, scientific, or reference purposes.

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 work assignments and radiation doses; the facility and occupational codes defined in DOE 231.1 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 reconstructions from lost or damaged dosimeters, or for unbadged workers
    c. Evaluations of non-uniform radiation doses.

5. Internal dose records shall include committed effective dose equivalent [see 835.702(c)(4)(i)], committed 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 dose and committed dose equivalent to any organ receiving a reportable dose shall be maintained for the individual receiving such dose [see 835.702(c)(5)(ii)].

7. The total effective dose equivalent 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 dose equivalent to the embryo/fetus of a declared pregnant worker shall be maintained [see 835.702(c)(6)] and should be maintained with the occupational dose records for that worker.

9. Individual dose records shall include the cumulative total effective dose equivalent [see 835.702(c)(5)(iii)].

10. 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.

11. Counseling of individuals about radiological concerns should be documented and this documentation retained. The counseled individual should sign the documentation to acknowledge participation.

12. Records of authorization to exceed administrative control levels should be retained.

13. 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.

14. 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).

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. Preemployment medical records, if available, and reports of periodic medical examinations should be maintained.

2. Physical examination reports and fit testing results for respirator use should be maintained for respirator users.

3. Medical evaluations and treatment performed in support of the radiological control program should be documented.

4. Maintenance of records of non-occupational radiation doses, such as significant therapeutic or diagnostic radiation doses for medical purposes, is encouraged. Where practical, maintenance of records of preemployment non-occupational radiation doses is encouraged.

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 sheets with instructor's name
   c. Employee's name, identification number and signature
   d. Date of training
   e. Identification of the examination or evaluation form, including sufficient data to identify which test each 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
   d. Members of the public training for unescorted access.

   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.

5. 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.

6. 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. 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 chronological sequence that will allow correlation with the corresponding support information. For example, procedures for performing radiation surveys should be identifiable with the survey results. Completed radiological work permits should be maintained.

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 414.1 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. 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 and 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

1. 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.

753 Airborne Radioactivity Monitoring

1. 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 numbers of the sampler and laboratory counting instrument when available or unique identifier of each sampler and 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. Air concentrations in general airborne areas and breathing zones
    e. Supporting parameters, including collection efficiency, flow rate, duration of sampling, correction factors, and filter medium
    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

1. 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
   b. Contamination levels (using appropriate units) and appropriate supporting parameters including counting efficiency, counting time, correction factors, type of radiation, and whether the contamination was fixed or removable
   c. Location of areas found to contain hot particles or high concentrations of localized contamination
   d. Follow-up survey results for decontamination processes cross-referenced to the original survey.

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 appropriate supporting parameters including counting efficiency, counting time, correction factors, and type of radiation
   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 records should include frequencies, method, dates, personnel, training, and traceability of calibration sources to National Institute of Standards and Technology 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 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 copy after storage for the specified period. The following controls should be administered:

1. Verification that the resultant copy is legible

2. Confirmation that printed sides are copied

3. Periodic quality audits of the final filmed copy.

773 Computerization of Records

1. Records may be transferred to magnetic storage media provided certain precautions are taken to ensure that the information is maintained in a retrievable configuration.

2. Controls for the use and handling of magnetic storage media should include the following:

    a. A master index of documents on the magnetic storage medium
    b. A program to ensure back-up and retrievability of information
    c. Quality control during data entry and analysis
    d. An index identifying software applications used in conjunction with the data
    e. Software validation and verification
    f. Periodic quality audits of software
    g. Prevention of unauthorized manipulation of data
    h. Assurance that previously stored information is retrievable and useable after system modifications.

3. Optical disks may be used to archive records if the optical disks satisfy the following:

    a. A reliable system to prevent overwriting or erasure of records
    b. Software and user controls consistent with Article 773.2
    c. Manufacturer recommendations relating to software control, disk life expectancy, environmental storage conditions, and maintenance incorporated into policies and procedures
    d. Quality controls on the copying and imaging processes consistent with Article 772.

774 Retention

1. 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, consistent with the Privacy Act [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 232.1 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.

782 Annual Radiation Report

DOE O 231.1, 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.

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GLOSSARY

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.

accountable sealed radioactive source: A sealed radioactive source having a half-life equal to or greater than 30 days and an isotopic activity equal to or greater than the corresponding value provided in Appendix 4A of this Standard [see 835.2(a)].

