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Radiological Control: Radiological Standards

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CHAPTER 2 RADIOLOGICAL STANDARDS

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PART 1 Administrative Control Levels and Dose Limits

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

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

211 Administrative Control Level

1. Approval by the appropriate Secretarial Officer or designee should be required prior to allowing an individual to exceed 2,000 millirem in a year.
2. Facility management should establish an annual facility administrative control level based upon an evaluation of historical and projected radiation exposures, work load, and mission. This control level should be reevaluated annually. The choice of a low level for one year does not preclude choosing either a higher or lower level in a subsequent year. The facility administrative control level should be approved by the contractor senior site management.
3. When there is wide variation in the expected doses to the various work groups at a single facility, facility management should develop work group-specific administrative control levels to control worker doses below the regulatory limits.
4. No individual should be allowed to exceed the facility administrative control level without the prior written approval of the radiological control organization and cognizant facility management. Authorization by the contractor senior management is recommended.

212 Lifetime Control Level

1. Efforts should be made to control each individual's lifetime occupational dose below a lifetime control level of N rem where N is the age of the individual in years. Article 216 discusses special control levels for radiological workers who have doses exceeding N rem. This is applicable only to radiological workers because they are the only individuals expected to receive greater than 100 mrem in a year; see Article 721 for supporting information.
2. To ensure compliance with the lifetime control level, efforts should be made to determine the lifetime occupational dose of individuals expected to receive more than 1 rem in a year. The lifetime occupational dose is determined by summing all occupational internal and external doses received during the individual's lifetime.
3. The internal contribution to lifetime occupational dose from intakes prior to January 1, 1989, may be calculated in terms of either cumulative annual effective dose or committed effective dose equivalent. The committed effective dose equivalent should be used to the extent that adequate data are available to calculate doses in these terms.

213 Occupational Dose Limits

1. Occupational dose limits are provided in Table 2-1 and shall not be exceeded [see 835.202(a)(1)-(4)]. All occupational dose received during the current year, (including that received from accidents and non DOE employment), except the dose resulting from planned special exposures and emergency exposures shall be included when demonstrating compliance with Table 2-1 limits [see 835.202(b) & 702(d)]. If formal records of an individual's prior occupational dose during the year cannot be obtained, a written estimate signed by the individual may be accepted [see 835.702(d)]. Written estimates should not be used as a basis for authorizing planned special exposures or emergency exposures.
2. In the following exceptional situations, a radiological worker may be authorized to receive a dose in excess of the values of the limits specified in Table 2-1:
 - a. Planned special exposures may be authorized for an individual to receive doses in addition to and accounted for separately from doses received under the Table 2-1 limits [see 10 CFR 835.204].
 - b. Under emergency conditions, individuals may be authorized to receive doses that exceed the limits established in Table 2-1 [see 835.1301 & 1302]. The provisions of this Standard do not limit actions necessary to protect health and safety under these conditions [see 10 CFR 835.3(d)].

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

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

214 Member of the Public Dose Limit

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

215 Embryo/Fetus Dose Controls

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

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

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

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

Table 2-1: Summary of Occupational Dose Limits

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

Notes:

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

216 Special Control Levels

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

1. A special control level of 5000 millirem in a year for equivalent dose to the lens of the eye should be considered for radiological workers performing work in non-uniform radiation fields where the maximum exposure is to the worker's head. Of particular interest are non-uniform x ray and beta exposures to the head. When this special control level is implemented in conjunction with the 2000 millirem administrative control level, the equivalent dose to the lens of the eye will not exceed 5000 millirem in a year. *(Note that in April 2011, ICRP recommended lowering the limit on the equivalent dose to the lens of the eye (EqD-Eye) from 15 rem/year to 10 rem in 5 years with the dose in any single year limited to 5 rem. The ICRP based this recommendation on a review of information they interpreted as indicating that the threshold for radiation-induced effects in the lens of the eye was significantly lower than previously expected.)*
2. A special control level for annual occupational exposure should be offered to each radiological worker with a lifetime occupational dose exceeding N rem, where N is the age of the individual in years. The special control level should allow the individual's lifetime occupational dose to approach and, if practicable, fall below N rem during ensuing years as additional occupational dose is received.
3. An employer should be attentive to special circumstances of employees, such as those undergoing radiation therapy, and offer to establish special control levels, at the employee's discretion, as appropriate.
4. Special controls on an individual dose should not be implemented in a manner that interferes with that individual's right to work. If reasonable efforts to implement the special control level below 1 rem per year threaten to restrict the individual's right to work or are otherwise unsuccessful, the contractor senior site executive should authorize any doses in excess of the special control level, but not to exceed the regulatory dose limits.

