Radiological Control: Conduct of Radiological Work

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CHAPTER 3 CONDUCT OF RADIOLOGICAL WORK

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PART 1 Planning Radiological Work

311 General

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

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

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

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

312 Planning for Maintenance, Operations, and Modifications

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

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

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

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

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

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

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

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

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

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

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

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

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

313 Infrequent or First-Time Activities

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

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

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

3. Review and approval by the ALARA Committee

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

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

314 Temporary Shielding

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

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

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

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

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

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

315 Technical Work Documents

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

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

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

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

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

316 Control of Internal Exposure

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

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

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

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

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

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

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

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

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

PART 2 Work Preparation

321 Radiological Work Permits

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

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

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

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

322 Use of Radiological Work Permits

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

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

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

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

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

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

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

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

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

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

323 Radiological Work Permit Preparation

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

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

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

324 Pre-Job Briefings

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

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

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

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

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

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

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

325 Use of Personal Protective Equipment and Clothing

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

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

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

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

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

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

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

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

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

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

PART 3 Entry and Exit Provisions

331 Controlled Areas

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

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

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

332 Radiological Buffer Areas

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

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

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

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

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

334 Radiation, High Radiation, and Very High Radiation Areas

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

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

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

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

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

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

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

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

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

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

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

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

335 Contamination, High Contamination, and Airborne Radioactivity Areas

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

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

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

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

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

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

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

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

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

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

336 Member of the Public Entry Provisions

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

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

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

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

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

337 Controlling the Spread of Contamination

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

1. Use solid barriers to enclose areas wherever practicable

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

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

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

338 Monitoring for Personnel Contamination

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

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

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

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

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

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

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

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

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

Table 3-1: Radiological Control Training Guidelines

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

Footnotes:

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

PART 4 Radiological Work Controls

341 General

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

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

342 Work Conduct and Practices

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

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

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

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

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

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

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

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

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

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

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

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

343 Logs and Communications

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

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

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

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

344 Review of Work in Progress

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

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

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

345 Stop Radiological Work Authority

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

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

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

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

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

346 Response to Abnormal Situations

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

348 Controls for Hot Particles

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

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

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

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

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

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

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

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

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

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

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

PART 5 Evaluation of Performance

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

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

351 Critiques

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

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

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

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

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

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

352 Post-Job Reviews

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

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

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

353 Lessons Learned

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

PART 6 Special Applications

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

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

361 Plutonium Operations

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

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

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

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

362 Uranium Operations

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

363 Tritium Operations

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

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

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

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

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

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

364 Accelerator Operations

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

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

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

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

365 Radiation Generating Devices

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

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

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

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

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

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

5. Control requirements for radiographic devices include the following:

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

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

PART 7 [Reserved]

Part 8 Design and Control

381 Radiological Design Criteria

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

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

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

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

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

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

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

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

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

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

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

382 Administrative Control Procedures

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

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

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

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

Appendix 3A

Checklist for Reducing Occupational Radiation Exposure

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

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

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

- Include special radiological control requirements in technical work documents
- Perform ALARA pre-job review
- Select and optimize engineered and administrative controls to control doses
- Plan access to and exit from the work area
- Provide for service lines (air, welding, ventilation)
- Provide communication (sometimes includes closed-circuit television)
- Remove or shield sources of radiation
- Plan for installation of temporary shielding
- Decontaminate
- Work in lowest radiation levels
- Perform as much work as is practical outside radiological areas
- State requirements for standard tools
- Consider special tools, including robots
- State staging requirements for materials, parts and tools
- Incorporate radiological control hold points
- Analyze personal protective equipment (PPE) requirements to ensure optimization of hazard control, risks, and costs
- Minimize discomfort of workers
- Revise estimates of collective dose
- Prepare radiological work permits (RWPs)

Appendix 3A (continued)

Temporary Shielding

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

- Design shielding to include stress considerations
- Control installation and removal by written procedure
- Inspect after installation
- Conduct periodic radiation surveys
- Prevent damage caused by weight of heavy temporary shielding
- Balance radiation exposure received in installation against exposure saved by installation
- Shield travel routes
- Shield components with abnormally high radiation levels early in the maintenance period
- Shield position(s) occupied by worker
- Perform directional surveys to to maximize the protection provided by the shield design.
- Use mock-ups to plan temporary shielding design and installation
- Consider use of water-filled shielding

Rehearsing and Briefing

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

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

Performing Work

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

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

Appendix 3B

Physical Access Controls for High and Very High Radiation Areas

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

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

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

3. Physical access controls over high and very high radiation areas shall be established in a manner that does not prevent an individual from leaving the area [see 835.502(d)].