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.

airborne radioactivity: Radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases [see 835.2(a)].

airborne radioactivity area: Any area, accessible to individuals, where:

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

b. an individual present in the are without respiratory protection could receive an intake exceeding 12 DAC-hours in a week [see 835.2(a)].

annual limit on intake (ALI): The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man (ICRP Publication 23) that would result in a committed effective dose equivalent of 5 rems (0.05 sievert) or a committed dose equivalent of 50 rems (0.5 sievert) to any individual organ or tissue [see 835.2(a)].

As Low As is Reasonably Achievable (ALARA): The approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. As used in this Standard, ALARA is not a dose limit but a process that has the objective of attaining doses as far below the applicable controlling limits as is reasonably achievable [see 835.2(a)].

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.

background radiation: Radiation from:

(1) Naturally occurring radioactive materials which have not been technologically enhanced;
(2) Cosmic sources;
(3) Global fallout as it exists in the environment (such as from the testing of nuclear explosive devices);
(4) Radon and its progeny in concentrations or levels existing in buildings or the environment which have not been elevated as a result of current or prior activities; and
(5) Consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation [see 835.2(a)].

becquerel (Bq): The International System (SI) unit for activity of radioactive material. One becquerel is that quantity of radioactive material in which one atom is transformed per second or undergoes one disintegration per second.

bioassay: The determination of the kinds, quantities, or concentrations, and, in some cases, locations of radioactive material in the human body, whether by direct measurement or by analysis and evaluation of radioactive materials excreted or removed from the human body [see 835.2(a)].

calibration: The process of adjusting or determining either:

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

(2) The strength of a radiation source relative to a standard (e.g., primary, secondary, or tertiary) or conventionally true value [see 835.2(a)].

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.

contamination area: Any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in Chapter 2, Table 2-2, but do not exceed 100 times those values [see 835.2(a)].

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: Any entity under contract with the Department of Energy with the responsibility to perform activities at a DOE site or facility [see 835.2(a)].

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.

controlled area: Any area to which access is managed by or for DOE to protect individuals from exposure to radiation and/or radioactive material. [see 835.2(a)].

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.

declared pregnant worker: A woman who has voluntarily declared to her employer, in writing, her pregnancy for the purpose of being subject to the occupational exposure limits to the embryo/fetus as provided in Article 215. This declaration may be revoked, in writing, at any time by the declared pregnant worker [see 835.2(a)] .

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

derived air concentration (DAC): For the radionuclides listed in Appendix A of 10 CFR 835, the airborne concentration that equals the ALI divided by the volume of air breathed by an average worker for a working year of 2000 hours (assuming a breathing volume of 2400m^3). For radionuclides listed in Appendix C of 10 CFR 835, the air immersion DACs were calculated for a continuous, non-shielded exposure via immersion in a semi-infinite atmospheric cloud. The values are based upon the derived airborne concentration found in Table 1 of the U. S. Environmental Protection Agency's Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, published September 1988 [see 835.2(a)].

derived air concentration-hour (DAC-hour): The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide, in hours [see 835.2(a)].

disintegration per minute (dpm): The rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

DOE activity: An activity taken for or by the DOE in a DOE operation of facility that has the potential to result in the occupational exposure of an individual to radiation or radioactive material. The activity may be, but is not limited to, design, construction, operation, decontamination or decommissioning. To the extent appropriate, the activity may involve a single DOE facility or operation or a combination of facilities and operations, possibly including an entire site or multiple DOE sites [see 835.2(a)].

DOELAP: Department of Energy Laboratory Accreditation Program for personnel dosimetry and bioassay programs.

dose: A general term for absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent [see 835.2(b)]. Various technical terms, such as dose equivalent, effective dose equivalent, and collective dose, are used to describe the amount of radiation an exposed individual receives. These terms are used to describe the differing interactions of radiation with tissue as well as to assist in the management of personnel exposure to radiation.

> Some types of radiation, such as neutron and alpha, deposit their energy more densely in affected tissue than gamma radiation, thereby causing more damage to tissue. The term **dose equivalent**, measured in units of rem, is used to take into account this difference in tissue damage. Therefore 1 rem from gamma radiation causes damage **equivalent** to 1 rem from alpha radiation. However, it takes one-twentieth as much energy from alpha radiation, as compared with gamma radiation, to produce this 1 rem **dose equivalent**.

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

absorbed dose (D): Energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray) [see 835.2(b)].