PART 2 Contamination Control and Control Levels

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

221 Personnel Contamination Control

1. Article 338 provides personnel contamination monitoring requirements and guidance. This guidance is not relevant to individuals exiting areas containing only radionuclides, such as tritium, that cannot be detected using hand-held or automatic frisking equipment.
2. Monitoring for contamination should be performed using frisking equipment that can detect total contamination at or below the values specified in Table 2-2. DOE encourages the use of automatic monitoring units that meet the above requirements.
3. Individuals found with detectable contamination on their skin or personal clothing, other than noble gases, radon progeny, or natural background radioactivity, should be promptly decontaminated as described in Article 541.

222 Contamination Control Levels

1. A surface is considered contaminated if either the removable or total surface contamination is detected above the levels in Table 2-2. Controls shall be implemented for these surfaces commensurate with the nature of the contaminant and level of contamination [see 10 CFR 835.1102(b)]. Appropriate postings and controls are established in Chapters 2, 3, and 4 of this Standard.
2. Surfaces exceeding the values of Table 2-2 for total contamination may be covered with a fixative coating to prevent the spread of contamination. However, reasonable efforts should be made to decontaminate an area before a coating is applied. A fixative coating should not be applied without the approval of the radiological control manager or designee.
3. Appropriate controls for areas of fixed contamination are provided in Article 224.
4. For areas with contaminated soil that is not releasable in accordance with the requirements in DOE O 458.1, a soil contamination area should be considered that:
 - a. Is posted as specified in Article 238.
 - b. Meets the requirements of Article 231.1 through 231.8.
5. Soil contamination areas may be located outside a controlled area (including a radiological buffer area).
6. Radioactive material, equipment and real property, on a DOE site, that have been documented to meet the conditions for their release specified in a DOE authorized limit approved by a Secretarial Officer in consultation with the Chief Health, Safety and Security Officer, are not subject to the values in Table 2-2 [see §§835.1(b)(6) and 835.2(a)].

223 Airborne Radioactivity Control Levels

1. Use of engineered and administrative controls to reduce the potential for internal exposure should be evaluated before allowing individuals, with or without respiratory protection, to enter airborne radioactivity areas.
2. Posting requirements for airborne radioactivity areas are specified in Article 235. Values of Derived Air Concentrations are provided in 10 CFR 835.

224 Areas of Fixed Contamination

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

1. Periodic surveys shall be conducted to ensure the surface contamination remains fixed to the surface and removable surface contamination levels remain below Table 2-2 values [see 10 CFR 835.1102(c)(1)].
2. Markings indicating the status of the area shall be applied [see 10 CFR 835.1102(c)(2)]. These markings should be applied directly to the surface (or at the access points) to provide appropriate warning. These markings may also provide appropriate instructions to individuals entering the area or contacting the surface (i.e., "Fixed Contamination" or "Fixed Contamination, Notify Radiological Control Personnel Prior to Removing Paint"). Signs, stencils, or other appropriate markings may be used.
3. Markings and postings should be maintained in a legible condition.
4. Appropriate written procedures should be implemented to prevent unplanned or uncontrolled removal of the contamination. These procedures should address issues such as access controls and fixative coatings, if needed, survey techniques and frequency, area tracking and maintenance, and required markings.
5. If surveys indicate that contamination is likely to be transferred from the area, fixative coatings should be applied. When paint is used as a fixative coating, it should consist of two layers having contrasting colors, to provide indication of erosion of the top layer. Other fixative coatings, such as strippable coatings and applied plastics and foams, should be periodically evaluated for evidence of degradation. Removable contamination should be reduced to the minimum practicable level before application of fixative coatings.
6. Areas meeting these requirements are exempt from the posting requirements of Articles 232 - 238 and the entry and exit requirements of Chapter 3.