Appendix 3C

Contamination Control Practices

Selection of Protective Clothing (PC)

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

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

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

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

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

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

5. Use of industrial safety equipment, such as hard hats, in contamination, high contamination, and airborne radioactivity areas should be controlled by the radiological work permit. Reusable industrial safety equipment designated for use in such areas should be distinctly colored or marked.

6. Shoe covers and gloves should be secured or taped at the coverall legs and sleeves when necessary to prevent worker contamination. Tape should be tabbed to permit easy removal.

7. Supplemental pocket or electronic dosimeters should be worn outside the protective clothing, in a manner accessible to the worker. Workers should protect such dosimeters from contamination by placing them in an outer coverall pocket or in plastic bags or pouches.

Appendix 3C (continued)

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

Removal of Protective Clothing

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

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

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

1. Remove exposed tape
2. Remove rubber overshoes
3. Remove gloves (Remove potentially contaminated gloves; replace with 'clean' gloves if a second glove was not originally worn.)
4. Remove hood from front to rear
5. Remove respiratory protection, as applicable
6. Remove coveralls, inside out, touching inside only
7. Take down barrier closure, as applicable
8. Remove tape or fastener from inner shoe cover
9. Remove each shoe cover, placing shoe onto clean step-off pad

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

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

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

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

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

1. Remove exposed tape
2. Remove rubber overshoes
3. Remover outer gloves
4. Remove hood from front to rear
5. Remove respiratory protection, as applicable
6. Remove outer coverall, inside out, touching inside only
7. Remove tape from inner coverall and sleeves
8. Remove each outer shoe cover, stepping on inner step-off pad as each is removed.

Appendix 3C (continued)

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

9. Remove inner rubber gloves
10. Remove inner coveralls, inside out, touching inside only
11. Take down barrier closure, as applicable
12. Remove tape or fastener from inner shoe cover
13. Remove each inner shoe cover, placing shoe on clean outer step-off pad

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

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

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

Use of Multiple Step-Off Pads

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

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

Appendix 3D

Guidelines for Selecting Protective Clothing (PC)

WORK ACTIVITY	REMOVABLE CONTAMINATION LEVELS		
	LOW (1 to 10 times Table 2-2 values)	**MODERATE** (10 to 100 times Table 2-2 values)	**HIGH** (> 100 times Table 2-2 values)
	RECOMMENDED PROTECTIVE CLOTHING[1,2]		
Routine	Full set of PCs	Full set of PCs	Full set of PCs, double gloves, double shoe covers
Heavy work	Full set of PCs, work gloves	Double set of PCs, work gloves	Double set of PCs, work gloves
Work with pressurized or large volume liquids, closed system breach	Full set of non-permeable PCs	Double set of PCs (outer set non-permeable), rubber boots	Double set of PCs and non-permeable outer clothing, rubber boots

Footnotes:

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

Appendix 3E

Guidelines for Personnel Contamination Monitoring with Hand-Held Survey Instruments

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

General Guidelines

1. Verify that the instrument is in service, has a valid source check, is set to the proper scale, and the audio output can be heard during frisking.

2. Hold probe less than 1/2 inch from surface being surveyed for beta and gamma contamination, approximately 1/4 inch for alpha contamination.

3. Move probe slowly over surface, approximately 2 inches per second.

4. If the count rate increases during frisking, pause for 5 to 10 seconds over the area to provide adequate time for instrument response.

5. If the count rate increases to a value greater than a preestablished contamination limit or the instrument alarms, remain in the area and notify radiological control personnel.

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

Sequence of Monitoring:

1. Frisk the hands before picking up the probe.

2. Perform the frisk in the following order:

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

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

Appendix 3F

Radiological Control Limiting Conditions

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

Dose and dose-rate

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

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

   For example:

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

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

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

   For example:

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

Appendix 3F (continued)

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

   For example:

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

Removable contamination levels

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

For example:

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

Airborne concentrations

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

For example:

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