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

committed dose equivalent ($H_{T,50}$): The dose equivalent calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem (or sievert) [see 835.2(b)].

committed effective dose equivalent ($H_{E,50}$): The sum of the committed dose equivalents to various tissues in the body ($H_{T,50}$), each multiplied by the appropriate weighting factor (w_T) - that is $H_{E,50}=\Sigma w_T H_{T,50}$. Committed effective dose equivalent is expressed in units of rem (or sievert) [see 835.2(b)].

cumulative total effective dose equivalent: The sum of all total effective dose equivalent values recorded for an individual, where available, for each year occupational exposure was received, beginning January 1, 1989 [see 835.2(b)].

deep dose equivalent: The dose equivalent derived from external radiation at a depth of 1 cm in tissue [see 835.2(b)].

dose equivalent (H): The product of the absorbed dose (D) (in rad or gray) in tissue, a quality factor (Q), and other modifying factors (N). Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert) [see 835.2(b)].

effective dose equivalent (H_E): The summation of the products of the dose equivalent received by specified tissues of the body (H_T) and the appropriate weighting factors (W_T) - that is ($H_E = \Sigma W_T H_T$). It includes the dose from radiation sources internal and/or external to the body. For purposes of demonstrating compliance with the regulatory dose limits, deep dose equivalent to the whole body may be used as effective dose equivalent for external exposures. The effective dose equivalent is expressed in units of rem (or sievert) [see 835.2(b)].

external dose or exposure: That portion of the dose equivalent received from radiation sources outside the body (e.g., "external sources") [see 835.2(b)].

extremity: Hands and arms below the elbow or feet and legs below the knee [see 835.2(b)].

internal dose or exposure: That portion of the dose equivalent received from radioactive material taken into the body (e.g., "internal sources") [see 835.2(b)].

lens of the eye dose equivalent: The external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 cm [see 835.2(b)].

quality factor: The modifying factor used to calculate the dose equivalent from the absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate quality factor (Q) [see 835.2(b)]. Quality factors are provided in 10 CFR 835.

shallow dose equivalent: The dose equivalent deriving from external radiation at a depth of 0.007 cm in tissue [see 835.2(b)].

total effective dose equivalent (TEDE): The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures) [see 835.2(b)].

weighting factor (w_T): The fraction of the overall health risk, resulting from uniform, whole body irradiation, attributable to specific tissue (T). The dose equivalent to the affected tissue (H_T) is multiplied by the appropriate weighting factor to obtain the effective dose equivalent contribution from that tissue [see 835.2(b)].

whole body: For the purposes of external exposure, head, trunk (including male gonads), arms above and including the elbow, or legs above and including the knee [see 835.2(b)].

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.

engineering 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.

entrance or access point: Any location through which an individual could gain access to areas controlled for the purposes of radiation protection. This includes entry or exit portals of sufficient size to permit human entry, irrespective of their intended use [see 835.2(a)].

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.

general employee: An individual who is either a DOE or DOE contractor employee; an employee of a subcontractor to a DOE contractor; or a visitor who performs work for or in conjunction with DOE or utilizes DOE facilities [see 835.2(a)].

gestation period: The time from conception to birth, approximately 9 months.

gray (Gy): SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule per kilogram (100 rads).

high-efficiency particulate air (HEPA) filter: Throwaway extended pleated medium dry-type filter with 1) a rigid casing enclosing the full depth of the pleats, 2) a minimum particle removal efficiency of 99.97 percent for thermally generated monodisperse di-octyl phthalate smoke particles with a diameter of 0.3 micrometer, and 3) a maximum pressure drop of 1.0 inch w.g. when clean and operated at its rated airflow capacity.

high contamination area: Any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed 100 times the removable surface contamination values specified in Chapter 2, Table 2-2 [see 835.2(a)].

high radiation area: Any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.1 rem (0.001 Sv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates [see 835.2(a)].

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 shallow dose equivalent 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.

individual: Any human being [see 835.2(a)].

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

irradiator: Sealed radioactive material used to irradiate other materials that has the potential to create a radiation level exceeding 500 rad (5 grays) in 1 hour at 1 meter. Although not addressed in this Standard, acceptable radiological controls for irradiator use are specified in Title 10, Code of Federal Regulations, Part 20.1603.

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.

member of the public: An individual who is not a general employee. An individual is not a "member of the public" during any period in which the individual receives an occupational dose [see 835.2(a)].

minor: An individual less than 18 years of age [see 835.2(a)].