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

Surface Contamination Values¹ in dpm/100 cm²

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

Footnotes:

1. The values in this appendix, with the exception noted in footnote 6 below, apply to radioactive contamination deposited on, but not incorporated into the interior or matrix of, the contaminated item. Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides apply independently.
2. As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
3. The levels may be averaged over one square meter provided the maximum surface activity in any area of 100 cm² is less than three times the value specified. For purposes of averaging, any square meter of surface shall be considered to be above the surface contamination value if: (1) from measurements of a representative number of sections it is determined that the average contamination level exceeds the applicable value; or (2) it is determined that the sum of the activity of all isolated spots or particles in any 100 cm² area exceeds three times the applicable value.
4. The amount of removable radioactive material per 100 cm² of surface area should be determined by swiping the area with dry filter or soft absorbent paper, applying moderate pressure, and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. (Note - The use of dry material may not be appropriate for tritium.) When removable contamination on objects of surface area less than 100 cm² is determined, the activity per unit area shall be based on the actual area and the entire surface shall be wiped. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.
5. This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.
6. Tritium contamination including special tritium compounds (STCs) may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may migrate to the surface in order to ensure the surface contamination value provided in this appendix is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a "Total" value does not apply. In certain cases, a "Total" value of 10,000 dpm/100 cm² may be applicable either to metals of the types from which insoluble special tritium compounds are formed, that have been exposed to tritium, or to bulk materials to which insoluble special tritium compound particles are fixed to a surface.
7. These limits apply only to the alpha emitters within the respective decay series.

PART 3 Posting

231 General Posting Provisions

1. Radiological postings are intended to alert individuals to the presence of radiation and radioactive materials and to aid them in controlling exposures and preventing the spread of contamination. Boundaries used for radiological control purposes are depicted in Figure 2-1.
2. Signs shall contain the standard radiation symbol (radiation warning trefoil) colored magenta or black on a yellow background [see 10 CFR 835.601(a)]. Lettering should be either magenta or black. Magenta is the preferred color. Standardized signs, as described in DOE's core training and the 10 CFR 835 Guide, should be used where practicable.
3. Signs shall be conspicuously posted at each access point [see 835.601, 603], clearly worded, and, where appropriate, may include radiological control instructions [see 835.601(b)]. Radiological postings should be displayed only to signify actual or potential radiological conditions. Signs used for training should be clearly marked, such as "For Training Purposes Only."
4. Posted areas should be as small as practicable for efficiency.
5. Postings should be maintained in a legible condition and updated based upon the results of the most recent surveys.
6. If more than one radiological condition (such as contamination and high radiation) exists in the same area, each condition shall be identified [see 835.603].
7. In areas of ongoing work activities, the dose rate and contamination level or range of each should be included on or in conjunction with each posting as applicable.
8. Postings at entrance points to areas of ongoing work activities controlled for radiological purposes should state basic entry requirements, such as dosimetry, radiological work permit (RWP) or other written authorization, and respiratory protection requirements.
9. Rope, tape, chain, and similar barriers used to designate the boundaries of posted areas should be distinctive (e.g., yellow and magenta or yellow and black in color).
10. Physical barriers should be placed so that they are clearly visible from all directions and at various elevations. They should not be easily walked over or under, except at identified access points. These barriers shall be set up such that they do not impede the intended use of emergency exits or evacuation routes [see 835.501(e), 502(d)].
11. Areas shall be clearly and conspicuously posted [see 835.601(b)]. Posting of doors should be such that the postings remain visible when doors are open or closed.
12. A radiological posting that signifies the presence of an intermittent radiological condition should include a statement specifying when the radiation is present, such as "CAUTION: RADIATION AREA WHEN RED LIGHT IS ON."

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

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

232 Posting Controlled Areas

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

1. Each access point to a controlled area shall be posted whenever radiological areas or radioactive material areas may be present in the area [see 835.602(a)].
2. The contractor may select the type of sign (colors and words) used to avoid conflict with local security requirements [see 835.602(b)]. This selection should be approved by the contractor senior site executive.

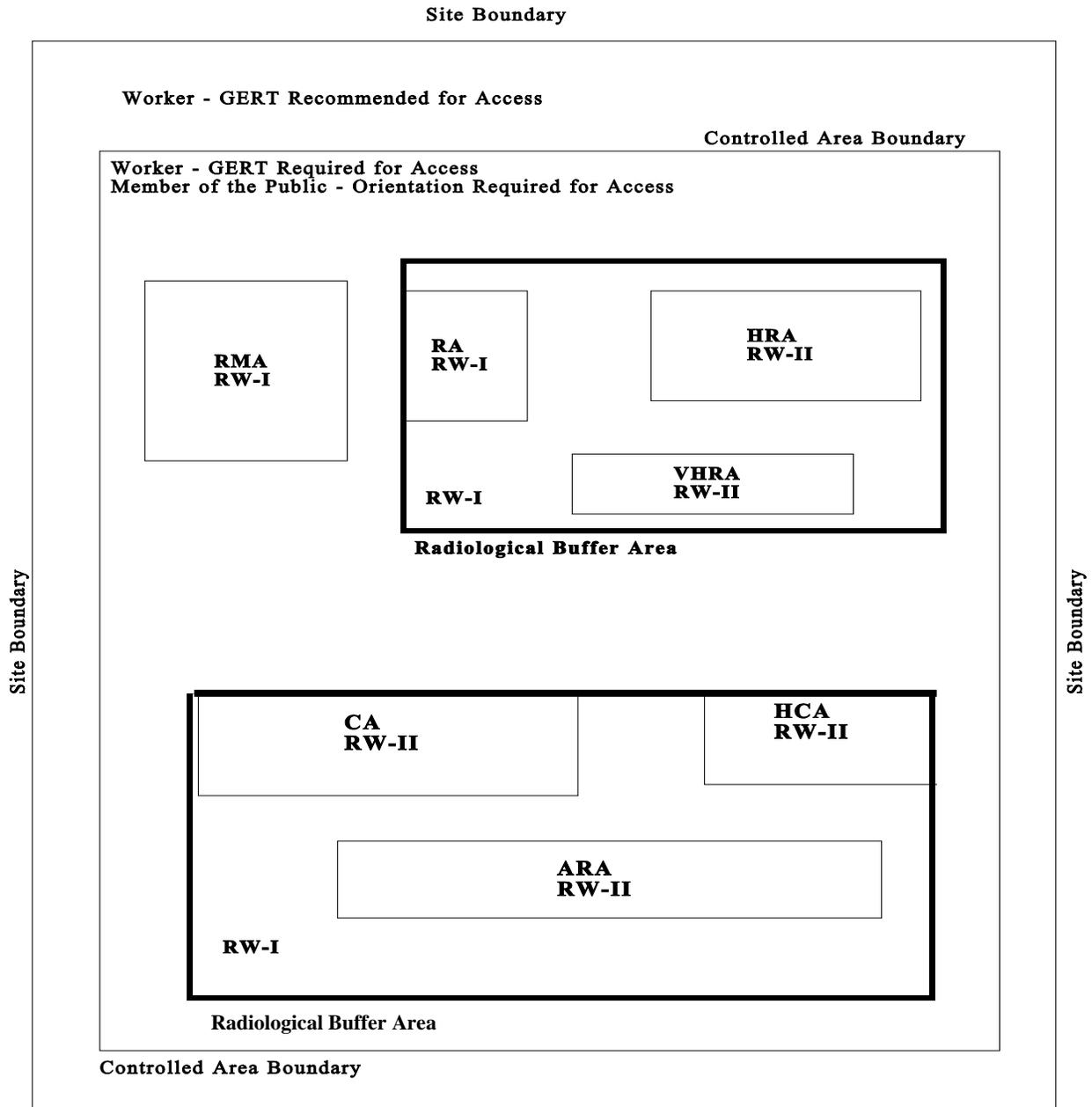
233 Posting Radiological Buffer Areas

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

1. A radiological buffer area should be established for contamination control adjacent to any entrance to or exit from a contamination, high contamination, or airborne radioactivity area. The size of the radiological buffer area should be commensurate with the potential for the spread of contamination. A radiological buffer area may also be established in areas such as Change Rooms, where low-level contamination may be present, but where radioactive material handling is not specifically authorized. Radiological buffer areas established for contamination control should be located within controlled areas.
2. A radiological buffer area should be established as needed for exposure control. The boundary for the radiological buffer area should be established to limit radiation doses (TED) to general employees to less than 100 millirem in a year or as needed to keep radiation doses to general employees ALARA.
3. A radiological buffer area is not warranted for:
 - a. High contamination or airborne radioactivity areas that are completely within contamination areas
 - b. Inactive contamination, high contamination, or airborne radioactivity areas (i.e., areas to which entry has been prohibited by posting or barricades)
 - c. Exposure control, if other posted boundaries or controls provide equivalent employee protection
 - d. Exposure control, if general employees who are not trained as radiological workers are restricted from unescorted entry to controlled areas.
 - e. Exposure control, if general employees who are not trained as radiological workers are unlikely to be present in the area long enough to receive 100 mrem in a year.

4. The need for radiological buffer areas around radioactive material areas, soil contamination areas, and underground radioactive material areas should be determined by the Radiological Control Organization (RCO) based upon the potential for exposure of unmonitored individuals and the spread of contamination.