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

monitoring: The measurement of radiation levels, airborne radioactivity concentrations, radioactive contamination levels, quantities of radioactive material, or individual doses and the use of the results of these measurements to evaluate radiological hazards or potential and actual doses resulting from exposures to ionizing radiation [see 835.2(a)].

occupational dose: An individual's ionizing radiation dose (external and internal) as a result of that individual's work assignment. Occupational dose does not include doses received as a medical patient or doses resulting from background radiation or participation as a patient in medical research programs [see 835.2(a)].

personal protective equipment: Equipment such as respirators, face shields, and safety glasses 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 dose equivalent 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).

radiation or ionizing radiation: Alpha particles, beta particles, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this Standard, does not include non-ionizing radiation, such as radio- or micro-waves, or visible, infrared, or ultraviolet light [see 835.2(a)].

radiation area: Any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.005 rem (0.05 mSv) in one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates [see 835.2(a)].

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 material area: Any area within a controlled area, accessible to individuals, in which items or containers of radioactive material exist and the total activity of radioactive material exceeds the applicable values provided in appendix 4A of this Standard [see 835.2(a)].

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 area: Any area(s) within a controlled area (but not including the controlled area) defined as a "radiation area," "high radiation area," "very high radiation area," "contamination area," "high contamination area," or "airborne radioactivity area" [see 835.2(a)].

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 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.

radiological worker A general employee whose job assignment involves operation of radiation producing devices or working with radioactive materials, or who is likely to be routinely occupationally exposed above 0.1 rem (0.001 sievert) per year total effective dose equivalent [see 835.2(a)].

real-time air monitoring: Measurement of the concentrations or quantities of airborne radioactive materials on a continuous basis [see 835.2(a)]. Also see "continuous air monitor."

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 guidelines in DOE 5400.5.

rem: Unit of dose equivalent. Dose equivalent in rem is numerically equal to the absorbed dose in rad multiplied by a quality factor, distribution factor and any other necessary modifying factor (1 rem = 0.01 sievert).

removable contamination: Radioactive material that can be removed from surfaces by non-destructive means, such as casual contact, wiping, brushing, or washing.

respiratory protective device: An apparatus, such as a respirator, worn by an individual for the purpose of reducing the individual's intake of airborne radioactive materials [see 835.2(a)].

sealed radioactive source: A radioactive source manufactured, obtained, or retained for the purpose of utilizing the emitted radiation. The sealed radioactive source consists of a known or estimated quantity of radioactive material contained within a sealed capsule, sealed between layer(s) of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material. Sealed radioactive sources do not include reactor fuel elements, nuclear explosive devices, and radioisotope thermoelectric generators [see 835.2(a)].

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 dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rems).

site: An area managed by DOE where access can be limited for any reason. The site boundary encompasses controlled areas.

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.

source leak test: A test to determine if a sealed radioactive source is leaking radioactive material [see 835.2(a)].

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.

transuranic waste: Without regard to source or form, waste that is contaminated with alpha-emitting transuranic radionuclides having half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay.

unusual occurrence: Non-emergency occurrence that has significant impact or potential for impact on safety, environment, health, security, or operations. Examples of the types of occurrences that are to be categorized as unusual occurrences are contained in DOE Order 232.1, *Occurrence Reporting and Processing of Operations Information.*

very high radiation area: Any area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in one hour at 1 meter from a radiation source or from any surface that the radiation penetrates [see 835.2(a)].

week: A period of seven consecutive days [see 835.2(a)].

whole body dose: The sum of the effective dose equivalent for external exposures and the committed effective dose equivalent for internal exposures. Also referred to as total effective dose equivalent.

year: The period of time beginning on or near January 1 and ending on or near December 31 of that same year used to determine compliance with the provisions of 10 CFR 835. The starting date of the year used to determine compliance may be changed provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years [see 835.2(a)].

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CONCLUDING MATERIAL

Review Activity:

DOE	Operations Offices	Field Offices
DP	AL	OH
EH	CH	
EM	ID	
NE	NV	
SC	OR	
	RL	
	OAK	
	SR	

National Laboratories
ANL
BNL
FNAL (Fermi)
INEEL
LANL
LLNL
PNNL
Sandia

Facilities
Pantex
RFETS
WVNS

Preparing Activity:
DOE-EH-52

Project Number:
SAFT-0039