5. Posting of radiological buffer areas should be in accordance with Article 231 and contain the wording "CAUTION, RADIOLOGICAL BUFFER AREA."

**Figure 2-1
Establishing Posted Areas**



GERT; General Employee Radiological Training
 RW-I; Radiological Worker I Training
 RW-II; Radiological Worker II Training
 RMA; Radioactive Material Area
 RA; Radiation Area

HRA; High Radiation Area
 VHRA; Very High Radiation Area
 CA; Contamination Area
 HCA; High Contamination Area
 ARA; Airborne Radioactivity Area

234 Posting Radiation Areas

1. Areas shall be posted to alert individuals to the presence of external radiation in accordance with Table 2-3 [see 835.601, 603]. In addition to the 'required posting' contractors may add supplemental information; examples of typical supplemental information are shown in Table 2-3. In addition, hot spots should be labeled as described below to provide warning of discrete radiation sources.
2. Radiation areas and high radiation areas shall be identified based on the dose rates at a distance of 30 centimeters either from the source or from any surface penetrated by the radiation [see 835.2(a), radiation area and high radiation area]. Very high radiation areas shall be identified based on the dose rate at a distance of 100 centimeters either from the source or from any surface penetrated by the radiation [see 835.2(a), very high radiation area].
3. Hot spots are localized sources of radiation, normally located within piping or components, with contact radiation levels greater than 100 millirem per hour (penetrating radiation dose) and more than 5 times greater than the general area dose rate. Contact readings should be used to determine the need for labeling hot spots. Measures taken to identify sources of elevated general area radiation levels while conducting routine radiation surveys should be sufficient to identify hot spot locations. Special surveys for the sole purpose of identifying hot spots are not required.
4. A label reading "Caution, Hot Spot" and marking the location of the hot spot should be placed on or as near the spot as practicable. The provisions of Article 231.7 through 231.11 do not apply to the hot spot labeling. Labeling of hot spots is not required in areas with general area dose rates greater than 1 rem/hr. However, the locations of such hot spots should be noted on area surveys and discussed in pre-job briefings.
5. Dose received in an hour may be used as the criterion for posting (Column 2 of Table 2-3). Very high dose rates (such as those in very high radiation areas) shall be recorded in units of "rads" rather than "rem" in an hour [see 835.2].

Table 2-3: Criteria for Posting Radiation Areas

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

Footnote:

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

235 Posting Contamination, High Contamination, and Airborne Radioactivity Areas

1. Areas shall be posted to alert individuals to the presence (or likely presence) of removable surface contamination and airborne radioactivity in accordance with Table 2-4 [see 835.603].
2. Derived Air Concentration (DAC) values found in 10 CFR 835 shall be used in posting airborne radioactivity areas in accordance with Table 2-4 [see 835.209(a)].

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

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

Footnote:

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

236 Posting Radioactive Material Areas

1. Accessible areas where items or containers of radioactive material in quantities exceeding the values provided in Appendix E of 10 CFR 835 are used, handled, or stored shall be posted "CAUTION or DANGER, RADIOACTIVE MATERIAL" [see 835.603(g)].
2. Radioactive material areas shall be within a controlled area [see 835.2(a), radioactive material area].
3. Radioactive material areas may be excepted from the posting requirements when:
 - a. The area is posted as a radiological area in accordance with Article 234 or 235 [see 835.604(b)(1)]; or
 - b. Each item or container of radioactive material in the area is clearly labeled to warn individuals of the hazards [see 835.604(b)(2)]; or
 - c. The radioactive material of concern consists solely of structures or installed components which have been activated (such as by exposure to neutron radiation or particles produced in an accelerator); or
 - d. The area contains only packages of radioactive material received from radioactive material transportation while awaiting monitoring in accordance with Articles 552 and 554 [see 835.604(c)]; or
 - e. For periods of eight continuous hours or less, the area is under the continuous observation and control of an individual knowledgeable of, and empowered to implement, required access and exposure control measures [see 835.604(a)].
4. Provisions for labeling radioactive material are specified in Chapter 4.

237 Posting Underground Radioactive Material Areas

1. Underground radioactive material areas should be established to indicate the presence of underground items that contain radioactive materials, such as pipelines, radioactive cribs, covered ponds, covered ditches, catch tanks, inactive burial grounds, and sites of known, covered, unplanned releases (spills).
2. Underground radioactive material areas should be posted "UNDERGROUND RADIOACTIVE MATERIAL." Posting should include instructions or special warnings to workers such as "Consult Radiological Control Organization before Digging" or "Subsurface Contamination Exists." The posting should meet the applicable requirements of Article 231. Underground radioactive material areas need not be posted if physical or administrative controls are implemented to ensure appropriate radiological controls are established prior to excavating, penetrating, or otherwise disturbing underground radioactive materials.
3. Underground radioactive material areas may be located outside controlled areas unless access is likely to result in individual doses (total effective dose) greater than 100 millirem in a year from underground radioactive material.
4. Underground radioactive material areas are exempt from the entry and exit requirements of Chapter 3 when access is not likely to result in individual doses greater than 100 millirem in a year. Article 333.1 provides entry provisions for instances in which access is likely to result in individual doses greater than 100 millirem in a year.

238 Posting Soil Contamination Areas

1. For areas with contaminated soil that is not releasable in accordance with the requirements in DOE O 458.1, a soil contamination area should be established that is posted in accordance with the requirements in Article 231.1 through 231.8. Posting should include the words "Caution, Soil Contamination Area" and instructions or special warnings to workers, such as "Consult with Radiological Control Organization before Digging" or "Subsurface Contamination Exists."
2. Soil contamination areas may be located outside controlled areas if exposure to the material in the area is not likely to cause any individual to receive a total effective dose in excess of 100 millirem in a year.
3. If the contamination levels in the area exceed the values provided in Table 2-2 (as evidenced by the likelihood of tracking contamination out of the area at levels exceeding these values), then the area is a contamination area or high contamination area and shall be posted in accordance with Article 235 [see 835.2(a), contamination area and high contamination area and 835.603(d) and (e)].

Appendix 2A

[Reserved]

Appendix 2B

Radiation Weighting Factors¹, w_R

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

Footnotes:

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

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

Appendix 2C

Tissue Weighting Factors for Various Organs and Tissues, w_T

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

Footnotes:

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

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

Appendix 2D

Non-Uniform Exposure of the Skin

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

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

Footnote:

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